O/c

adani

APSEZ/EnvCell/2017-18/035

Date: 22.11.2017

To

Additional Principal Chief Conservator of Forests (C),
Ministry of Environment, Forest and Climate Change,
Regional Office (WZ), E-5, Kendriya
Paryavaran Bhawan, Arera Colony,
Link Road No. – 3, Bhopal – 462 016.
E-mail: rowz.bpl-mef@nic.in

Sub : Half yearly Compliance report of Environment and CRZ Clearance for "Handling facility of General Cargo / LPG /Chemicals and their storage terminal at Navinal Island, Mundra taluka of Kutch district, Gujarat"

Ref : Environment and CRZ clearance granted to M/s Adani Ports & SEZ Limited vide letter dated 25th August, 1995 bearing no. J-16011/13/95-IA.III

Dear Sir,

Please refer to the above cited reference for the said subject matter. In connection to the same, it is to state that copy of the compliance report for the Environmental and CRZ Clearance for the period of April – 2017 to September – 2017 is enclosed here for your records. The stated information is also provided in form of a CD (soft copy).

Thank you,
Yours Faithfully,
For, **M/s Adani Ports and Special Economic Zone Limited**

Ennarasu

Ennarasu Karunesan
Chief Executive Officer
Mundra & Tuna Port

Encl: As above

Copy to:

1) The Director (IA Division), Ministry of Environment, Forests & Climate Change, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi-110003
2) Zonal Officer, Regional Office, CPCB – Western Region, Parivesh Bhawan, Opp. VMC Ward Office No. 10, Subhanpura, Vadodara – 390 023
3) Member Secretary, GPCB – Head Office, Paryavaran Bhavan, Sector 10 A, Gandhi Nagar – 382 010
4) Deputy Secretary, Forests & Environment Department, Block – 14, 8th floor, Sachivalaya, Gandhi Nagar – 382 010
5) Regional Officer, Regional Office GPCB (Kutch-East), Gandhidham, 370201

01/12/17

कार्यालय पर्यावरण एवं वन मंत्रालय (केन्द्रीय) Ministry of Environment & Forests Regional Office (Western) क्षेत्रीय कार्यालय (पश्चिम) भोपाल (म.प्र.) OFFICE

Environmental Clearance Compliance Report

Multi-Purpose Jetty and Storage Facilities at Navinal Island, Mundra, Dist. Kutch, Gujarat

of

Adani Ports and Special Economic Zone Limited

For the Period of:

April-2017 to September-2017

Index

Compliance Report

adani	Adani Ports and SEZ Limited	From : April'17 To : September'17
Status of the Conditions Stipulated in Environment and CRZ Clearance		

Half yearly Compliance report of Environment and CRZ Clearance for "Handling facility of General Cargo / LPG /Chemicals and their storage terminal at Navinal Island, Mundra taluka of Kutch district, Gujarat" issued vide letter no. J-16011/13/95-IA.III dated 25th Aug., 1995

<table>
<tr><th>Sr. No.</th><th>Conditions</th><th>Compliance Status as on 30-09-2017</th></tr>
<tr><td>2(i)</td><td>All construction designs / drawings relating to various project activities should have the approval of the concerned State Government departments / Agencies.</td><td>Complied.

Information has been already submitted to the Ministry of Environment, Forest & Climate Change & there is no further change.</td></tr>
<tr><td>2(ii)</td><td>To prevent discharge of bilge wastes, sewage and other liquid wastes from the oil tankers / ships into marine environment, adequate system for collection, treatment and disposal of liquid wastes including shore line installation and special hose connections for ships to allow for discharge of sewage must be provided.</td><td>Complied.

Ships berthing at Mundra Port comply with MARPOL regulations.

No discharge such as bilge wastes, sewage or any other liquid wastewater is allowed into marine environment inside port limits

APSEZL does not receive sewage/liquid waste from ship.

As a general practice APSEZ receives slop oil from vessels and water and oil particles from the same are separated in Oil Water Separator system. Separated oil from the same is being sold to authorized recycler /re-processor. However, no slope oil was received during the compliance period.</td></tr>
<tr><td>2(iii)</td><td>The quality of treated effluents, solid wastes, emissions and noise levels etc. must confirm to the standards laid down by the competent authorities including the central and State Pollution Control Boards under the Environment (Protection) act, 1986 whichever are more stringent.</td><td>Complied.

ETP is provided to treat the wastewater/wash water. Also the sewage generated from port is being treated in designated ETP. Treated water is used for horticultural purposes.
<table>
<tr><th>Location</th><th>Capacity</th><th>Quantity of Wastewater</th><th>Type of ETP / STP</th></tr>
<tr><td>LT</td><td>265 KLD</td><td>150 KLD</td><td>Activated Sludge</td></tr>
</table>
Third party analysis of the treated water is being carried out once in a month by NABL accredited and MoEF&CC approved agency namely M/s. Pollucon Laboratory Pvt. Ltd. Summary of the same for duration from Apr'17 to Sep'17 is mentioned below.
<table>
<tr><th>Parameter</th><th>Unit</th><th>Max</th><th>Min</th><th>Perm. Limit$</th></tr>
</table>
</td></tr>
</table>

Sr. No.	Conditions	Compliance Status as on 30-09-2017

pH	--	7.55	6.78	6.5 – 8.5
TSS	mg/L	62	22	100
TDS	mg/L	1528	950	2100
COD	mg/L	144	28	100
BOD (3 Days @ 27 °C)	mg/L	32	8	30
Ammonical Nitrogen as NH_3	mg/L	12.6	1.74	50

$ as per CC&A granted by GPCB

Waste Management:
APSEZ adopted 5R concept for environmentally sound management of different types of solid & liquid waste.
Municipal Solid Waste
A well-established system for segregation of dry & wet waste is in place, by which all wet waste (Organic waste) is being segregated & utilized for compost manufacturing; compost is further used by our horticulture team for green belt development.
Dry Recyclable Waste - is being sorted out in various categories & finally being sent for recycling.
E- Waste & Used Batteries - is being sold to registered recycler.
Solid Hazardous Waste - is being disposed through common facility i.e. CHWIF and / or co-processing at cement industries.
Used/Waste Oil - It is being sold to authorized recycler/reprocesser.
Downgrade Chemicals - It is being sold to authorized solvent recover.
Slop Oil – Slop oil from vessels are received and water and oil particles from the same are separated in Oil Water Separator system. Separated oil from the same is being sold to authorized recycler /reprocessor.
Summary of the waste management from Apr'17 to Sep'17 for different types of wastes at APSEZ, Mundra is as below:

Waste	Quantity in MT	Disposal method
Hazardous Waste		
ETP Sludge	1.04	Landfilling at TSDF Site
Pig Waste	3.52	Co-processing at cement industries

<table>
<tr><th>Sr. No.</th><th>Conditions</th><th>Compliance Status as on 30-09-2017</th></tr>
<tr><td></td><td></td><td>
<table>
<tr><td>Tank Bottom Sludge</td><td>1.73</td><td>Co-processing at cement industries</td></tr>
<tr><td>Oily Cotton waste</td><td>29.23</td><td>Co-processing at Cement Industries</td></tr>
<tr><td>Used / Spent Oil</td><td>41.41</td><td>Sell to registered recycler</td></tr>
<tr><td>Discarded Containers</td><td>4.18</td><td>Sell to registered recycler</td></tr>
<tr><td colspan="3">Municipal Solid Waste</td></tr>
<tr><td>Dry Waste</td><td>115</td><td>After recovery sent for recycling</td></tr>
<tr><td>Wet Waste</td><td>98</td><td>Converted to Manure for Horticulture use</td></tr>
</table>
<u>Ambient Air Quality</u> (twice in a week) and <u>Noise</u> (once in a month) monitoring are being carried out by NABL accredited and MoEF&CC approved agency namely M/s. Pollucon Laboratories Pvt. Ltd. Summary of the same for duration from Apr'17 to Sep'17 is mentioned below.
Total Ambient Air Sampling Locations: 4 Nos.
<table>
<tr><th>Parameter</th><th>Unit</th><th>Max</th><th>Min</th><th>Perm. Limit$</th></tr>
<tr><td>PM_{10}</td><td>$\mu g/m^3$</td><td>96.6</td><td>37.6</td><td>100</td></tr>
<tr><td>$PM_{2.5}$</td><td>$\mu g/m^3$</td><td>55.4</td><td>15.4</td><td>60</td></tr>
<tr><td>SO_2</td><td>$\mu g/m^3$</td><td>27.6</td><td>5.3</td><td>80</td></tr>
<tr><td>NO_2</td><td>$\mu g/m^3$</td><td>45.4</td><td>14.2</td><td>80</td></tr>
</table>
$ as per NAAQ standards, 2009
Total Noise Monitoring Locations: 4 Nos.
<table>
<tr><th>Noise</th><th>Unit</th><th>Average</th><th>Perm. Limit</th></tr>
<tr><td>Day Time</td><td>dB(A)</td><td>65.9</td><td>75</td></tr>
<tr><td>Night Time</td><td>dB(A)</td><td>63.8</td><td>70</td></tr>
</table>
The quality of treated effluents, solid wastes, emissions and noise levels are being regularly analyzed by NABL accredited and MoEF&CC approved agency. Approximately INR 12 Lakh is spent for all environmental monitoring activities during the F.Y. 2017-18 (till Sept' 17). The six monthly environment monitoring report is attached as Annexure – 1.
</td></tr>
<tr><td>2(iv)</td><td>Adequate provision for infrastructure facilities such as water supply, roads, sanitation etc. should be ensured so as</td><td>Complied.

Construction activity is already completed. Adequate infrastructure facility was provided to labours during construction phase.</td></tr>
</table>

Sr. No.	Conditions	Compliance Status as on 30-09-2017
	to avoid environmental degradation in the surrounding areas. These facilities should be brought into existence during the construction phase and will remain in existence thereafter as part of the infrastructure build up in the area for local developmental purposes.	The facility for drinking water, toilet and rest shelter are provided for the dignity of operation labours. Photographs of the same were provided along with the compliance submission for the duration of Oct'16 to Mar'17.
2(v)	Adequate noise control measures should be ensured in various project activities and due to increase in the traffic which is likely to take place during construction and operational phases.	Complied. Construction phase is completed. For operation phase, following noise control measures are taken: • All DG sets are installed with acoustic enclosure. • Green Belt has been developed at road sides. • Traffic control measures such as signage, speed regulation, traffic guides etc. are in place to reduce the unnecessary honking by cargo vehicles.
2(vi)	The water quality parameters such as dissolved oxygen, ammonical nitrogen and other nutrients etc. should be measured at regular intervals to ensure adherence to the prescribed standards of water qualities. Suitable ground water monitoring should also be undertaken around the sludge lagoons and regular reports to be submitted to the Ministry for evaluation.	Complied. ETP is provided for treatment of wastewater. Treated water is used for horticulture purpose. The watery sludge is transferred to sludge drying bed, where the excess wastewater is recirculated to ETP. Third party analysis of the treated water is being carried out twice in a month by NABL accredited and MoEF&CC approved agency namely M/s. Pollucon Laboratories Pvt. Ltd. Summary of the same for duration of Apr'17 to Sep'17 is mentioned in compliance condition no. 2(iii) above. <u>Marine Monitoring:</u> Marine monitoring is being carried out once in a month by NABL accredited and MoEF&CC approved agency namely M/s. Pollucon Laboratory Pvt. Ltd. Summary of the same for duration from Apr'17 to Sep'17 is mentioned below. Monitoring Reports are attached as **Annexure – 1** for the same. **Total Sampling Locations: 09 Nos.**

Parameter	Unit	Surface	Bottom

Sr. No.	Conditions	Compliance Status as on 30-09-2017

		Max	Min	Max	Min
pH	--	8.28	7.55	8.38	7.27
TSS	mg/L	30	12	40	16
BOD (3 Days @ 27 °C)	mg/L	8	3	9	4
DO	mg/L	6	4.8	5.4	4.4
Salinity	mg/L	48.45	31.4	49	32.3
TDS	ppt	53670	30830	54820	32620
COD	mg/L	29	5	38	14

Ground Water Monitoring:

There are no sludge lagoons however, to monitor the ground water quality, bore wells are provided at various location in the port and SEZ areas. Third party analysis of the ground water is being carried out twice a year by NABL accredited and MoEF&CC approved agency namely M/s. Pollucon Laboratories Pvt. Ltd. Summary of the same for duration of Apr'17 to Sep'17 is mentioned below. Monitoring Reports are attached as **Annexure – 1** for the same.

Parameter	Unit	Minimum	Maximum
pH	-	7.43	7.68
Salinity	mg/L	0.55	12.73
Oil & Grease	mg/L	1.2	5.3
Hydrocarbon	mg/L	BDL	BDL
Lead as Pb	mg/L	0.06	0.53
Arsenic as As	mg/L	BDL	BDL
Nickel as Ni	mg/L	0.2	0.2
Total Cromium as Cr	mg/L	0.004	0.008
Cadmium as Cd	mg/L	0.008	0.13
Mercury as Hg	mg/L	BDL	BDL
Zinc as Zn	mg/L	0.043	1.81
Copper as Cu	mg/L	0.04	0.755
Iron as Fe	mg/L	0.67	17.05
Insecticides/Pesticides	mg/L	BDL	BDL

*BDL = Below Detectable Limit

Approx. INR 12 Lakh is spent for all environmental monitoring activities during the F.Y. 2017-18 (till Sept' 17).

Sr. No.	Conditions	Compliance Status as on 30-09-2017
2(vii)	Adequate culverts should be provided for smaller creeks so that breeding grounds for crabs, mud snappers and other marine organisms are not cut off by road construction activities.	Complied. Prominent creek system (main creeks and small branches of creeks) in the region are: (1) Kotdi (2) Baradimata (3) Navinal (4) Bocha (5) Mundra (Oldest port (Juna Bandar) leading to Bhukhi river) All above creeks are in existence allowing free flow of water and there is no filling or reclamation of any creek area. APSEZL has so far constructed 19 culverts having total length of approx. 1100 m with total cost of INR 20 Crores. Apart from that three RCC Bridges have been constructed over Kotdi creek with total length of 230 m and cost of INR 10 Crores. Photographs of the same are attached as **Annexure – 2**.
2(viii)	A hundred meter wide mangrove belt should be created all along the west of Navinal Creek till its junction up to new road. Green belt of 50 M width should also be provided all along the periphery of the plant site and along the roads, storage tanks etc. at 1500 trees per hectare. All details regarding the Mangrove belt and other afforestation work must be worked out in consultation with the State Forest Department, and details sent to the Ministry.	Complied. 24 hectare of Mangrove afforestation was carried out with a cost of INR 25.00 Lac at west of Navinal creek. All Mangrove plantations were done in consultation with Dr. Maity, Mangrove consultant of India. Green belt was developed in 15.15 ha. Total 51605 trees were planted with the density of 3406 trees per hectare. Green belt Location: Liquid terminal & bitumen area (5.85 ha.) and along main road & Navinal creek (5.7 + 3.60 Ha.) of MPT. It may be noted that to enhance the marine biodiversity, till date APSEZ has carried out mangrove afforestation in more than 2800 ha. area across the coast of Gujarat. Total expenditure for the same till date is INR 782 lakh. So, far APSEZ has developed more than 400 ha. area as greenbelt with plantation of more than 8.0 Lacs saplings within the APSEZ area. Details on mangroves afforestation & Green belt development carried out by APSEZ till date is annexed as **Annexure – 3**.
2(ix)	Arrangements should be made for ensuring fresh water availability for	Complied. Present source of water for various project activities is

Sr. No.	Conditions	Compliance Status as on 30-09-2017
	various project related activities. Special water harvesting programs should be undertaken in the project impact area. Details of these activities should be reported to the Ministry.	desalination plant of APSEZ and/or Narmada water through Gujarat Water Infrastructure Limited. Average water consumption for entire APSEZ area is 5.6 MLD out of which 2.8 MLD is obtained from Desalination plant whereas remaining 2.8 MLD is obtained from GWIL. Groundwater recharge cannot be done at the project site since the entire project is in the intertidal / sub tidal areas. Rain water within project area is managed through storm water drainage. However, APSEZ has carried out pond deepening activity at Mota Bhadiya and Bhujpur villages during the compliance period to envisage rainwater harvesting.
2(x)	While filling the storage tanks, compatibility of the chemicals should be ensured for chemical safety. Since 5000 MT capacity is proposed to be created for cryogenic conditions, necessary HAZOP study should be initiated and submitted to the Ministry within three months. Calculations carried out on the basis of EFFECT MODEL for this storage should be rechecked for various accident scenarios. Keeping in view the safety aspects, Horton spheres of 1250 MT capacity each should be preferred.	Complied. Risk assessment study was carried out by M/s. Comet Consultancy Services in January 1995 as a part of EIA for storage of various chemicals in tanks for chemical safety and the same was submitted to MoEF&CC while processing EC application. Recently a risk assessment study is carried out by iFluids Engineering for handling and storage of LPG in three parts as mentioned below. 1. QRA for LPG Jetty Area 2. QRA for LPG Pipeline 3. QRA for LPG Tank farm A copy of the same is attached as **Annexure - 4.**
2(xi)	The measures suggested by the Gujarat State Pollution Control Board in February, 1995 while according "No Objection Certificate" should be strictly followed and authorization certificate required for converting	Complied. Consent to Operate (CC&A) was granted by GPCB based on the compliance of conditions of the No Objection Certificate (CtE). This CC&A is renewed from time to time based on its validity. The last renewal was obtained vide GPCB consent no. AWH-88317 valid till 20th November, 2021. Copy of the same was submitted along with compliance submission for the period of Oct'16 to Mar'17.

Sr. No.	Conditions	Compliance Status as on 30-09-2017
	NOC into "consent to operate" should be submitted within three months.	Consent to Operate (CtO) is obtained and renewed/amended from time to time as per the progress of the project activity. CtO-Amendment obtained vide Order No. WH-88317 dated 03.10.2017 valid up to 20.11.2021. This consent order is processed for necessary correction from state pollution control board. Copy of the same is attached as **Annexure – 8**.
2(xii)	For ensuring the acceptance of the project by the local people, a Resolution of the Official Panchayat of the Region should be obtained offering their concurrence in writing by the project proponents and submitted to the Ministry by 31st October, 1995.	Complied. Resolution from the Panchayat has been obtained and submitted to the Ministry of Environment, Forest & Climate Change on 31st July, 2012.
2(xiii)	A permanent staff structure should be created with latest R&D facilities and suitable equipments for environmental and forestry activities through creation of Environmental cell. Adequate funds should be earmarked for this cell.	Complied. APSEZL has a well structured Environment Cell, staffed with qualified manpower for implementation of the Environmental Management Plan. The structured organogram is attached as **Annexure - 5** Budget for environmental management measures (including horticulture) for the FY 2017-18 is to the tune of INR 966 lakh. Out of which, Approx. INR 682 lakhs are spent during compliance period. Detailed breakup of the expenditures is attached as **Annexure – 6**.
2(xiv)	Landsat imagery should be obtained on a continuous basis covering various seasons to study the change in the land use pattern due to the project and project related activities.	Complied. Project is in operation phase since many years and there is no change in the land use pattern during the period from Apr'17 to Sep'17.
2(xv)	With a view to providing adequate job opportunities to local people, facilities for	Complied. • Adani Skill Development Center (ASDC), Mundra is providing skill development training to the locals for Soft

Sr. No.	Conditions	Compliance Status as on 30-09-2017
	technical training and development of skills should be made available in consultation with the state Harbour Department, and to this end it must be ensured that there is allocation of adequate funds. The local people should be involved in the afforestation program proposed for the scheme to ensure public participation and success of vegetation programmes.	Skill, Technical Training and Carrier Guidance & knowledge based training. Total 400 students were enrolled as per above topics during Apr'17 to Sep'17. Allocation of fund for education is availed by Adani Foundation. Total INR 59.70 Lacs are allotted for community education & skill development out of which INR 16.33 Lacs are spent for the purpose till Sep'17. • Preference is given to local people for employment based on their qualification and experience. • All Mangrove plantations are done in consultation with GUIDE and Local forest dept. • 24 hectare of mangrove afforestation at Mundra was done through active participation of local fishermen at the cost of INR 25.0 Lac • Details on skill development training imparted during period of Apr'17 to Sep'17 by Adani Foundation are enclosed as **Annexure – 7**.
2(xvi)	Prior clearance must be taken under the Hazardous Chemicals (manufacture, import and storage) Rules 1989, as amended up to date, from the competent authority. Such clearance will have to be taken prior to the commissioning of the project.	Complied. Approval from the PESO is taken for import of hazardous chemicals as per License No. P/HQ/GJ/15/2050 (P12369) dated 18/07/2016 which is valid up to 31/12/2024 for Class A & Class C petroleum. A copy of the same was submitted along with the compliance report submission for the period of Oct'16 to Mar'17 and there is no further change. Storage permission is taken from the GPCB vide consent no. AWH-88317 valid till 20th November, 2021. The same was submitted along with the compliance report submission for the period of Oct'16 to Mar'17. License under Factories Act is taken dated 07.10.1998 and last renewed vide license no. 0102 on 20.04.2017 (Sr. No. 70707) is valid up to 31.12.2018. The same was submitted along with the compliance report submission for the period of Oct'16 to Mar'17.
2(xvii)	A detailed progress report should be submitted to the Ministry on each of the conditions stipulated above in respect of the follow-up action taken	Being complied regularly. Half yearly compliance report is being submitted regularly. Last half yearly compliance report was submitted to Ministry of Environment, Forest & Climate Change and other concerned government agencies / offices vide our letter reference No. APSEZL/EnvCell/2017-18/002 dated

Sr. No.	Conditions	Compliance Status as on 30-09-2017
	every six months. The first of these two reports should be sent in by 31.3.1996.	23.05.2017 in soft as well as hard copy. A copy of the same is also available on our website: https://www.adaniports.com/ports-downloads
2(xviii)	Financial requirements for implementation of the above indicated environmental mitigative measures should be worked out and included in the total cost of the project. Provision for enhancing this allocation in future should also be made.	Complied. Separate budget for the Environment protection measures is earmarked every year. All environment and horticulture activities are considered at corporate level and budget allocation is done accordingly. All the expenses are recorded in advanced accounting system of the organization. Details regarding environmental expenditures are as per compliance condition no. 2(xiii) above.

Annexure – 1

"HALF YEARLY ENVIRONMENTAL MONITORING REPORT"

FOR

adani

ADANI PORTS AND SPECIAL ECONOMIC ZONE LIMITED
TAL: MUNDRA, KUTCH, MUNDRA – 370 421

MONITORING PERIOD:
APRIL 2017 TO SEPTEMBER 2017

PREPARED BY:

Pollucon

POLLUCON LABORATORIES PVT.LTD.

PLOT NO.5/6 "POLLUCON HOUSE", OPP. BALAJI INDUSTRIAL SOCIETY,
OLD SHANTINATH SILK MILL LANE, NEAR GAYTRI FARSAN MART,
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TC - 5945 ISO 9001:2008 ISO 14001:2004 OHSAS 18001:2007

MARINE WATER MONITORING SUMMARY REPORT

RESULTS OF MARINE WATER [M1 LEFT SIDE OF BOCHA CREEK - N 22°45'183" E 069°43'241"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017		MAY 2017		JUNE 2017		JULY 2017		AUGUST 2017		SEPTEMBER 2017		TEST METHOD
			SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	
1	pH	--	7.96	8.04	8.02	8	8.08	8.19	8.14	8.18	8.11	8.23	7.96	8.04	IS3025(P11)83Re.02
2	Temperature	°C	28	29	29	30	29	30	28	29	28	29	29	30	IS3025(P9)84Re.02
3	Total Suspended Solids	mg/L	18	20	14	20	24	18	16	22	18	24	16	22	IS3025(P17)84Re.02
4	BOD (3 Days @ 27 °C)	mg/L	BDL*	BDL*	BDL*	BDL*	7	10	3	4	BDL*	4	BDL*	BDL*	IS 3025 (P44)1993Re.03Edition2.1
5	Dissolved Oxygen	mg/L	5.60	5.20	5.6	4.6	5.6	5	5	4.6	5.2	4.8	5.8	5.4	IS3025(P38)89Re.99
6	Salinity	ppt	41.40	41.80	41.2	42.8	40.54	41.17	38.21	39	34.6	35.8	31.4	32.8	APHA (22nd Edi) 2550 B
7	Oil & Grease	mg/L	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	APHA(22nd Edi)5520 D
8	Nitrate as NO_3	mg/L	0.500	0.730	0.532	0.598	0.673	0.734	0.63	0.72	0.54	0.7	0.6	0.69	IS3025(P34)88
9	Nitrite as NO_2	mg/L	0.022	0.035	0.03	0.047	0.06	0.072	0.058	0.069	0.06	0.067	0.021	0.033	IS3025(P34)88 NEDA
10	Ammonical Nitrogen as NH_3	mg/L	0.980	1.130	0.924	1.1	0.721	0.887	0.8	0.99	0.74	0.89	0.85	1.16	IS3025(P34)88Cla.2.3
11	Phosphates as PO_4	mg/L	0.048	0.100	1.03	1.215	0.636	0.781	0.75	0.83	0.46	0.64	0.044	0.98	APHA(22nd Edi) 4500 C
12	Total Nitrogen	mg/L	1.600	1.910	1.486	1.745	1.454	1.693	1.47	1.77	1.34	1.657	1.471	1.883	IS3025(P34)88
13	Petroleum Hydrocarbon	mg/L	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	PLPL-TPH
14	Total Dissolved Solids	mg/L	46980	47860	48593	48878	49870	50560	47580	48670	37580	38670	36980	37860	IS3025(P16)84Re.02
15	COD	mg/L	19	24	19	28	29	38	9	19	10	20	15	24	APHA(22nd Edi) 5520-D Open Reflux
16	Oxidisable Particular Organic Carbon	%	0.530	0.470	0.6	0.44	0.68	0.48	0.44	0.38	0.5	0.42	0.48	0.37	SOP – PLPL – 07
A	**Flora and Fauna**														
17	Primary productivity	mgC/L /day	2.700	1.350	1.125	0.338	2.02	0.9	1.91	0.428	2.21	0.522	2.7	1.46	APHA (22nd Edi) 10200-J
B	**Phytoplankton**														
18.1	Chlorophyll	mg/m^3	2.670	0.908	1.28	0.267	1.816	0.427	2.18	0.534	2.76	0.504	2.67	0.9	APHA (22nd Edi) 10200-H

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

18.2	Phaeophytin	mg/m^3	1.290	3.017	0.98	1.39	0.072	1.348	0.203	1.727	0.198	1.62	BDL*	1.03	APHA (22nd Edi) 10200-H
18.3	Cell Count	Unit x 10^3/L	250.0	314.0	147	52	186	45	232	54	178	52	252	110	APHA (22nd Edi) 10200-H
18.4	Name of Group Number and name of group species of each group	--	Bacillariophyceae Coscinodiscus sp. Pinnularia sp. synendra sp. Navicula sp. Pleurosigma sp. Green algae Volvox sp. Chlorella sp. Ulothrix sp. Cyanophyceae Oscillatoria sp. Nostoc sp.	Bacillariophyceae Fragillaria sp. Navicula sp. Pinnularia sp. Melosira sp. Green algae Spirogyra sp. Spirogyra sp. Cyanophyceae Oscillatoria sp.	Bacillariophyceae Nitzschia sp. Rhizosolenia sp. Navicula sp. Asterionella sp. Cymbella sp. Synedra sp. Green Algae Pandorina sp. Pediastrum sp. Ulothrix sp. Cyanophyceae Oscillatoria sp. --	Bacillariophyceae Navicula sp. Fragillaria sp. Pinnularia sp. Biddulphia sp. Green Algae Ulothrix sp. Cyanophyceae Oscillatoria sp. Spirulina sp. -- -- -- --	Bacillariophyceae Asterioello.sp Navicula sp. Nitzschia sp. Coscinodiscus sp. Pinnularia sp. Rhizosolenia sp. Amphora sp. Cyanophyceae Chlorella sp. Volvox sp. Hydrodictyon sp. Hydrodictyon sp. --	Bacillariophyceae Asterionella sp. Cyclotella sp. Fragillaria sp. Coscinodiscus sp. -- -- Cyanophyceae Oscillatoria sp. Spirulina sp. Green Algae Chlorella sp. Spirogyra sp. --	Bacillariophyceae Biddulphia sp. Fragillaria sp. Gomphonema sp. Rhizosolenia sp. Cymbella sp. Thallasiosira sp. Cyanophyceae Anabaena sp. Oscillatoria sp. Nostoc sp. Green Algae Chlorella sp. Hydrodictyon sp.	Bacillariophyceae Gomphonema sp. Nitzschia sp. Synedra sp. Fragillaria sp. Cyanophyceae Spirulina sp. Oscillatoria sp. Green Algae Chlorella sp. Hydrodictyon sp. -- -- --	Bacillariophyceae Biddulphia sp. Fragillaria sp. Gomphonema sp. Rhizosolenia sp. Cymbella sp. Thallasiosira sp. Cyanophyceae Anabaena sp. Oscillatoria sp. Nostoc sp. Green Algae Hydrodictyon sp. Pediastrum sp.	Bacillariophyceae Fragillaria sp. Synedra sp. Nitzschia sp. Gomphonema sp. Cyanophyceae Spirulina sp. Green Algae Chlorella sp. Hydrodictyon sp. -- -- -- --	Bacillariophyceae Coscinodiscus sp. Gomphonema sp. Gyrosigma sp. Pleurosigma sp. Navicula sp. Synedra sp. Pinnularia sp. Cyanophyceae Oscillatoria sp. Nostoc sp. Anabaena sp. Green Algae Ankistrodesmus sp Chlorella sp. Pandorina sp. Ulothrix sp.	Bacillariophyceae Coscinodiscus sp Nitzschia sp. Gomphonema sp. Skeletonema sp. Thallasionema sp. Cyanophyceae Microcystis sp. Oscillatoria sp. Green Algae Chlorella sp. Pandorina sp. Pediastrum sp. -- -- -- --	APHA (22nd Edi) 10200-H
C	**Zooplanktons**														
19.1	Abundance (Population)	no/m^2	313	38	280	60	275	100	240	80	250	78	425	150	APHA (22nd Edi) 10200-G

H. T. Shah
Lab Manager

SURAT-3 POLLUCON LABORATORIES PVT. LTD.

Dr. ArunBajpai
Lab Manager (Q)

19.2	Name of Group Number and name of group species of each group	--	copepods Fish egg Cyclops Gastropods	Copepods Cyclops Daphnia	Gastropods Isopods Decapods Krill Namatodes Molluscans Copepods	Copepods Polychaete worms Crustaceans -- --	Crustaceans Cyclops Decapods Copepods Gastropods Rotifers --	Copepods Crustaceans Platinelminths -- -- -- --	Copepods Decapods Ostracods Crustaceans Krill Barnades	Polychaetes Worms Crustaceans Gastropods -- -- --	Copepods Decapods Ostracods Crustaceans Krill Barnades	Polychaete worms Crustaceans Gastropods -- -- --	Copepods Decapods Gastropods Polychaete worms Cyclops	Echinoderms -- --	APHA (22nd Edi) 10200-G
19.3	Total Biomass	ml/100 m^3	225	4	38	23	91	18	87.8	8.4	77.3	8.2	76.3	12.1	APHA (22nd Edi) 10200-G
D	**Microbiological Parameters**														
20.1	Total Bacterial Count	CFU/ml	1780	1520	1130	870	1840	1580	1480	1020	1680	1160	1780	1520	IS 5402:2002
20.2	Total Coliform	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	APHA(22ndEdi)9221-D
20.3	Ecoli	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS:1622:1981Edi.2.4 (2003-05)
20.4	Enterococcus	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 15186 :2002
20.5	Salmonella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-3)
20.6	Shigella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 1887 (P-7)
20.7	Vibrio	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-5)

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

RESULTS OF SEDIMENT ANALYSIS [M1 LEFT SIDE OF BOCHA CREEK - N 22°45'183" E 069°43'241"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017	MAY 2017	JUNE 2017	JULY 2017	AUGUST 2017	SEPTEMBER 2017	TEST METHOD
			SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	
1	Organic Matter	%	0.48	0.352	0.622	0.5	0.45	0.47	FCO:2007
2	Phosphorus as P	µg/kg	140	146	144	127	133	138	APHA(22ndEdi) 4500 C
3	Texture	--	Sandy loam	Sandy Loam	Sandy Loam	Sandy loam	Sandy Loam	Sandy Loam	--
4	Petroleum Hydrocarbon	mg/kg	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	PLPL-TPH
5	**Heavy Metals**								
5.1	Aluminum as Al	%	5.05	4.99	5.59	4.85	5.86	4.92	AAS APHA 3111 B
5.2	Total Chromium as Cr^{+3}	µg/kg	189	189	188	200	198	210	AAS 3111B
5.3	Manganese as Mn	µg/kg	709	789	860	689	884	722	AAS APHA 3111 B
5.4	Iron as Fe	%	3.95	2.61	2.12	4.07	2.06	4.02	AAS APHA(22ndEdi)3111 B
5.5	Nickel as Ni	µg/kg	52.29	57.96	50	51.96	51.89	54.4	AAS APHA(22ndEdi)3111 B
5.6	Copper as Cu	µg/kg	39.13	37.99	32	37.96	36.12	34.42	AAS APHA(22ndEdi)3111 B
5.7	Zinc as Zn	µg/kg	137	143	139	143	140	148	AAS APHA(22ndEdi)3111 B
5.8	Lead as Pb	µg/kg	1.63	1.13	1.18	1.54	1.66	1.28	AAS APHA(22ndEdi)3111 B
5.9	Mercury as Hg	µg/kg	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	AAS APHA- 3112 B
6	**Benthic Organisms**								
6.1	Macrobenthos	--	Polychaete Worms Echinoderms Mysids	Crabs Anthozoans Isopods Decapods	polychaete worms isopods Decapods mysids	Polychaete worms Mysids Decapods	Polychaete worms Mysids Decapods	Polychaete worms Hydrozoa Nematodes Isopods	APHA (22nd Edi) 10500-C
6.2	MeioBenthos	--	Isopods Nematodes Hydrozans	Copepods Foraminiferans --	Copepods ostracodes --	Foraminiferans Nematodes Ciliates	Foraminiferans Nematodes Ciliates	Mysids Echinoderms	APHA (22nd Edi) 10500-C
6.3	Population	no/m2	503	288	440	357	399	470	APHA (22nd Edi) 10500-C

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

RESULTS OF MARINE WATER [M2 MOUTH OF BOCHA & NAVINAL CREEK - N 22°44'239" E 069°43'757"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017		MAY 2017		JUNE 2017		JULY 2017		AUGUST 2017		SEPTEMBER 2017		TEST METHOD
			SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	
1	pH	--	7.96	8.04	8.02	8	8.08	8.19	8.14	8.18	8.11	8.23	7.96	8.04	IS3025(P11)83Re.02
2	Temperature	°C	28	29	29	30	29	30	28	29	28	29	29	30	IS3025(P9)84Re.02
3	Total Suspended Solids	mg/L	18	20	14	20	24	18	16	22	18	24	16	22	IS3025(P17)84Re.02
4	BOD (3 Days @ 27 °C)	mg/L	BDL*	BDL*	BDL*	BDL*	7	10	3	4	BDL*	4	BDL*	BDL*	IS 3025 (P44)1993Re.03 Edition2.1
5	Dissolved Oxygen	mg/L	5.6	5.2	5.6	4.6	5.6	5	5	4.6	5.2	4.8	5.8	5.4	IS3025(P38)89Re.99
6	Salinity	ppt	41.4	41.8	41.2	42.8	40.54	41.17	38.21	39	34.6	35.8	31.4	32.8	APHA (22nd Edi) 2550 B
7	Oil & Grease	mg/L	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	APHA(22nd Edi)5520D
8	Nitrate as NO_3	mg/L	0.5	0.73	0.532	0.598	0.673	0.734	0.63	0.72	0.54	0.7	0.6	0.69	IS3025(P34)88
9	Nitrite as NO_2	mg/L	0.022	0.035	0.03	0.047	0.06	0.072	0.058	0.069	0.06	0.067	0.021	0.033	IS3025(P34)88 NEDA
10	Ammonical Nitrogen as NH_3	mg/L	0.98	1.13	0.924	1.1	0.721	0.887	0.8	0.99	0.74	0.89	0.85	1.16	IS3025(P34)88Cla.2.3
11	Phosphates as PO_4	mg/L	0.048	0.1	1.03	1.215	0.636	0.781	0.75	0.83	0.46	0.64	0.044	0.98	APHA(22nd Edi) 4500 C
12	Total Nitrogen	mg/L	1.6	1.91	1.486	1.745	1.454	1.693	1.47	1.77	1.34	1.657	1.471	1.883	IS3025(P34)88
13	Petroleum Hydrocarbon	mg/L	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	PLPL-TPH
14	Total Dissolved Solids	mg/L	46980	47860	48593	48878	49870	50560	47580	48670	37580	38670	36980	37860	IS3025(P16)84Re.02
15	COD	mg/L	19	24	19	28	29	38	9	19	10	20	15	24	APHA(22nd Edi) 5520-D Open Reflux
16	Oxidisable Particular Organic Carbon	%	0.53	0.47	0.6	0.44	0.68	0.48	0.44	0.38	0.5	0.42	0.48	0.37	SOP – PLPL - 07
A	**Flora and Fauna**														
17	Primary productivity	mgC/L/day	2.7	1.35	1.125	0.338	2.02	0.9	1.91	0.428	2.21	0.522	2.7	1.46	APHA (22nd Edi) 10200-J
B	**Phytoplankton**														
18.1	Chlorophyll	mg/m^3	2.67	0.908	1.28	0.267	1.816	0.427	2.18	0.534	2.76	0.504	2.67	0.9	APHA (22nd Edi) 10200-H
18.2	Phaeophytin	mg/m^3	1.29	3.017	0.98	1.39	0.072	1.348	0.203	1.727	0.198	1.62	BDL*	1.03	APHA (22nd Edi) 10200-H
18.3	Cell Count	Unit x 10^3/L	250	314	147	52	186	45	232	54	178	52	252	110	APHA (22nd Edi) 10200-H

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

18.4	Name of Group Number and name of group species of each group	--	Bacillariop hyceae Coscinodi scus sp. Pinnularia sp. synendra sp. Navicula sp. Pleurosig ma sp. Green algae Volvox sp. Chlorella sp. Ulothrix sp. Cyanophy ceae Oscillatori a sp. Nostoc sp.	Bacillariop hyceae Fragillaria sp. Navicula sp. Pinnularia sp. Melosira sp. Green algae Spirogyra sp. Spirogyra sp. Cyanophy ceae Oscillatori a sp.	Bacillariop hyceae Nitzschia sp. Rhizosole nia sp. Navicula sp. Asterionel la sp. Cymbella sp. Synedra sp. Green Algae Pandorina sp. Pediastru m sp. Ulothrix sp. Cyanophy ceae Oscillatori a sp. --	Bacillariop hyceae Navicula sp. Fragillaria sp. Pinnularia sp. Biddulphi a sp. Green Algae Ulothrix sp. Cyanophy ceae Oscillatori a sp. Spirulina sp. -- -- -- --	Bacillariop hyceae Asterioell o.sp Navicula sp. Nitzschia sp. Coscinodi scus sp. Pinnularia sp. Rhizosole nia sp. Amphora sp. Cyanophy ceae Chlorella sp. Volvox sp. Hydrodict yon sp. Hydrodict yon sp. --	Bacillariop hyceae Asterionel la sp. Cyclotella sp. Fragillaria sp. Coscinodi scus sp. -- Cyanophy ceae Oscillatori a sp. Spirulina sp. Green Algae Chlorella sp. Spirogyra sp. --	Bacillariop hyceae Biddulphi a sp. Fragillaria sp. Gomphon ema sp. Rhizosole nia sp. Cymbella sp. Thallasios ira sp. Cyanophy ceae Anabaena sp. Oscillatori a sp. Nostoc sp. Green Algae Chlorella sp. Hydrodict yon sp.	Bacillariop hyceae Gomphon ema sp. Nitzschia sp. Synedra sp. Fragillaria sp. Cyanophy ceae Spirulina sp. Oscillatori a sp. Green Algae Chlorella sp. Hydrodict yon sp. --	Bacillariop hyceae Biddulphi a sp. Fragillaria sp. Gomphon ema sp. Rhizosole nia sp. Cymbella sp. Thallasios ira sp. Cyanophy ceae Anabaena sp. Oscillatori a sp. Nostoc sp. Green Algae Hydrodict yon sp. Pediastru m sp.	Bacillariop hyceae Fragillaria sp. Synedra sp. Nitzschia sp. Gomphone ma sp. Cyanophyc eae Spirulina sp. Green Algae Chlorella sp. Hydrodicty on sp. -- -- -- --	Bacillariop hyceae Coscinodi scus sp. Gomphon ema sp. Gyrosigm a sp. Pleurosig ma sp. Navicula sp. Synedra sp. Pinnularia sp. Cyanophy ceae Oscillatori a sp. Nostoc sp. Anabaena sp. Green Algae Ankistrod esmus sp Chlorella sp. Pandorina sp. Ulothrix sp.	Bacillariop hyceae Coscinodi scus sp Nitzschia sp. Gomphon ema sp. Skeletone ma sp. Thallasion ema sp. Cyanophy ceae Microcysti s sp. Oscillatori a sp. Green Algae Chlorella sp. Pandorina sp. Pediastru m sp. -- -- -- --	APHA (22nd Edi) 10200-H
C			Zooplanktons												
19.1	Abundance (Population)	no/m2	313	38	280	60	275	100	240	80	250	78	425	150	APHA (22nd Edi) 10200-G

H. T. Shah
Lab Manager

SURAT-3 POLLUCON LABORATORIES PVT. LTD.

Dr. ArunBajpai
Lab Manager (Q)

19.2	Name of Group Number and name of group species of each group	--	copepods Fish egg Cyclops Gastropo ds	Copepods Cyclops Daphnia	Gastropod s Isopods Decapods Krill Namatode s Molluscan s Copepods	Copepods Polychaet e worms Crustacea ns -- --	Crustacea ns Cyclops Decapods Copepods Gastropo ds Rotifers	Copepods Crustacea ns Platinelmi nths -- -- --	Copepods Decapods Ostracods Crustacea ns Krill Barnades	Polychaet es Worms Crustacea ns Gastropo ds -- -- --	Copepods Decapods Ostracods Crustacea ns Krill Barnades	Polychaet e worms Crustacea ns Gastropod s -- -- --	Copepods Decapods Gastropo ds Polychaet e worms Cyclops	Echinoder ms -- -- -- --	APHA (22nd Edi) 10200-G
19.3	Total Biomass	ml/100 m^3	225	4	38	23	91	18	87.8	8.4	77.3	8.2	76.3	12.1	APHA (22nd Edi) 10200-G
D	**Microbiological Parameters**														
20.1	Total Bacterial Count	CFU/ml	1780	1520	1130	870	1840	1580	1480	1020	1680	1160	1780	1520	IS 5402:2002
20.2	Total Coliform	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	APHA(22ndEdi)9 221-D
20.3	Ecoli	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS:1622:1981Ed i.2.4(2003-05)
20.4	Enterococcus	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 15186 :2002
20.5	Salmonella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-3)
20.6	Shigella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 1887 (P-7)
20.7	Vibrio	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-5)

H. T. Shah
Lab Manager

Dr. ArunBajpai
Lab Manager (Q)

RESULTS OF SEDIMENT ANALYSIS [M2 MOUTH OF BOCHA & NAVINAL CREEK – N 22°44'239" E 069°43'757"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017	MAY 2017	JUNE 2017	JULY 2017	AUGUST 2017	SEPTEMBER 2017	TEST METHOD
			SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	
1	Organic Matter	%	0.68	--	--	--	--	--	FCO:2007
2	Phosphorus as P	µg/kg	159	--	--	--	--	--	APHA(22ndEdi) 4500 C
3	Texture	--	Sandy loam	--	--	--	--	--	--
4	Petroleum Hydrocarbon	mg/kg	BDL*	--	--	--	--	--	PLPL-TPH
5	**Heavy Metals**								
5.1	Aluminum as Al	%	5.22	--	--	--	--	--	AAS APHA 3111 B
5.2	Total Chromium as Cr+3	µg/kg	146	--	--	--	--	--	AAS 3111B
5.3	Manganese as Mn	µg/kg	808	--	--	--	--	--	AAS APHA 3111 B
5.4	Iron as Fe	%	2.06	--	--	--	--	--	AAS APHA(22ndEdi)3111 B
5.5	Nickel as Ni	µg/kg	36.61	--	--	--	--	--	AAS APHA(22ndEdi)3111 B
5.6	Copper as Cu	µg/kg	80.88	--	--	--	--	--	AAS APHA(22ndEdi)3111 B
5.7	Zinc as Zn	µg/kg	120	--	--	--	--	--	AAS APHA(22ndEdi)3111 B
5.8	Lead as Pb	µg/kg	1.12	--	--	--	--	--	AAS APHA(22ndEdi)3111 B
5.9	Mercury as Hg	µg/kg	BDL*	--	--	--	--	--	AAS APHA- 3112 B
6	**Benthic Organisms**								
6.1	Macrobenthos	--	Isopods Decapods Echonodems	--	--	--	--	--	APHA (22nd Edi) 10500-C
6.2	MeioBenthos	--	Nematodes isopods ciliats	--	--	--	--	--	APHA (22nd Edi) 10500-C
6.3	Population	no/m^2	314	--	--	--	--	--	APHA (22nd Edi) 10500-C

H. T. Shah
Lab Manager

Dr. ArunBajpai
Lab Manager (Q)

544, BelgiumTowers, Ring Road, Opp. Linear Bus Stand, Surat-395003. (Guj.).
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RESULTS OF MARINE WATER [M3 EAST OF BOCHAISLAND - N 22°46'530" E 069°41'690"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017		MAY 2017		JUNE 2017		JULY 2017		AUGUST 2017		SEPTEMBER 2017		TEST METHOD
			SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	
1	pH	--	7.84	8.19	7.62	8.08	7.55	7.92	7.86	8.09	7.77	8.18	7.83	8.2	IS3025(P11)83Re.02
2	Temperature	°C	29	30	29	30	29	30	30	31	28	29	28	29	IS3025(P9)84Re.02
3	Total Suspended Solids	mg/L	22	26	22	25	30	38	24	28	20	24	20	24	IS3025(P17)84Re.02
4	BOD (3 Days @ 27°C)	mg/L	5	9.0	BDL*	BDL*	4	5	5	6	4	8	6	10	IS 3025 (P44)1993Re.03Edition2.1
5	Dissolved Oxygen	mg/L	5.60	4.50	5.4	4.6	5.6	4.8	5.4	4.6	5.2	4.8	5.4	4.6	IS3025(P38)89Re.99
6	Salinity	ppt	41.60	42.80	42.8	43.02	41.66	42.92	37.84	38.33	32.6	33.6	41.6	42.5	APHA (22ndEdi) 2550 B
7	Oil & Grease	mg/L	BDL*	BDL*	0.2	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	APHA(22ndEdi)5520D
8	Nitrate as NO_3	mg/L	0.370	0.450	0.3	0.42	0.28	0.36	0.3	0.4	0.32	0.43	0.41	0.49	IS3025(P34)88
9	Nitrite as NO_2	mg/L	0.013	0.023	0.019	0.028	0.02	0.026	0.018	0.023	0.016	0.025	0.017	0.026	IS3025(P34)88 NEDA
10	Ammonical Nitrogen as NH_3	mg/L	0.580	0.687	0.8	0.9	0.7	0.8	0.63	0.7	0.6	0.69	0.48	0.51	IS3025(P34)88Cla.2.3
11	Phosphates as PO_4	mg/L	0.073	0.099	0.64	0.81	0.58	0.72	0.54	0.7	0.58/	0.73	BDL*	BDL*	APHA(22ndEdi) 4500 C
12	Total Nitrogen	mg/L	0.91	1.143	1.12	1.35	1.08	1.21	0.948	1.123	0.92	1.14	0.907	1.026	IS3025(P34)88
13	Petroleum Hydrocarbon	mg/L	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	PLPL-TPH
14	Total Dissolved Solids	mg/L	50900	51220	51288	51492	49920	51430	49380	50840	40890	41360	51500	51910	IS3025(P16)84Re.02
15	COD	mg/L	16	30	18	28	20	26	18	24	14	28	22	32	APHA(22ndEdi) 5520-D Open Reflux
16	Oxidisable Particular Organic Carbon	%	0.290	0.170	0.31	0.2	0.28	0.21	0.26	0.22	0.3	0.2	0.27	0.19	SOP – PLPL - 07
A	**Flora and Fauna**														
17	Primary productivity	mgC/L /day	2.295	0.450	2.25	0.225	1.46	0.113	2.08	0.526	1.77	0.319	2.13	0.675	APHA (22nd Edi) 10200-J
B	**Phytoplankton**														
18.1	Chlorophyll	mg/m^3	3.520	0.267	2.05	0.053	1.01	0.24	2.184	0.484	1.597	0.362	2.2	0.507	APHA (22ndEdi) 10200-H
18.2	Phaeophytin	mg/m^3	1.520	4.064	0.523	2.52	1.56	2.17	BDL*	1.628	BDL*	1.62	BDL*	1.5	APHA (22ndEdi) 10200-H

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18.3	Cell Count	Unit x 10^3/L	262.0		254	25	178	18	220	46	199	32	241	58	APHA (22nd Edi) 10200-H
18.4	Name of Group Number and name of group species of each group	--	Bacillariophyceae Asterionella sp. Gyrosigma sp. Fragillaria sp. Rhizosolenia sp. Green algae Hydrodictyon sp. Ulothrix sp. Oedogonium sp. Cyanophyceae microcystis sp. Nostoc sp.	Bacillariophyceae Fragillaria sp. Melosira sp. Rhizosolenia sp. Green algae Scenedesmus sp. Cyanophyceae Anabaena sp. Nostoc sp.	Bacillariophyceae Synedra sp. Nitzschia sp. Rhizosolenia sp. Thallasiosira sp Coscinodiscus sp. Green Algae Scenedesmus sp. Chlorella sp. Spirogyra sp. Cyanophyceae Nostoc sp. Oscillatoria sp. --	Bacillariophyceae Nitzschia sp. Navicula sp. Gyrosigma sp. Green Algae Chlorella sp. Desmids Closterium sp. -- -- -- -- -- --	Bacillariophyceae Cymbella sp. Pinnularia sp. Coscinodiscus sp. Rhizosolenia sp. Green Algae Chlorella sp. Oedogonium sp. Oscillatoria sp. Anabaena sp. --	Bacillariophyceae Fragillaria sp. Pinnularia sp. Navicula sp. Nitzschia sp. Gyrosigma sp. Green Algae Chlorella sp. -- -- --	Bacillariophyceae Tabellaria sp. Thallasiosira sp. Rhizosolenia sp. Fragillaria sp. Cyclotella sp. Cheatoceros sp. Biddulphia sp. Cyanophyceae Spirulina sp. Nostoc sp. Microcystis sp. Green Algae Pediastrum sp. Hydrodictyon sp. Chlorella sp.	Bacillariophyceae Gyrosigma sp. Melosira sp. Skeletonema sp. Nitzschia sp. Cyclotella sp. Cyanophyceae Oscillatoria sp. Green Algae Scenedesmus sp. Pandorina sp. --	Bacillariophyceae Biddulphia sp. Cheatoceros sp. Cyclotella sp. Fragillaria sp. Rhizosolenia sp. Thallasiosira sp. Tabellaria sp. Cyanophyceae Microcystis sp. Nostoc sp. Spirulina sp. Green Algae Hydrodictyon sp. Pediastrum sp.	Bacillariophyceae Cyclotella sp. Nitzschia sp. Skeletonema sp. Melosira sp. Gyrosigma sp. Cyanophyceae Oscillatoria sp. Green Algae Pandorina sp. Scenedesmus sp. -- -- -- --	Bacillariophyceae Tabellaria sp. Thallasiosira sp. Rhizosolenia sp. Fragillaria sp. Cyclotella sp. Cheatoceros sp. Biddulphia sp. Cyanophyceae Microcystis sp. Nostoc sp. Spirulina sp. Green Algae Chlorella sp. Hydrodictyon sp. Pediastrum sp.	Bacillariophyceae Gyrosigma sp. Melosira sp. Skeletonema sp. Nitzschia sp. Cyclotella sp. Cyanophyceae Oscillatoria sp. Green Algae Scenedesmus sp. Pandorina sp. -- -- -- --	APHA (22nd Edi) 10200-H
C	**Zooplanktons**														
19.1	Abundance (Population)	no/m^2	188	63	150	30	213	25	208	56	210	40	233	67	APHA (22nd Edi) 10200-G

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19.2	Name of Group Number and name of group species of each group	--	Copepods Crustaceans Ctenophores Ostracods	Crustaceans Polychaete worms Nematodes	Polychaete Worms Echinoderms Molluscans -- --	Gastropods Isopods -- -- --	Copepods Ostracods Crustaceans Krill Ctenophores -- --	Polychaetes Decapods Nauplius larvae -- -- -- --	Copepods Cyclops Krill Ctenophores Chaetognathes Ostracods Decapods	Polychaete worms Copepods -- -- -- -- --	Copepods Decapods Ostracods Chaetognathes Ctenophores Krill Cyclops	Polychaete worms Copepods -- -- -- --	Copepods Decapods Ostracods Chaetognathes Ctenophores Krill Cyclops	Copepods Polychaetes -- -- -- -- --	APHA (22nd Edi) 10200-G
19.3	Total Biomass	ml/100 m^3	225	5	46	7	54	9	90.6	8.4	96.5	8.9	93.55	8.65	APHA (22nd Edi) 10200-G
D	**Microbiological Parameters**														
20.1	Total Bacterial Count	CFU/ml	1590	1220	1840	1550	1680	1375	1850	1280	1640	1120	1560	1220	IS 5402:2002
20.2	Total Coliform	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	APHA(22ndEdi)9221-D
20.3	Ecoli	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS:1622:1981Edi.2.4(2003-05)
20.4	Enterococcus	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 15186 :2002
20.5	Salmonella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-3)
20.6	Shigella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 1887 (P-7)
20.7	Vibrio	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-5)

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RESULTS OF SEDIMENT ANALYSIS [M3 RIGHT SIDE OF BOCHA CREEK - N 22°46'530" E 069°41'690"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017	MAY 2017	JUNE 2017	JULY 2017	AUGUST 2017	SEPTEMBER 2017	TEST METHOD
			SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	
1	Organic Matter	%	0.59	0.52	--	0.54	0.6	0.57	FCO:2007
2	Phosphorus as P	µg/kg	142	150	--	140	146	140	APHA(22nd Edi) 4500 C
3	Texture	--	sandyloam	Sandy Loam	--	Sandy loam	Sandy Loam	Sandy Loam	--
4	Petroleum Hydrocarbon	mg/kg	BDL*	BDL*	--	BDL*	BDL*	BDL*	PLPL-TPH
5	**Heavy Metals**								
5.1	Aluminum as Al	%	4.78	5.4	--	5.6	5.2	5.4	AAS APHA 3111 B
5.2	Total Chromium as Cr^{+3}	µg/kg	182	140	--	180	160	168	AAS 3111B
5.3	Manganese as Mn	µg/kg	866	890	--	790	810	850	AAS APHA 3111 B
5.4	Iron as Fe	%	1.9	2.02	--	2.28	2.22	2.3	AAS APHA(22nd Edi)3111 B
5.5	Nickel as Ni	µg/kg	52	52	--	56	54	58	AAS APHA(22nd Edi)3111 B
5.6	Copper as Cu	µg/kg	36	36	--	32	34	32	AAS APHA(22nd Edi)3111 B
5.7	Zinc as Zn	µg/kg	142	138	--	140	136	130	AAS APHA(22nd Edi)3111 B
5.8	Lead as Pb	µg/kg	1.46	1.6	--	1.34	1.32	1.29	AAS APHA(22nd Edi)3111 B
5.9	Mercury as Hg	µg/kg	BDL*	BDL*	--	BDL*	BDL*	BDL*	AAS APHA- 3112 B
6	**Benthic Organisms**								
6.1	Macrobenthos	--	Bivalxes Echinoderms Decapods Amphipods	Polychaete Worms Bivalves Anthozoans --	--	Polychaete worms Isopods Echinoderms Decapods	Echinoderms Polychaete worms Isopods Decapods	Echinoderms Polychaetes Isopods Decapods	APHA (22nd Edi) 10500-C
6.2	MeioBenthos	--	Nematodes ostrucodes Gastrotriches	Foraminiferans Copepods --	--	Ostracods --	Ostracods	Ostracods	APHA (22nd Edi) 10500-C
6.3	Population	no/m^2	252	337	--	294	377	273	APHA (22nd Edi) 10500-C

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Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

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Lab Manager (Q)

RESULTS OF MARINE WATER [M4 JUNA BANDAR N 22°47'577" E 069°43'620"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017		MAY 2017		JUNE 2017		JULY 2017		AUGUST 2017		SEPTEMBER 2017		TEST METHOD
			SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	
1	pH	--	8.03	8.13	8.02	8	7.98	8.13	7.98	8.14	8.01	8.12	7.69	8.17	IS3025(P11)83Re.02
2	Temperature	°C	29	30	29	30	29	30	29	30	29	30	28	29	IS3025(P9)84Re.02
3	Total Suspended Solids	mg/L	16	22	28	32	24	30	19	22	16	20	18	16	IS3025(P17)84Re.02
4	BOD (3 Days @ 27 °C)	mg/L	6	6	BDL*	BDL*	7	9	4	5	3	4	4	5	IS 3025 (P44)1993Re.03 Edition2.1
5	Dissolved Oxygen	mg/L	5	4.80	5.8	4.8	5.6	4.8	5.2	4.4	5.4	4.8	5.6	4.8	IS3025(P38)89Re.99
6	Salinity	ppt	42.40	43.80	38.4	39.1	39.82	40.54	34.52	38.41	32.4	33.2	42.2	43	APHA (22^{nd}Edi) 2550 B
7	Oil & Grease	mg/L	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	APHA(22^{nd}Edi)5520D
8	Nitrate as NO_3	mg/L	0.49	0.620	0.384	0.222	0.367	0.397	0.46	0.55	0.33	0.2	0.51	0.59	IS3025(P34)88
9	Nitrite as NO_2	mg/L	0.052	0.067	0.054	0.076	0.051	0.065	0.054	0.07	0.059	0.077	0.047	0.066	IS3025(P34)88 NEDA
10	Ammonical Nitrogen as NH_3	mg/L	0.720	0.840	1.01	1.29	0.702	0.776	0.74	0.82	0.91	1.15	0.69	0.74	IS3025(P34)88Cla.2.3
11	Phosphates as PO_4	mg/L	0.068	0.089	0.54	0.675	0.248	0.353	0.18	0.17	0.02	0.11	0.057	0.073	APHA(22^{nd}Edi) 4500 C
12	Total Nitrogen	mg/L	1.262	1.467	1.448	1.588	1.12	1.238	1.254	1.44	1.3	1.42	1.247	1.396	IS3025(P34)88
13	Petroleum Hydrocarbon	mg/L	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	PLPL-TPH
14	Total Dissolved Solids	mg/L	52840	54110	45313	46173	46890	48030	53670	54820	32990	34280	52910	54310	IS3025(P16)84Re.02
15	COD	mg/L	14	19	14	24	24	28	14	18	14	19	16	20	APHA(22^{nd}Edi) 5520-D Open Reflux
16	Oxidisable Particular Organic Carbon	%	0.840	0.380	0.5	0.46	0.82	0.46	0.82	0.38	0.8	0.43	0.8	0.36	SOP – PLPL - 07
A	Flora and Fauna														
17	Primary productivity	mgC/L/day	1.8	0.45	1.575	0.675	1.688	0.788	2.36	0.563	3.03	1.46	97	8.2	APHA (22nd Edi) 10200-J
B	Phytoplankton														
18.1	Chlorophyll	mg/m^3	3.040	0.801	1.89	0.16	1.789	0.587	1.816	0.721	2.48	0.69	2.148	0.654	APHA (22^{nd}Edi) 10200-H
18.2	Phaeophytin	mg/m^3	2.480	3.420	0.067	1.69	0.23	1.207	0.24	1.03	BDL*	1.36	0.2	1.11	APHA (22^{nd}Edi)

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															10200-H
18.3	Cell Count	Unit x 10^3/L	302	30.0	162	33	189	41	214	68	326	82	264	75	APHA (22nd Edi) 10200-H
18.4	Name of Group Number and name of group species of each group	--	Bacillariophyceae Melosira sp. synendra sp. Tabellaria sp. Cheatocerous sp. Green algae Ulothrix sp. Pediastrum sp. Cyanophyceae Oscillatoria sp. Spirulina sp.	Bacillariophyceae synendra sp. Navicula sp. Nitzschia sp. Green algae Chlorella sp. Cyanophyceae Oscillatoria sp. Lyngbya sp.	Bacillariophyceae Asterionella sp. Coscinodiscus sp. Navicula sp. Nitzschia sp. Fragillaria sp. Surirella sp. Thallasionema sp. Green Algae Ankistrodesmus sp. Chlorella sp. Pandorina sp. Cyanophyceae Anabaena sp.	Bacillariophyceae Tabellaria sp. Navicula sp. Gyrosigma sp. Coscinodiscus sp. Asterionella sp. Cyanophyceae Oscillatoria sp. Nostoc sp. -- -- -- -- --	Bacillariophyceae Nitzschia sp. Coscinodiscus sp. Pleurosigma sp. Pinnularia sp. Cyanophyceae Oscillatoria sp. Spirulina sp. Green Algae Chlorella sp. Ulothrix sp. Ankistrodesmus sp. Volvox sp. -- --	Bacillariophyceae Pinnularia sp. Fragillaria sp. Nitzschia sp. Navicula sp. Cyanophyceae Anabaena sp. #VALUE! Green Algae Pandorina sp. Ankistrodesmus sp. -- -- --	Bacillariophyceae Asterionella sp. Biddulphia sp. Gomphonema sp. Rhizosolenia sp. Pinnularia sp. Skeletonema sp. Nitzschia sp. Navicula sp. Cocconeis sp. Cyanophyceae Oscillatoria sp. Anabaena sp. Green Algae Ankistrodesmus sp. Oedogonium sp. Pediastrum sp.	Bacillariophyceae Coscinodiscus sp. Pleurosigma sp. Nitzschia sp. Fragillaria sp. Navicula sp. Cyanophyceae Anabaena sp. Oscillatoria sp. Spirulina sp. Green Algae Oedogonium sp. Pediastrum sp. -- -- -- --	Bacillariophyceae Amphora sp. Asterionella sp. Coscinodiscus sp. Fragillaria sp. Gomphonema sp. Skeletonema sp. Cyclotella sp. Cyanophyceae Microcystis sp. Oscillatoria sp. Green Algae Ankistrodesmus sp. Chlorella sp. Pandorina sp. Scenedesmus sp.	Bacillariophyceae Cymbella sp. Fragillaria sp. Melosira sp. Nitzschia sp. Cyanophyceae Oscillatoria sp. Microcystis sp. Nostoc sp. Green Algae Chlorella sp. Hydrodictyon sp. Scenedesmus sp. Volvox sp.-- -- --	Bacillariophyceae Pleurosigma sp. Coscinodiscus sp. Nitzschia sp. Thallasiosira sp. Pinnularia sp. Cyanophyceae Oscillatoria sp. Spirulina sp. Green Algae Chlorella sp. Volvox sp. Ankistrodesmus sp. Ulothrix sp.	Bacillariophyceae Navicula sp. Nitzschia sp. Fragillaria sp. Pinnularia sp. Cyanophyceae Oscillatoria sp. Anabaena sp. Green Algae Ankistrodesmus sp. Pandorina sp. -- -- --	APHA (22nd Edi) 10200-H
C	**Zooplanktons**														
19.1	Abundance (Population)	no/m^2	213	25	267	133	350	75	275	50	300	160	312.5	62.5	APHA (22nd Edi) 10200-G

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19.2	Name of Group Number and name of group species of each group	--	Chaetognaths Copepods Nematodes Nauplius larvae Cyclops	Cyclops Copepods Crustaceans	Gastropods Copepods Decapods Ostracods Krill Crustaceans Cyclops	Ctenophores Gastropods Krill Nematodes --	Copepods Chaetognathes Ctenophores Krill Cyclops Decapods Rotifiers	Copepods Decapods -- -- -- -- --	Ctenophores Ostracods Gastropods Decapods Polychaete worms	Copepods Decapods -- -- --	Copepods Polychaetes Crustaceans Nematodes Mysids Rotifers	Crustaceans Gastropods Nematodes -- -- --	Copepods Krill Decapods Chaetognathes Cyclops Rotifers Ctenophores	Copepods Decapods -- -- -- -- --	APHA (22nd Edi) 10200-G
19.3	Total Biomass	ml/100 m^3	194	5	75	15	97	8.2	97.4	7.8	62.4	7.4	79.9	7.6	APHA (22nd Edi) 10200-G
D	**Microbiological Parameters**														
20.1	Total Bacterial Count	CFU/ml	1750	1590	1850	1680	2130	1870	1560	1220	1700	1580	1610	1280	IS 5402:2002
20.2	Total Coliform	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	APHA(22ndEdi)9 221-D
20.3	Ecoli	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS:1622:1981Edi .2.4(2003-05)
20.4	Enterococcus	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 15186 :2002
20.5	Salmonella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-3)
20.6	Shigella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 1887 (P-7)
20.7	Vibrio	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-5)

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RESULTS OF SEDIMENT ANALYSIS [M4 JUNA BANDAR N 22°47'577" E 069°43'620"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017	MAY 2017	JUNE 2017	JULY 2017	AUGUST 2017	SEPTEMBER 2017	TEST METHOD
			SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	
1	Organic Matter	%	0.42	0.495	0.463	0.51	0.425	0.63	FCO:2007
2	Phosphorus as P	µg/kg	174	172	178	192	175	150	APHA(22nd Edi) 4500 C
3	Texture	--	Sandy loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	--
4	Petroleum Hydrocarbon	mg/kg	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	PLPL-TPH
5	**Heavy Metals**								
5.1	Aluminum as Al	%	5.42	5.21	5.19	5.08	5.41	5.62	AAS APHA 3111 B
5.2	Total Chromium as Cr^{+3}	µg/kg	118	127	165	146	119	129	AAS 3111B
5.3	Manganese as Mn	µg/kg	854	896	885	798	856	809	AAS APHA 3111 B
5.4	Iron as Fe	%	1.76	2.33	2.4	2.82	1.75	266	AAS APHA(22nd Edi)3111 B
5.5	Nickel as Ni	µg/kg	57.94	49.9	49.97	52	57.99	44.19	AAS APHA(22nd Edi)3111 B
5.6	Copper as Cu	µg/kg	43.9	45.9	43.97	48	43.98	40.22	AAS APHA(22nd Edi)3111 B
5.7	Zinc as Zn	µg/kg	162	179	166	190	160	189	AAS APHA(22nd Edi)3111 B
5.8	Lead as Pb	µg/kg	1.84	1.94	1.96	1.88	1.87	0.91	AAS APHA(22nd Edi)3111 B
5.9	Mercury as Hg	µg/kg	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	AAS APHA- 3112 B
6	**Benthic Organisms**								
6.1	Macrobenthos	--	Bivalves Decapods Lobsters	Polychaete worms Echinoderms Isopods Anthozoans	Echinoderms Decapods Isopods --	Polychaete worms Echinoderms Isopods	Echinoderms Isopods --	Echinoderms Polychaete worms Mysids	APHA (22nd Edi) 10500-C
6.2	MeioBenthos	--	Bryozoans Water bears Foraminiferans	Namatodes Foraminiferans Hydrozoa --	Nematodes Foraminiterams --	Nematodes Foraminiferans --	Nematodes Foraminiferans Hydrozoa	Nematodes Foraminiferans Ciliotes	APHA (22nd Edi) 10500-C
2	Population	no/m^2	440	440	314	314	433	481	APHA (22nd Edi) 10500-C

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POLLUCON LABORATORIES PVT. LTD. SURAT-3

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Lab Manager (Q)

RESULTS OF MARINE WATER [M5 TOWARDS WESTERN SIDE OF EAST PORT – N 22°46'041" E 069°47'296"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017		MAY 2017		JUNE 2017		JULY 2017		AUGUST 2017		SEPTEMBER 2017		TEST METHOD
			SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	
1	pH	--	8.04	8.13	8.08	8.14	8.02	8.11	7.87	7.7	8.14	7.73	8.02	8.17	IS3025(P11)83Re .02
2	Temperature	°C	28	29	28	29	29	30	29	30	29	30	29	30	IS3025(P9)84Re. 02
3	Total Suspended Solids	mg/L	14	18	26	30	24	32	18	24	18	24	28	20	IS3025(P17)84Re .02
4	BOD (3 Days @ 27 °C)	mg/L	3	4	BDL*	BDL*	4	5	BDL*	3	3	4	BDL*	BDL*	IS 3025 (P44)1993Re.03Edition2.1
5	Dissolved Oxygen	mg/L	5.60	5.40	5.4	4.6	5.8	4.6	48.45	4.6	5.9	4.6	5.8	5.2	IS3025(P38)89Re .99
6	Salinity	ppt	40.80	41.40	39.2	40.4	38.2	39.37	38.45	49	44.8	46.4	40.6	41.2	APHA (22nd Edi) 2550 B
7	Oil & Grease	mg/L	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	APHA(22nd Edi)5520D
8	Nitrate as NO_3	mg/L	0.640	0.690	0.518	0.607	0.627	0.704	0.61	0.67	0.916	0.6777	0.58	0.65	IS3025(P34)88
9	Nitrite as NO_2	mg/L	0.047	0.031	0.036	0.025	0.047	0.039	0.047	0.035	0.008	0.035	0.038	0.029	IS3025(P34)88 NEDA
10	Ammonical Nitrogen as NH_3	mg/L	0.320	0.440	0.48	0.619	0.277	0.397	0.37	0.44	0.6	0.44	0.29	0.38	IS3025(P34)88Cl a.2.3
11	Phosphates as PO_4	mg/L	0.026	0.096	0.45	0.27	0.158	0.171	0.24	0.57	0.922	0.157	0.021	0.088	APHA(22nd Edi) 4500 C
12	Total Nitrogen	mg/L	1.000	1.120	1.034	1.251	0.951	1.14	1	1.1	1.041	1.155	0.908	1.059	IS3025(P34)88
13	Petroleum Hydrocarbon	mg/L	0.84	BDL*	0.42	BDL*	2	BDL*	0.8	BDL*	0.8	BDL*	0.6	BDL*	PLPL-TPH
14	Total Dissolved Solids	mg/L	44620	45130	45966	46874	47860	48320	46800	47300	42800	47300	44260	45590	IS3025(P16)84Re .02
15	COD	mg/L	9	14	9	24	14	19	5	14	9	14	9	19	APHA(22nd Edi) 5520-D Open Reflux
16	Oxidisable Particular Organic Carbon	%	0.540	0.420	0.5	0.42	0.58	0.46	0.56	0.42	0.56	0.42	0.58	0.46	SOP – PLPL - 07
A	**Flora and Fauna**														
17	Primary productivity	mgC/L /day	2.250	0.670	1.688	0.563	1.463	0.788	1.6	0.56	1.688	0.563	1.57	0.45	APHA (22nd Edi) 10200-J
B	**Phytoplankton**														
18.1	Chlorophyll	mg/m^3	2.770	0.960	1.362	0.294	1.922	0.721	1.8	0.61	ND*	0.614	2.08	0.9	APHA (22nd Edi) 10200-H
18.2	Phaeophytin	mg/m^3	2.793	3.300	0.806	0.959	0.134	0.737	0.61	1.27	5.3	1.274	0.179	0.98	APHA (22nd Edi) 10200-H

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

18.3	Cell Count	Unit x 10^3/L	546	24.0	215	40	196	52	145	32	145	32	222	58	APHA (22nd Edi) 10200-H
18.4	Name of Group Number and name of group species of each group	--	Bacillariop hyceae Biddulphi a sp. Cymbella sp. Navicula sp. sydra sp. pinnularia sp. Green algae Volvox sp. Pediastru m sp. Ulothrix sp. Cyanophy ceae Lyngbya sp. Nostoc sp.	Bacillariop hyceae Cocconeis sp. Fragillaria sp. Navicula sp. Green algae Chlorella sp. Pediastru m sp. Cyanophy ceae Spirulina sp.	Bacillariop hyceae Rhizosole nia sp. Synedra sp. Navicula sp. Coscinodi scus sp. Skeletone ma sp. Green Algae Spirogyra sp. Pediastru m sp. Hydrodict yon sp. Desmids Cosmariu m sp. --	Bacillariop hyceae Nitzschia sp. Pinnularia sp. Fragillaria sp. Biddulphi a sp. Cyanophy ceae Anabaena sp. Nostoc sp. -- -- -- -- --	Bacillariop hyceae Gomphon ema sp. Pleurosig ma sp. Nitzschia sp. Synedra sp. Rhizosole nia sp. Surirella sp. Tabellaria sp. Biddulphi a sp. Cyanophy ceae Microcysti s sp. Oscillatori a sp. Green Algae Chlorella sp. Ulothrix sp. Scenedes mus sp. --	Bacillariop hyceae Asterionel la sp. Cyclotella sp. Cymbella sp. Gyrosigm a sp. Pinnularia sp. Cocconeis sp. Green Algae Oedogoni um sp. Hydrodict yon sp. Scenedes mus sp. -- -- -- -- -- --	Bacillariop hyceae Cyclotella sp. Cocconeis sp. Pinnularia sp. Skeletone ma sp. Pleurosig ma sp. Biddulphi a sp. Amphipro ra sp. Cyanophy ceae Anabaena sp. Oscillatori a sp. Green Algae Ankistrod esmus sp. Chlorella sp. Pediastru m sp. Volvox sp.	Bacillariop hyceae Gomphon ema sp. Pleurosig ma sp. Navicula sp. Nitzschia sp. Coscinodi scus sp. Cyanophy ceae Oscillatori a sp. Green Algae Pandorina sp. -- -- -- -- -- --	Bacillariop hyceae Amphipro ra sp.. Biddulphi a sp. Pleurosig ma sp. Skeletone ma sp. Pinnularia sp. Cocconeis sp. Cyclotella sp. Cyanophy ceae Anabaena sp. Oscillatori a sp. Spirulina sp. Green Algae Ankistrod esmus sp. Chlorella sp. Pediastru m sp. Volvox sp.	Bacillariop hyceae Coscinodi scus sp. Nitzschia sp. Pleurosig ma sp. Navicula sp. Gomphon ema sp. Cyanophy ceae Oscillatori a sp. Green Algae Pandorina sp. -- -- -- -- -- -- --	Bacillariop hyceae Navicula sp. Synedra sp. Nitzschia sp. Coscinodi scus sp. Thallasion ema sp. Pleurosig ma sp. Cyclotella sp. Skeletone ma sp. Cyanophy ceae Anabaena sp. Nostoc sp. Oscillatori a sp. Green Algae Ankistrod esmus sp. Pandorina sp. Scenedes mus sp.	Bacillariop hyceae Navicula sp. Fragillaria sp. Gomphon ema sp. Pleurosig ma sp. Coscinodi scus sp. Cyanophy ceae Oscillatori a sp. Lyngbya sp. Green Algae Chlorella sp. Pediastru m sp. Pandorina sp. -- -- -- --	APHA (22nd Edi) 10200-H
C	**Zooplanktons**														
19.1	Abundance (Population)	no/m^2	250	30	260	60	250	50	210	60	200	50	275	100	APHA (22nd Edi) 10200-G

H. T. Shah
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POLLUCON LABORATORIES PVT. LTD. SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

19.2	Name of Group Number and name of group species of each group	--	Crustaceans Nematodes Nauplius larvae Gastropods	Bivalves Rotifers Nematodes	Copepods Cyclops Decapods Krill Polychaete worms	Copepods Polychaete worms Ostracods -- --	copepods krill Polychaete worms Siphonophores Rotifers Cyclops	Gastropods Polychaete worms -- -- -- --	Copepods Decapods Ostracods Gastropods Crustaceans	Polychaetes Gastropods Absent -- --	Copepods Decapods Ostracods Gastropods Crustaceans	Polychaete worms Gastropods -- -- --	Nematodes Gastropods Crustaceans Mysids	Copepods Cyclops Nematodes --	APHA (22nd Edi) 10200-G
19.3	Total Biomass	ml/100 m^3	189	7	69	11	75	15	72	13	85	0.7	45.2	7.4	APHA (22nd Edi) 10200-G
D	**Microbiological Parameters**														
20.1	Total Bacterial Count	CFU/ml	1640	1500	1830	1630	1650	1370	1740	1480	1740	1480	1620	1480	IS 5402:2002
20.2	Total Coliform	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	APHA(22ndEdi)9221-D
20.3	Ecoli	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS:1622:1981Edi. 2.4(2003-05)
20.4	Enterococcus	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 15186 :2002
20.5	Salmonella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-3)
20.6	Shigella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 1887 (P-7)
20.7	Vibrio	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-5)

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

RESULTS OF SEDIMENT ANALYSIS [M5 TOWARDS WESTERN SIDE OF EAST PORT – N 22°46'041" E 069°47'296"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017	MAY 2017	JUNE 2017	JULY 2017	AUGUST 2017	SEPTEMBER 2017	TEST METHOD
			SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	
1	Organic Matter	%	0.62	0.546	0.701	0.64	0.58	0.6	FCO:2007
2	Phosphorus as P	µg/kg	182	148	189	180	166	162	APHA(22^{nd}Edi) 4500 C
3	Texture	--	sandyloam	Sandy Loam	Sandy Loam	Sandy loam	Sandy Loam	SandyLoam	--
4	Petroleum Hydrocarbon	mg/kg	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	PLPL-TPH
5	**Heavy Metals**								
5.1	Aluminum as Al	%	5.66	5.39	5.6	5.79	5.82	5.61	AAS APHA 3111 B
5.2	Total Chromium as Cr^{+3}	µg/kg	120	131	120	119	132	121	AAS 3111B
5.3	Manganese as Mn	µg/kg	722	789	760	729	756	745	AAS APHA 3111 B
5.4	Iron as Fe	%	2.38	2.09	2.45	2.41	2.12	2.32	AAS APHA(22^{nd}Edi)3111 B
5.5	Nickel as Ni	µg/kg	48.34	46.77	48.32	48.21	58.6	97.57	AAS APHA(22^{nd}Edi)3111 B
5.6	Copper as Cu	µg/kg	52.48	36.39	52.52	54.52	44.48	49.82	AAS APHA(22^{nd}Edi)3111 B
5.7	Zinc as Zn	µg/kg	176	161	166	179	182	167	AAS APHA(22^{nd}Edi)3111 B
5.8	Lead as Pb	µg/kg	2.04	1.8	2.02	2.02	2.08	2.06	AAS APHA(22^{nd}Edi)3111 B
5.9	Mercury as Hg	µg/kg	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	AAS APHA- 3112 B
6	**Benthic Organisms**								
6.1	Macrobenthos	--	Bivalxes Sponges Tubellaria	Crabs Polychaete worms Mysids Decapods Bivalves	Echinoderms Decapods Isopods Chaetognaths	Isopods Polychaete worms Echinoderms	Echinoderms Isopods Polychaete worms	Crabs Bivalves Echinoderms	APHA (22^{nd} Edi) 10500-C
6.2	MeioBenthos	--	Copepodes Cilliates Decapods	Gastrotriches Ostracods --	Gadtrotriches Bryozoans Ostracods	Bryozoans Copepods --	Copepods Bryozoans	Hydrozoa Nematodes	APHA (22^{nd} Edi) 10500-C
6.3	Population	no/m2	252	385	337	440	361	377	APHA (22^{nd} Edi) 10500-C

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT LTD SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

RESULTS OF MARINE WATER [M7 EAST PORT N 22°47'120" E 069°47'110"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017		MAY 2017		JUNE 2017		JULY 2017		AUGUST 2017		SEPTEMBER 2017		TEST METHOD
			SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	
1	pH	--	8.06	8.17	8.1	8.18	7.94	8.08	7.86	7.99	7.89	7.66	8.02	8.13	IS3025(P11)83Re.02
2	Temperature	°C	28	29	29	30	29	30	29	30	30	31	28	29	IS3025(P9)84Re.02
3	Total Suspended Solids	mg/L	16	24	18	22	14	16	18	20	16	22	25	20	IS3025(P17)84Re.02
4	BOD (3 Days @ 27°C)	mg/L	8.0	6.0	BDL*	BDL*	6	4	7	6	8	7	6	4	IS 3025 (P44)1993Re.03Edition2.1
5	Dissolved Oxygen	mg/L	5.40	5.00	5.6	4.8	5.8	4.6	5.6	4.8	5.4	4.8	5.4	4.6	IS3025(P38)89Re.99
6	Salinity	ppt	38.50	39.12	38.1	39.2	39.37	40.18	38.19	39.3	35.2	36.4	38.42	39.26	APHA (22^{nd}Edi) 2550 B
7	Oil & Grease	mg/L	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	0.1	BDL*	APHA(22^{nd}Edi)5520D
8	Nitrate as NO_3	mg/L	0.520	0.780	0.681	0.784	0.616	0.857	0.42	0.7	0.17	0.162	0.52	0.81	IS3025(P34)88
9	Nitrite as NO_2	mg/L	0.057	0.049	0.063	0.05	0.067	0.053	0.024	0.022	0.026	0.021	0.037	0.52	IS3025(P34)88 NEDA
10	Ammonical Nitrogen as NH_3	mg/L	0.150	0.310	0.295	0.554	0.203	0.488	0.2	0.36	0.22	0.38	0.13	0.34	IS3025(P34)88Cla.2.3
11	Phosphates as PO_4	mg/L	0.190	0.170	0.54	0.585	0.545	0.492	0.16	0.15	0.17	0.162	0.21	0.22	APHA(22^{nd}Edi) 4500 C
12	Total Nitrogen	mg/L	0.710	1.590	1.039	1.189	0.886	1.399	0.644	1.082	0.707	1.15	0.687	1.67	IS3025(P34)88
13	Petroleum Hydrocarbon	mg/L	10.20	BDL*	1.4	BDL*	1.4	BDL*	2	BDL*	2.2	BDL*	1	BDL*	PLPL-TPH
14	Total Dissolved Solids	mg/L	47020	47530	43186	43828	44020	44680	44620	45600	46800	33500	46930	47460	IS3025(P16)84Re.02
15	COD	mg/L	24	18	24	28	24	14	26	22	28	24	24	15	APHA(22ndEdi) 5520-D Open Reflux
16	Oxidisable Particular Organic Carbon	%	0.700	0.500	0.82	0.58	0.48	0.39	0.66	0.56	0.76	0.58	0.82	0.52	SOP – PLPL - 07
A	**Flora and Fauna**														
17	Primary productivity	mgC/L /day	1.350	0.675	1.35	0.45	2.138	0.563	1.808	0.686	1.913	0.787	1.91	0.56	APHA (22nd Edi) 10200-J
B	**Phytoplankton**														
18.1	Chlorophyll	mg/m^3	3.097	0.748	1.682	0.107	2	0.507	2.18	0.808	2.296	0.988	1.2	0.26	APHA (22^{nd}Edi) 10200-H
18.2	Phaeophytin	mg/m^3	1.239	4.410	0.598	2.02	0.053	1.287	BDL*	0.8	BDL*	0.9	0.75	1.39	APHA (22^{nd}Edi) 10200-H

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

18.3	Cell Count	Unit x 10^3/L	276	24.0	227	29	202	56	108	46	184	48	180	20	APHA (22nd Edi) 10200-H
18.4	Name of Group Number and name of group species of each group	--	Bacillariophyceae Cymbella sp. Navicula sp. Nitzschia sp. Surirella sp. Green algae Hydrodictyon sp. Scenedesmus sp. Cyanophyceae oscillatoria sp. Spirulina sp.	Bacillariophyceae Asterionella sp. Melosira sp. Nitzschia sp. Green algae Pandorina sp. Spirogyra sp. Cyanophyceae Nostoc sp.	Bacillariophyceae Nitzschia sp. Synedra sp. Coscinodiscus sp. Pleurosigma sp. Thallasiosira sp. Pinnularia sp. Green Algae Chlorella sp. Pandorina sp. Ulothrix sp. Desmids Closterium sp. --	Bacillariophyceae Navicula sp. Fragillaria sp. Cyclotella sp. Tabellaria sp. Cyanophyceae Oscillatoria sp. Nostoc sp. Green Algae Chlorella sp. -- -- -- --	Bacillariophyceae Navicula sp. Coscinodiscus sp. Fragillaria sp. Asterionella sp. Cymbella sp. Rhizosolenia sp. Skeletonema sp. Coscinodiscus sp. Biddulphia sp. Green Algae Ankistrodesmus sp. Chlorella sp. Pandorina sp. Desmids Cosmarium sp. Closterium sp.	Bacillariophyceae Fragillaria sp. Biddulphia sp. Pleurosigma sp. Thallasiosira sp. Pinnularia sp. Cyanophyceae Oscillatoria sp. Spirulina sp. Lyngbya sp. -- -- -- -- -- -- --	Bacillariophyceae Nitzschia sp. Fragillaria sp. Gyrosigma sp. Pinnularia sp. Cheatocerous sp. Cyanophyceae Pediastrum sp. Ankistrodesmus sp. Oscillatoria sp. Microcystis sp.	Bacillariophyceae Rhizosolenia sp. Cocconeis sp. Cheatocerous sp. Biddulphia sp. Achnanthes sp. Cyanophyceae Spirulina sp. Nostoc sp. Oscillatoria sp. Microcystis sp.	Bacillariophyceae Gyrosigma sp. Cheatocerous sp. Fragillaria sp. Pinnularia sp. Nitzschia sp. Pleurosigma sp. Cyanophyceae Microcystis sp. Oscillatoria sp. Spirulina sp. Green Algae Ankistrodesmus sp. Pediastrum sp.	Bacillariophyceae Achnanthes sp. Biddulphia sp. Cheatocerous sp. Cocconeis sp. Rhizosolenia sp. Cyanophyceae Microcystis sp. Oscillatoria sp. Nostoc sp. Green Algae Pandorina sp. Scenedesmus sp. --	Bacillariophyceae Asterionella sp. Navicula sp. Synedra sp. Rhizosolenia sp. Melosira sp. Skeletonema sp. Coscinodiscus sp. Cyanophyceae Oscillatoria sp. Nostoc sp. Green Algae Ankistrodesmus sp. Chlorella sp. Pandorina sp. Scenedesmus sp.	Bacillariophyceae Nitzschia sp. Fragillaria sp. Rhizosolenia sp. Coscinodiscus sp. Cyclotella sp. Cyanophyceae Oscillatoria sp. Nostoc sp. Green Algae Chlorella sp. Hydrodictyon sp. Pediastrum sp. Pandorina sp. -- --	APHA (22nd Edi) 10200-H
C	**Zooplanktons**														
19.1	Abundance (Population)	no/m^2	275	75	280	40	300	125	166	50	140	60	175	50	APHA (22nd Edi) 10200-G

H. T. Shah
Lab Manager

Dr. ArunBajpai
Lab Manager (Q)

19.2	Name of Group Number and name of group species of each group	--	copepods ctenophors molluscans Rotifry	Cylons Nematodes Bivalves	Copepods Krill Decapods Crustaceans Ostracods & Fish egg	Copepods Gastropods -- -- --	Copepods Crustaceans Decapods Krill Ostracods Rotiferd	Polychaetes worms Chaetognathes -- -- -- --	Gastropods Chaetognathes Ostracods Decapods Copepods	Decapods Ostracods Polychaetes -- --	Copepods Decapods Ostracods Ctenophores Gastropods Absent	Polychaete worms Ostracods Decapods -- -- --	Echinoderms Nematodes Decapods Gastropods	Bivalves Decapods Nematodes --	APHA (22^{nd} Edi) 10200-G
19.3	Total Biomass	ml/100 m^3	148	4	56	5	101	46	80.8	6.6	82.5	7.4	48.52	8.72	APHA (22^{nd} Edi) 10200-G
D	**Microbiological Parameters**														
20.1	Total Bacterial Count	CFU/ml	1870	1610	1760	1580	1970	1680	1790	1380	1680	1260	1890	1600	IS 5402:2002
20.2	Total Coliform	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	APHA(22^{nd}Edi)9221-D
20.3	Ecoli	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS:1622:1981Edi.2.4(2003-05)
20.4	Enterococcus	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 15186 :2002
20.5	Salmonella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-3)
20.6	Shigella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 1887 (P-7)
20.7	Vibrio	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-5)

H. T. Shah
Lab Manager

Dr. ArunBajpai
Lab Manager (Q)

RESULTS OF MARINE WATER [M8 RIGHT SIDE OF BOCHA CREEK N 22°45'987" E 069°43'119"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017		MAY 2017		JUNE 2017		JULY 2017		AUGUST 2017		SEPTEMBER 2017		TEST METHOD
			SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	
1	pH	--	8.08	8.17	8.04	8	8.1	8.16	8.03	8.23	8.13	8.28	7.78	8.01	IS3025(P11)83Re .02
2	Temperature	°C	28	29	28	29	29	30	28	29	28	29	29	30	IS3025(P9)84Re. 02
3	Total Suspended Solids	mg/L	22	24	16	20	18	22	20	28	22	26	22	30	IS3025(P17)84Re .02
4	BOD (3 Days @ 27 °C)	mg/L	6.0	7	BDL*	BDL*	5	6	4	6	4	5	5	6	IS 3025 (P44)1993Re.03Edition2.1
5	Dissolved Oxygen	mg/L	5.40	4.80	5.4	4.6	5.6	4.8	5.6	4.8	5.8	4.6	5.4	4.6	IS3025(P38)89Re .99
6	Salinity	ppt	44.80	45.22	38.8	39.6	39.82	40.54	44.6	45.8	30.96	34.88	44.2	45.6	APHA (22nd Edi) 2550 B
7	Oil & Grease	mg/L	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	APHA(22nd Edi)5520D
8	Nitrate as NO_3	mg/L	0.020	0.580	0.325	0.399	0.443	0.52	0.54	0.66	0.33	0.58	0.52	0.64	IS3025(P34)88
9	Nitrite as NO_2	mg/L	0.330	0.022	0.044	0.019	0.497	0.638	0.02	0.029	0.032	0.022	0.019	0.025	IS3025(P34)88 NEDA
10	Ammonical Nitrogen as NH_3	mg/L	0.032	0.520	0.554	0.591	0.684	0.748	0.62	0.7	0.59	0.52	0.6	0.68	IS3025(P34)88Cla .2.3
11	Phosphates as PO_4	mg/L	0.027	0.042	0.495	0.585	0.447	0.479	0.19	0.15	0.027	0.041	0.048	0.029	APHA(22nd Edi) 4500 C
12	Total Nitrogen	mg/L	0.952	1.12	0.923	1.009	1.624	1.906	1.18	1.389	0.96	1.13	1.1	1.4	IS3025(P34)88
13	Petroleum Hydrocarbon	mg/L	BDL*	BDL*	1.2	BDL*	0.4	BDL*	1	BDL*	0.88	BDL*	1.2	BDL*	PLPL-TPH
14	Total Dissolved Solids	mg/L	47250	47870	42750	43320	43460	45020	51990	53890	38830	39690	52090	54680	IS3025(P16)84Re .02
15	COD	mg/L	20	22.000	24	28	19	24	18	24	19	24	20	22	APHA(22nd Edi) 5520-D Open Reflux
16	Oxidisable Particular Organic Carbon	%	0.440	0.23	0.54	0.62	0.38	0.24	0.48	0.62	0.63	0.76	0.46	0.6	SOP – PLPL - 07
A							Flora and Fauna								
17	Primary productivity	mgC/L /day	1.350	0.450	1.463	0.113	1.193	0.45	1.35	0.338	1.12	0.033	78	22	APHA (22nd Edi) 10200-J
B							Phytoplankton								
18.1	Chlorophyll	mg/m^3	2.720	1.220	1.922	0.427	1.842	0.614	7.762	0.614	1.73	0.61	4.802	0.58	APHA (22nd Edi) 10200-H
18.2	Phaeophytin	mg/m^3	1.680	2.990	0.021	1.479	0.12	1.199	0.294	1.33	0.97	1.64	0.207	1.15	APHA (22nd Edi) 10200-H

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Lab Manager

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18.3	Cell Count	Unit x 10^3/L	282	36.0	202	33	178	32	220	51	188	31	199	41.5	APHA (22nd Edi) 10200-H
18.4	Name of Group Number and name of group species of each group	--	Bacillariophyceae Asterionella sp. Gyrosigma sp. Melosira sp. Fragillaria sp. Green algae Scenedesmus sp. Ulothrix sp. Cyanophyceae Microcystis sp. Nostoc sp.	Bacillariophyceae Biddulphia sp. Cymbella sp. Navicula sp. Fragillaria sp. Green algae Oedogonium sp. Ulothrix sp. Spirogyra sp. Cyanophyceae Spirulina sp.	Bacillariophyceae Asterionella sp. Fragillaria sp. Navicula sp. Synedra sp. Coscinodiscus sp. Cymbella sp. Pleurosigma sp. Cyanophyceae Oscillatoria sp. Nostoc sp. Green Algae Chlorella sp. Pediastrum sp.	Bacillariophyceae Fragillaria sp. Navicula sp. Nitzschia sp. Gyrosigma sp. Cyanophyceae Oscillatoria sp. Desmids Closterium sp. -- -- -- -- --	Bacillariophyceae Cheatocerous sp. Pinnularia sp. Thallasiosira sp. Biddulphia sp. Asterionella sp. Cyanophyceae Spirulina sp. Microcystis sp. Anabaena sp. Green Algae Scenedesmus sp. -- --	Bacillariophyceae Cyclotella sp. Thallasiosira sp. Fragillaria sp. Pinnularia sp. Nitzschia sp. Green Algae Volvox sp. Ulothrix sp. Chlorella sp. Pandorina sp. -- -- --	Bacillariophyceae Asterionella sp. Gyrosigma sp. Pinnularia sp. Synedra sp. Tabellaria sp. Gomphonema sp. Cyanophyceae Oscillatoria sp. Oedogonium sp. Hydrodictyon sp. Pandorina sp. Pediastrum sp.	Bacillariophyceae Fragillaria sp. Gomphonema sp. Navicula sp. Nitzschia sp. Cyanophyceae Oscillatoria sp. Spirulina sp. Green Alage Pandorina sp. -- -- --	Bacillariophyceae Asterionella sp. Biddulphia sp. Nitzschia sp. Rhizosolenia sp. Thallasiosira sp. Skeletonema sp. Cyclotella sp. Cyanophyceae Anabaena sp. Oscillatoria sp. Nostoc sp. Green Algae Ankistrodesmus sp. Pandorina sp. Pediastrum sp. Ulothrix sp.	Bacillariophyceae Fragillaria sp. Nitzschia sp. Biddulphia sp. Navicula sp. Cyanophyceae Oscillatoria sp. Microcystis sp. Nostoc sp. Green Algae Chlorella sp. Hydrodictyon sp. Pandorina sp. -- -- -- --	Bacillariophyceae Biddulphia sp. Pinnularia sp. Thallasiosira sp. Cheatocerous sp. Asterionella sp. Cyanophyceae Anabaena sp. Microcystis sp. Spirogyra sp. Green Algae Scenedesmus sp.	Bacillariophyceae Nitzschia sp. Fragillaria sp. Pinnularia sp. Thallasiosira sp. Cyclotella sp. Green Algae Pandorina sp. Chlorella sp. Ulothrix sp. Volvox sp. --	APHA (22nd Edi) 10200-H
C								Zooplanktons							
19.1	Abundance (Population)	no/m^2	350	6	240	80	375	50	280	100	200	80	327.5	75	APHA (22nd Edi) 10200-G

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Lab Manager

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Lab Manager (Q)

19.2	Name of Group Number and name of group species of each group	--	Nauplius larvae Nematodes Daphnia Mysids	Ostracods Nematodes Polychaete worms	Nematodes Copepods Krill Molluscans	Polychaete worms Isopods -- --	Copepods Krill Decapods Isopods Crustaceans Chaetognathes Rotifers	Ostracods Decapods -- -- -- -- --	Copepods Decapods Ostracods	Copepods Decapods Isopods	Copepods Ostracods Krill Crustaceans Echinoderms	Decapods Krill	Copepods Krill Isopods Decapods Crustaceans Chaetognathes	Ostracods Decapods -- -- -- --	APHA (22nd Edi) 10200-G
19.3	Total Biomass	ml/100 m^3	243	6	61	9	78	22	83.8	5.7	68.9	9	80.9	13.8	APHA (22nd Edi) 10200-G
D	**Microbiological Parameters**														
20.1	Total Bacterial Count	CFU/ml	1700	1540	1470	1110	1540	1220	1860	1340	1690	1500	1750	1280	IS 5402:2002
20.2	Total Coliform	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	APHA(22ndEdi)9221-D
20.3	Ecoli	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS:1622:1981Edi. 2.4(2003-05)
20.4	Enterococcus	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 15186 :2002
20.5	Salmonella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-3)
20.6	Shigella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 1887 (P-7)
20.7	Vibrio	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-5)

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Lab Manager

Dr. ArunBajpai
Lab Manager (Q)

RESULTS OF SEDIMENT ANALYSIS [M8 RIGHT SIDE OF BOCHA CREEK – N 22°45'987" E 069°43'119"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017	MAY 2017	JUNE 2017	JULY 2017	AUGUST 2017	SEPTEMBER 2017	TEST METHOD
			SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	
1	Organic Matter	%	0.544	0.441	0.569	0.53	0.51	0.52	FCO:2007
2	Phosphorus as P	µg/kg	146	187	170	200	170	198	APHA(22nd Edi) 4500 C
3	Texture	--	sandyloam	Sandy Loam	Sandy Loam	Sandy loam	Sandy loam	Sandy Loam	--
4	Petroleum Hydrocarbon	mg/kg	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	PLPL-TPH
5	**Heavy Metals**								
5.1	Aluminum as Al	%	5.7	5.59	5.33	5	5.09	5.6	AAS APHA 3111 B
5.2	Total Chromium as Cr^{+3}	µg/kg	136	99.98	87.99	98	101	102	AAS 3111B
5.3	Manganese as Mn	µg/kg	820	879	735	880	829	770	AAS APHA 3111 B
5.4	Iron as Fe	%	2.42	2.12	2.13	2.8	2.42	2.6	AAS APHA(22nd Edi)3111 B
5.5	Nickel as Ni	µg/kg	32.4	35.9	38.98	50	43.98	48	AAS APHA(22nd Edi)3111 B
5.6	Copper as Cu	µg/kg	40.18	45.9	43.97	54	47.98	52	AAS APHA(22nd Edi)3111 B
5.7	Zinc as Zn	µg/kg	182	162	162	160	148	174	AAS APHA(22nd Edi)3111 B
5.8	Lead as Pb	µg/kg	1.14	1.88	1.99	2.2	1.47	1.8	AAS APHA(22nd Edi)3111 B
5.9	Mercury as Hg	µg/kg	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	AAS APHA- 3112 B
6	**Benthic Organisms**								
6.1	Macrobenthos	--	Sponges Bivalxes Corals Prawns	Polychaete worms Isopods Decapods Prawn	Echinoderms Decapods Isopods --	Mysids Isopods Echinoderms	Polychaete worms Echinoderms Decapods	Echinoderms Decapods Isopods	APHA (22nd Edi) 10500-C
6.2	MeioBenthos	--	Copepodes Bryozoans Mysids	Namatodes Foraminiferans -- --	Gastrotriches Copepods Ostracodes	Polychaete worms Copepods Ostracods Ciliates	Nematodes Foraminiferans --	Gastropods Copepods Ostracods	APHA (22nd Edi) 10500-C
6.3	Population	no/m^2	252	433	503	317	385	503	APHA (22nd Edi) 10500-C

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Lab Manager (Q)

RESULTS OF MARINE WATER [M11 MPT T1 JETTY N 22°42'278" E 069°43'450"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017		MAY 2017		JUNE 2017		JULY 2017		AUGUST 2017		SEPTEMBER 2017		TEST METHOD
			SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	
1	pH	--	8.06	8.17	8	8.09	8.02	8.11	8.08	8.32	8.12	8.33	7.62	7.27	IS3025(P11)83Re .02
2	Temperature	°C	29	30	28	29	29	30	28	29	29	30	28	29	IS3025(P9)84Re. 02
3	Total Suspended Solids	mg/L	20	22	16	20	14	20	17	24	19	25	20	24	IS3025(P17)84Re .02
4	BOD (3 Days @ 27 °C)	mg/L	4	6	BDL*	BDL*	3	4	3	6	5	6	4	5	IS 3025 (P44)1993Re.03E dition2.1
5	Dissolved Oxygen	mg/L	5.40	5.00	5.4	4.8	5.8	4.8	5.2	5	5.4	4.6	5.6	4.8	IS3025(P38)89Re .99
6	Salinity	ppt	42.40	43.60	39.6	40.2	40.3	41.6	37.82	38.3	31.8	33	42.1	42.93	APHA (22ndEdi) 2550 B
7	Oil & Grease	mg/L	BDL*	BDL*	0.4	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	APHA(22ndEdi)552 0D
8	Nitrate as NO_3	mg/L	0.689	0.903	0.34	0.414	0.474	0.673	0.413	0.566	0.67	0.87	0.28	0.32	IS3025(P34)88
9	Nitrite as NO_2	mg/L	0.081	0.082	0.026	0.011	0.027	0.049	0.031	0.027	0.079	0.081	0.08	0.085	IS3025(P34)88 NEDA
10	Ammonical Nitrogen as NH_3	mg/L	0.489	0.602	0.221	0.351	0.64	0.76	0.672	0.766	0.69	0.79	0.44	0.46	IS3025(P34)88Cla .2.3
11	Phosphates as PO_4	mg/L	0.084	0.140	0.495	0.63	0.279	0.361	0.479	0.56	0.075	0.089	0.083	0.144	APHA(22ndEdi) 4500 C
12	Total Nitrogen	mg/L	1.258	1.593	0.587	0.776	1.141	1.482	1.116	1.359	1.45	1.74	0.8	0.865	IS3025(P34)88
13	Petroleum Hydrocarbon	mg/L	11.20	BDL*	6.2	BDL*	0.2	BDL*	19	BDL*	0.88	BDL*	1.7	BDL*	PLPL-TPH
14	Total Dissolved Solids	mg/L	35240	35180	46326	47880	47980	49710	39810	40180	38830	39620	34120	35330	IS3025(P16)84Re .02
15	COD	mg/L	16	22	9	19	14	18	24	28	24	28	18	20	APHA(22ndEdi) 5520-D Open Reflux
16	Oxidisable Particular Organic Carbon	%	0.940	0.380	0.55	0.43	0.44	0.62	0.48	0.29	0.78	0.49	0.88	0.4	SOP – PLPL - 07
A	**Flora and Fauna**														
17	Primary productivity	mgC/L /day	1.8	0.45	1.125	0.338	1.913	0.563	2.25	0.45	2.47	0.33	79.6	21	APHA (22nd Edi) 10200-J
B	**Phytoplankton**														
18.1	Chlorophyll	mg/m^3	2.290	0.740	1.44	0.32	1.816	0.908	1.7	0.507	2.35	0.32	1.922	0.824	APHA (22ndEdi) 10200-H

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18.2	Phaeophytin	mg/m^3	2.900	3.360	0.689	1.511	0.24	1.148	0.422	1.62	BDL*	1.86	0.32	0.992	APHA (22ndEdi) 10200-H
18.3	Cell Count	Unit x 10^3/L	316	32.0	196	42	210	63	172	34	314	162	240	98	APHA (22nd Edi) 10200-H
18.4	Name of Group Number and name of group species of each group	--	Bacillariophyceae Cocconeis sp. Cheatocerous sp. Biddulphia sp. Pinnularia sp. Green algae Pediastrum sp. Scenedesmus sp. Cyanophyceae Spirulina sp. Oscillatoria sp.	Bacillariophyceae Coscinodiscus sp. Gyrosigma sp. synendra sp. Pinnularia sp. Green algae Ulothrix sp. Pediastrum sp. Cyanophyceae Anabaena sp. Nostoc sp.	Bacillariophyceae Rhizosolenia sp. Nitzschia sp. Navicula sp. Coscinodiscus sp. Pleurosigma sp. Thallasionema sp. Cyanophyceae Oscillatoria sp. Nostoc sp. Green Algae Chlorella sp. Pediastrum sp. --	Bacillariophyceae Fragillaria sp. Nitzschia sp. Navicula sp. Gyrosigma sp. Green Algae Chlorella sp. Pandorina sp. -- -- -- -- -- --	Bacillariophyceae Rhizosolenia sp. Coscinodiscus sp. Gomphonema sp. Cymbella sp. Nitzschia sp. Navicula sp. Green Algae Ciismarium sp. Desmids Spirogyra sp. Hydrodictyon sp. Scenedesmus sp. --	Bacillariophyceae Nitzschia sp. Navicula sp. Pinnularia sp. Thallasiosira sp. Gyrosigma sp. Synedra sp. Green Algae Ulothrix sp. Chlorella sp. -- -- -- --	Bacillariophyceae Asterionella sp. Biddulphia sp. Synedra sp. Nitzschia sp. Navicula sp. Pinnularia sp.	Bacillariophyceae Pinnularia sp. Fragillaria sp. Navicula sp. -- Absent --	Bacillariophyceae Navicula sp. Nitzschia sp. Coscinodiscus sp. Fragillaria sp. Gomphonema sp. Skeletonema sp. Rhizosolenia sp. Cyanophyceae Anabaena sp. Microcystis sp. Oscillatoria sp. Green Algae Ankistrodesmus sp. Chlorella sp. Hydrodictyon sp. Volvox sp.	Bacillariophyceae Fragillaria sp. Gomphonema sp. Asterionella sp. Rhizosolenia sp. Cyanophyceae Microcystis sp. Oscillatoria sp. Nostoc sp. Green Algae Chlorella sp. Pandorina sp. Pediastrum sp. -- -- -- --	Bacillariophyceae Nitzschia sp. Navicula sp. Cymbella sp. Gomphonema sp. Coscinodiscus sp. Rhizosolenia sp. Green Algae Scenedesmus sp. Hydrodictyon sp. Spirogyra sp. Cosmarium sp.	Bacillariophyceae Synedra sp. Gyrosigma sp. Thallasiosira sp. Pinnularia sp. Navicula sp. Nitzschia sp. Green Algae Ulothrix sp. Chlorella sp. -- --	APHA (22nd Edi) 10200-H
C	**Zooplanktons**														
19.1	Abundance (Population)	no/m^2	200	50	325	75	225	75	220	50	367	100	250	100	APHA (22nd Edi) 10200-G

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19.2	Name of Group Number and name of group species of each group	--	decapods Echinoderms Fish egg Foraminiferans	Molluscans Bivalves Crustaceans	Polychaete worms Krill Isopods Gastropods --	Copepods Nematodes -- -- --	Chaetognathes Krill Ostracods Crustaceans Polychaetes --	Gastropods Decapods Nematods -- -- --	Nematodes Polychaete worms Gastrotrichs Crustaceans Isopods	Decapods Isopods Nematodes -- --	Polychaete worms Echinoderms Amphipods Krill	Nematodes Gastrotrichs -- --	Chaetognaths Krill Ostracods Cyclops Polychaete worms	Gastrotrichs Decapods Nematodes -- --	APHA (22nd Edi) 10200-G
19.3	Total Biomass	ml/100 m^3	159	29	72	11	79.6	21	142	48.8	80.24	16	110.8	34.6	APHA (22nd Edi) 10200-G
D	**Microbiological Parameters**														
20.1	Total Bacterial Count	CFU/ml	1860	1450	1470	1180	1820	1690	1770	1460	1840	1680	1820	1580	IS 5402:2002
20.2	Total Coliform	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	APHA(22ndEdi)9221-D
20.3	Ecoli	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS:1622:1981Edi. 2.4(2003-05)
20.4	Enterococcus	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 15186 :2002
20.5	Salmonella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-3)
20.6	Shigella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 1887 (P-7)
20.7	Vibrio	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-5)

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Lab Manager (Q)

RESULTS OF MARINE WATER [M12 SPM N 22°40'938" E 069°39'191"]

SR. NO.	TEST PARAMETERS	UNIT	APRIL 2017		MAY 2017		JUNE 2017		JULY 2017		AUGUST 2017		SEPTEMBER 2017		TEST METHOD
			SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	
1	pH	--	7.94	8.13	7.99	8.05	7.89	8.16	8.28	8.38	7.82	7.74	7.92	8.02	IS3025(P11)83Re.02
2	Temperature	°C	28	29	29	30	29	30	29	28	28	29	28	30	IS3025(P9)84Re.02
3	Total Suspended Solids	mg/L	20	24	20	26	20	29	21	26	24	30	16	26	IS3025(P17)84Re.02
4	BOD (3 Days @ 27°C)	mg/L	5	8	BDL*	BDL*	6	7	4	8	5	6	3	4	IS 3025 (P44)1993Re.03Edition2.1
5	Dissolved Oxygen	mg/L	5.20	5.00	5.8	4.6	5.8	4.8	5.6	4.8	5.2	4.8	5.8	4.8	IS3025(P38)89Re.99
6	Salinity	ppt	40.60	46.80	39.6	40.1	40.12	41.08	35.18	37.52	31.7	32.3	39.6	40.2	APHA (22nd Edi) 2550 B
7	Oil & Grease	mg/L	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	APHA(22nd Edi)5520D
8	Nitrate as NO_3	mg/L	0.580	0.720	0.458	0.888	0.474	0.581	0.612	0.566	0.508	0.61	0.24	0.18	IS3025(P34)88
9	Nitrite as NO_2	mg/L	0.084	0.088	0.037	0.063	0.044	0.068	0.054	0.061	0.075	0.097	0.089	0.09	IS3025(P34)88 NEDA
10	Ammonical Nitrogen as NH_3	mg/L	0.480	0.530	0.887	1.06	0.591	0.702	0.317	0.504	0.81	0.9	0.32	0.59	IS3025(P34)88Cla.2.3
11	Phosphates as PO_4	mg/L	0.120	0.340	0.585	0.675	0.117	0.139	0.56	0.718	0.16	0.189	0.09	0.15	APHA(22nd Edi) 4500 C
12	Total Nitrogen	mg/L	1.144	1.338	1.382	2.011	1.1	1.351	0.983	1.13	1.39	1.607	1.15	0.8	IS3025(P34)88
13	Petroleum Hydrocarbon	mg/L	BDL*	BDL*	1.56	BDL*	BDL*	BDL*	1.3	BDL*	1.8	BDL*	0.4	BDL*	PLPL-TPH
14	Total Dissolved Solids	mg/L	48130	48920	47310	47738	47980	48710	47900	48800	38400	39500	47290	48260	IS3025(P16)84Re.02
15	COD	mg/L	16	26	24	28	26	30	24	32	19	24	14	24	APHA(22nd Edi) 5520-D Open Reflux
16	Oxidisable Particular Organic Carbon	%	0.670	0.430	0.52	0.32	0.74	0.4	0.71	0.52	0.7	0.38	0.63	0.41	SOP – PLPL - 07
A	**Flora and Fauna**														
17	Primary productivity	mgC/L /day	2.47	0.450	1.575	0.225	2.138	0.338	1.755	0.563	2.25	0.789	2.25	0.22	APHA (22nd Edi) 10200-J
B	**Phytoplankton**														
18.1	Chlorophyll	mg/m^3	2.830	1.220	1.362	0.187	1.896	0.534	1.89	0.748	2.163	0.454	1.3	0.64	APHA (22nd Edi) 10200-H

POLLUCON LABORATORIES PVT. LTD. SURAT-3

H. T. Shah
Lab Manager

Dr. ArunBajpai
Lab Manager (Q)

18.2	Phaeophytin	mg/m^3	1.240	2.430	0.844	1.77	0.142	1.428	0.235	1.27	BDL*	1.602	0.74	1.11	APHA (22nd Edi) 10200-H
18.3	Cell Count	Unit x 10^3/L	304	38.0	225	31	208	60	164	26	223	62	178	70	APHA (22nd Edi) 10200-H
18.4	Name of Group Number and name of group species of each group	--	Bacillariophyceae Nitzschia sp. Surirella sp. Rhizosolenia sp. Pinnularia sp. Green algae Ankistrodesmus sp. Hydrodictyon sp. Pandorina sp. Desmids Closterium sp.	Bacillariophyceae Cocconeis sp. Navicula sp. Skeletonema sp. Green algae Spirogyra sp. Volvox sp. Cyanophyceae Anabaena sp. Spirulina sp.	Bacillariophyceae Rhizosolenia sp. Nitzschia sp. Navicula sp. Thallasionema sp. Coscinodiscus sp. Fragillaria sp. Cyanophyceae Oscillatoria sp. Nostoc sp. Green Algae Chlorella sp. Volvox sp.	Bacillariophyceae Thallasionema sp. Fragillaria sp. Synedra sp. Pleurosigma sp. Asterionella sp. Cyanophyceae Oscillatoria sp. Desmids Closterium sp. -- -- --	Bacillariophyceae Fragillaria sp. Navicula sp. Nitzschia sp. Pinnularia sp. Synedra sp. Skeletonema sp. Amphora sp. Biddulphia sp. Cyanophyceae oscillatoria sp. Anabaena sp. Nostoc sp. Green Algae Chlorella sp. Ankistrodesmus sp. Ulothrix sp.	Bacillariophyceae Melosira sp. Cheatocerous sp. Navicula sp. Coscinodiscus sp. Rhizosolenia sp. Green Algae Pandorina sp. Ulothrix sp. Volvox sp. -- -- -- -- -- -- --	Bacillariophyceae Synedra sp. Nitzschia sp. Navicula sp. Thallasionema sp. Coscinodiscus sp. Tubellaria sp. Cyclotella sp. Melosira sp. Sudioella sp. --	Bacillariophyceae Melosira sp. Fragillaria sp. Nitzschia sp. -- -- -- -- -- -- --	Bacillariophyceae Asterionella sp. Cocconeis sp. Fragillaria sp. Pinnularia sp. Rhizosolenia sp. Skeletonema sp. Thallasionema sp. Cyanophyceae Oscillatoria sp. Nostoc sp. Microcystis sp. Green Algae Ankistrodesmus sp. Chlorella sp. Hydrodictyon sp.	Bacillariophyceae Biddulphia sp. Pinnularia sp. Cocconeis sp. Gyrosigma sp. Thallasiosira sp. Cyanophyceae Microcystis sp. Green Algae Chlorella sp. Hydrodictyon sp. Pandorina sp. -- -- -- --	Bacillariophyceae Asterionella sp. Biddulphia sp. Coscinodiscus sp. Gyrosigma sp. Nitzschia sp. Rhizosolenia sp. Thallasiosira sp. Cyanophyceae Microcystis sp. Oscillatoria sp. Nostoc sp. Green Algae Ankistrodesmus sp. Chlorella sp. Pediastrum sp. Scenedesmus sp.	Bacillariophyceae Fragillaria sp. Nitzschia sp. Skeletonema sp. Asterionella sp. Cyanophyceae Oscillatoria sp. Nostoc sp. Green Algae Chlorella sp. Pandorina sp. Ankistrodesmus sp. -- -- -- -- --	APHA (22nd Edi) 10200-H

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POLLUCON LABORATORIES PVT. LTD. SURAT-3

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C	**Zooplanktons**														
19.1	Abundance (Population)	no/m^2	213	63	280	150	300	125	200	10	280	60	250	50	APHA (22nd Edi) 10200-G
19.2	Name of Group Number and name of group species of each group	--	Daphnia Copepods Fish egg Foraminiferans	Crustaceans Copepods Rotifers	Copepods Decapods Nematodes Isopods Krill	Isopods Hydrozoans Namatodes -- --	Copepods Decapods Nematods Gastropods Ostracods --	Polychaetes Chaetognathes Copepods -- -- --	Gastropods Polychaete worms Nematodes Isopods Mysids	Gastropods -- -- -- --	Copepods Ctenophores Krill Daphnia Ostracods Gastropods	Ctenophores Copepods -- -- -- --	Polychaete worms Echinoderms Amphipods Isopods Decapods	Copepods Molluscans -- -- --	APHA (22nd Edi) 10200-G
19.3	Total Biomass	ml/100 m^3	162	9	75	9	86.9	6.2	170	1.1	91.2	10.8	10.24	30.1	APHA (22nd Edi) 10200-G
D	**Microbiological Parameters**														
20.1	Total Bacterial Count	CFU/ml	1560	1320	1590	1320	1550	1230	1810	1560	1720	1360	1500	1310	IS 5402:2002
20.2	Total Coliform	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	APHA(22ndEdi)9221-D
20.3	Ecoli	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS:1622:1981Edi. 2.4(2003-05)
20.4	Enterococcus	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 15186 :2002
20.5	Salmonella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-3)
20.6	Shigella	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 1887 (P-7)
20.7	Vibrio	/ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	IS : 5887 (P-5)

H. T. Shah
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POLLUCON LABORATORIES PVT. LTD. SURAT-3

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RESULTS OF ETP WATER OUTLET

SR. NO.	PARAMETERS	UNIT	RESULTS OF ETP WATER OUTLET							GPCB Limit	TEST METHOD
			04/04/2017	03/05/2017	07/06/2017	16/06/2017	04/07/2017	04/08/2017	04/09/2017		
1	Colour	Co-pt	30	10	30	10	30	60	10	**100**	IS3025(P4)83Re.02
2	pH	--	6.55	6.78	7.04	6.58	7.55	6.9	6.93	**6.5 TO 8.5**	IS3025(P11)83Re.02
3	Temperature	°C	29	30	31	28	29	30	30	**40**	IS3025(P9)84Re.02
4	Total Suspended Solids	mg/L	28	22	34	22	30	62	58	**100**	IS3025(P17)84Re.02
5	Total Dissolved Solids	mg/L	1512	1302	1116	950	1528	1480	1436	**2100**	IS3025(P16)84Re.02
6	COD	mg/L	80	60	98	28	76	81	76	**100**	APHA(22nd Edi) 5520-D Open Reflux
7	BOD (3 Days @ 27 °C)	mg/L	21	18	26	8	22	27	22	**30**	IS 3025 (P44)1993Re.03Edition2.1
8	Chloride as Cl	mg/L	302	629	346	359	509	569	509	**600**	IS3025(P32)88Re.99
9	Oil & Grease	mg/L	BDL*	1.12	1.02	BDL*	1.04	1.08	BDL*	**10**	APHA(22nd Edi)5520D
10	Sulphate as SO_4	mg/L	60	152	138	33.52	138	130	112	**1000**	APHA(22nd Edi)4500 SO_4 E
11	Ammonical Nitrogen as NH_3	mg/L	2.44	2.52	2.4	2.39	2.4	12.6	1.74	**50**	IS3025(P34)88Cla.2.3
12	Phenolic Compound	mg/L	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	**1**	IS3025(P43)92Re.03
13	Copper as Cu	mg/L	0.014	0.014	0.024	0.015	0.017	0.031	0.027	**3**	AAS APHA(22nd Edi)3111 B
14	Lead as Pb	mg/L	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	**0.1**	AAS APHA(22nd Edi)3111 B
15	Sulphide as S	mg/L	BDL*	BDL*	BDL*	BDL*	1.24	0.96	0.34	**2**	APHA(22nd Edi) 4500-S
16	Cadmium as Cd	mg/L	BDL*	BDL*	BDL*	BDL*	BDL*	0.28	0.19	**2**	AAS APHA(22nd Edi)3111 B
17	Fluoride as F	mg/L	BDL*	BDL*	BDL*	BDL*	0.62	0.31	0.42	**2**	APHA(22nd Edi) 4500 F D SPANDS

*Below detection limit

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

RESULT OF AMBIENT AIR QUALITY MONITORING

ADANI PORT – T1 TERMINAL NR.MARINE BUILDING

Sr. No.	Date of Sampling	Particulate Matter (PM10) µg/m^3	Particulate Matter (PM 2.5) µg/m^3	Sulphur Dioxide (SO2) µg/m^3	Oxides of Nitrogen (NO2) µg/m^3	Carbon Monoxide as CO mg/m^3	Hydrocarbon as CH_4 mg/m^3	Benzene as C_6H_6 µg/m^3
1	04/04/2017	52.58	18.71	5.65	15.34	0.18	BDL*	BDL*
2	07/04/2017	82.44	46.56	14.35	34.41	0.53	BDL*	BDL*
3	11/04/2017	71.42	26.61	18.05	26.16	0.39	BDL*	BDL*
4	14/04/2017	81.53	44.52	15.93	35.80	0.69	BDL*	2.24
5	18/04/2017	68.58	40.32	9.69	19.06	0.30	BDL*	BDL*
6	21/04/2017	55.29	24.53	13.42	24.27	0.48	BDL*	BDL*
7	25/04/2017	79.60	42.40	16.85	31.39	0.22	BDL*	BDL*
8	28/04/2017	65.63	28.68	6.30	18.31	0.36	BDL*	BDL*
9	05/02/2017	58.43	32.43	14.96	26.81	0.52	BDL*	BDL*
10	05/05/2017	73.33	27.44	9.57	21.41	0.29	BDL*	BDL*
11	05/09/2017	84.22	37.41	18.72	34.56	0.17	BDL*	BDL*
12	05/12/2017	70.62	40.74	5.62	19.27	0.38	BDL*	BDL*
13	16/05/2017	61.50	24.53	11.59	23.46	0.44	BDL*	BDL*
14	19/05/2017	56.27	29.52	7.00	29.33	0.14	BDL*	BDL*
15	23/05/2017	89.27	45.73	17.71	39.93	0.77	BDL*	BDL*
16	26/05/2017	67.23	33.67	13.60	36.47	0.57	BDL*	BDL*
17	30/05/2017	75.60	34.50	20.66	30.26	0.40	BDL*	BDL*
18	02/06/2017	82.62	43.65	15.19	36.35	0.80	BDL*	BDL*
19	06/06/2017	60.40	31.59	18.77	24.37	0.60	BDL*	BDL*
20	06/09/2017	59.78	23.70	12.79	32.31	0.33	BDL*	BDL*
21	13/06/2017	68.28	30.76	20.49	28.51	0.55	BDL*	BDL*
22	16/06/2017	54.18	25.36	8.96	19.24	0.30	BDL*	BDL*
23	20/06/2017	81.33	45.73	7.04	26.51	0.17	BDL*	BDL*
24	23/06/2017	77.57	35.75	16.14	31.00	0.21	BDL*	BDL*
25	27/06/2017	53.19	22.45	11.06	21.38	0.46	BDL*	BDL*
26	30/06/2017	61.20	32.43	5.97	17.10	0.40	BDL*	BDL*
27	04/07/2017	68.40	40.74	18.23	25.39	0.54	BDL*	BDL*
28	07/07/2017	72.59	38.66	13.09	32.79	0.78	BDL*	BDL*
29	11/07/2017	66.68	29.52	15.21	21.16	0.60	BDL*	BDL*
30	14/07/2017	76.77	33.70	10.59	29.21	0.52	BDL*	BDL*

Continue …

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

Dr. ArunBajpai
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RESULT OF AMBIENT AIR QUALITY MONITORING

ADANI PORT – T1 TERMINAL NR. (MARINE BUILDING)								
Sr.No.	Date of Sampling	Particulate Matter (PM10) µg/m^3	Particulate Matter (PM 2.5) µg/m^3	Sulphur Dioxide (SO2) µg/m^3	Oxides of Nitrogen (NO2) µg/m^3	Carbon Monoxide as CO mg/m^3	Hydrocarbon as CH_4 mg/m^3	Benzene as C_6H_6 µg/m^3
31	18/07/2017	53.38	20.37	7.05	24.45	0.33	BDL*	BDL*
32	21/07/2017	46.73	19.54	12.92	17.45	0.29	BDL*	BDL*
33	25/07/2017	71.48	31.59	9.48	36.36	0.18	BDL*	BDL*
34	28/07/2017	59.23	34.50	5.64	19.39	0.45	BDL*	BDL*
35	01/08/2017	64.21	36.58	16.65	29.42	0.49	BDL*	BDL*
36	04/08/2017	71.60	44.48	11.64	31.69	0.42	BDL*	BDL*
37	08/08/2017	83.61	47.39	14.23	36.18	0.61	BDL*	BDL*
38	11/08/2017	56.27	26.61	19.95	28.46	0.46	BDL*	BDL*
39	15/08/2017	62.61	29.52	9.64	20.40	0.39	BDL*	BDL*
40	18/08/2017	76.28	33.67	12.88	26.48	0.66	BDL*	BDL*
41	22/08/2017	44.33	17.46	5.59	15.60	0.13	BDL*	BDL*
42	25/08/2017	79.30	35.75	15.21	27.33	0.24	BDL*	BDL*
43	29/08/2017	51.28	24.53	7.95	23.88	0.14	BDL*	BDL*
44	01/09/2017	50.30	19.54	6.25	17.21	0.11	BDL*	BDL*
45	05/09/2017	87.61	46.56	15.31	27.10	0.21	BDL*	BDL*
46	08/09/2017	72.89	32.43	18.77	32.26	0.44	BDL*	BDL*
47	12/09/2017	82.62	43.65	12.09	35.49	0.38	BDL*	BDL*
48	15/09/2017	57.63	27.44	14.22	30.54	0.14	BDL*	BDL*
49	19/09/2017	92.60	52.38	17.85	39.20	0.53	BDL*	BDL*
50	22/09/2017	68.40	29.52	10.61	22.59	0.41	BDL*	BDL*
51	26/09/2017	52.58	25.36	13.26	29.58	0.47	BDL*	BDL*
52	29/09/2017	76.22	33.67	16.01	25.33	0.61	BDL*	BDL*
	TEST METHOD	IS:5182(Part 23):Gravimetric CPCB - Method (Vol.I,May-2011)	Gravimetric-CPCB - Method (Vol.I,May-2011)	IS:5182(Part II):Improved West and Gaeke	IS:5182(Part VI):Modified Jacob & Hochheiser (NaOH-NaAsO2)	NDIR Digital Gas Analyzer	SOP: HC: GC/GCMS/Gas analyzer	IS 5182 (Part XI):2006/CPCB Method

*Below detection limit

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

RESULT OF AMBIENT AIR QUALITY MONITORING

NEAR FIRE STATION								
Sr. No.	Date of Sampling	Particulate Matter (PM10) µg/m³	Particulate Matter (PM 2.5) µg/m³	Sulphur Dioxide (SO2) µg/m³	Oxides of Nitrogen (NO2) µg/m³	Carbon Monoxide as CO mg/m³	Hydrocarbon as CH_4 mg/m³	Benzene as C_6H_6 µg/m³
1	04/04/2017	77.71	42.49	11.64	30.34	0.56	BDL*	BDL*
2	07/04/2017	67.77	37.49	7.28	20.27	0.47	BDL*	BDL*
3	11/04/2017	82.38	40.40	10.41	24.18	0.66	BDL*	BDL*
4	14/04/2017	90.51	52.46	19.76	38.56	0.96	BDL*	BDL*
5	18/04/2017	79.59	44.57	23.22	42.37	0.54	BDL*	BDL*
6	21/04/2017	64.01	30.41	15.36	33.35	0.34	BDL*	BDL*
7	25/04/2017	88.62	50.40	5.32	21.62	0.11	BDL*	BDL*
8	28/04/2017	72.50	32.49	14.46	27.12	0.46	BDL*	BDL*
9	02/05/2017	67.59	35.41	17.80	36.45	0.33	BDL*	BDL*
10	05/05/2017	83.41	32.49	25.69	33.39	0.60	BDL*	BDL*
11	09/05/2017	94.32	52.48	5.95	23.74	0.31	BDL*	BDL*
12	12/05/2017	77.77	44.57	15.18	29.68	0.47	BDL*	BDL*
13	16/05/2017	90.93	49.57	22.25	41.37	0.78	BDL*	BDL*
14	19/05/2017	82.68	46.65	12.69	32.47	0.45	BDL*	BDL*
15	23/05/2017	96.20	54.57	20.75	44.52	0.87	BDL*	BDL*
16	26/05/2017	73.23	37.49	7.96	22.34	0.49	BDL*	BDL*
17	30/05/2017	87.17	41.65	11.89	27.23	0.72	BDL*	BDL*
18	06/02/2017	59.41	49.57	19.94	41.69	0.90	BDL*	BDL*
19	06/06/2017	65.77	34.57	15.85	33.67	0.49	BDL*	BDL*
20	09/06/2017	52.62	26.66	8.72	21.81	0.29	BDL*	BDL*
21	13/06/2017	79.23	38.32	10.67	25.34	0.34	BDL*	BDL*
22	16/06/2017	86.32	45.40	23.85	31.40	0.62	BDL*	BDL*
23	20/06/2017	73.59	41.65	12.04	30.88	0.45	BDL*	BDL*
24	23/06/2017	89.17	47.49	14.97	22.96	0.32	BDL*	BDL*
25	27/06/2017	69.53	31.66	21.54	39.20	0.81	BDL*	BDL*
26	30/06/2017	56.38	40.40	13.25	27.62	0.47	BDL*	BDL*
27	04/07/2017	89.29	48.32	9.62	22.00	0.36	BDL*	BDL*
28	07/07/2017	64.20	35.41	17.69	36.44	0.93	BDL*	BDL*
29	11/07/2017	77.23	31.66	22.85	29.20	0.51	BDL*	BDL*
30	14/07/2017	84.19	37.47	5.54	16.63	0.71	BDL*	BDL*

Continue …

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

RESULT OF AMBIENT AIR QUALITY MONITORING

NEAR FIRE STATION								
Sr.No.	Date of Sampling	Particulate Matter (PM10) µg/m^3	Particulate Matter (PM 2.5) µg/m^3	Sulphur Dioxide (SO2) µg/m^3	Oxides of Nitrogen (NO2) µg/m^3	Carbon Monoxide as CO mg/m^3	Hydrocarbon as CH_4 mg/m^3	Benzene as C_6H_6 µg/m^3
31	18/07/2017	72.38	29.57	15.87	27.11	0.29	BDL*	BDL*
32	21/07/2017	62.50	26.66	7.16	19.17	0.64	BDL*	BDL*
33	25/07/2017	55.41	23.74	19.30	29.97	0.45	BDL*	BDL*
34	28/07/2017	82.38	44.57	12.78	38.79	0.86	BDL*	BDL*
35	01/08/2017	79.47	45.40	25.57	36.90	0.41	BDL*	BDL*
36	04/08/2017	89.29	54.57	17.87	39.19	0.57	BDL*	BDL*
37	08/08/2017	74.20	41.65	19.59	42.45	0.73	BDL*	BDL*
38	11/08/2017	68.20	33.74	21.43	24.42	0.29	BDL*	BDL*
39	15/08/2017	90.32	43.74	12.90	38.59	0.68	BDL*	BDL*
40	18/08/2017	82.38	37.49	16.81	33.76	0.53	BDL*	BDL*
41	22/08/2017	56.68	23.74	9.89	20.90	0.19	BDL*	BDL*
42	25/08/2017	65.59	30.41	10.39	29.84	0.44	BDL*	BDL*
43	29/08/2017	59.41	27.49	11.62	26.77	0.37	BDL*	BDL*
44	01/09/2017	61.89	25.41	10.88	23.42	0.22	BDL*	BDL*
45	05/09/2017	70.20	35.41	12.99	32.26	0.39	BDL*	BDL*
46	08/09/2017	86.38	39.57	27.60	39.26	0.36	BDL*	BDL*
47	12/09/2017	96.63	53.32	20.71	42.30	0.52	BDL*	BDL*
48	15/09/2017	77.41	34.57	17.92	28.08	0.37	BDL*	BDL*
49	19/09/2017	82.50	48.74	22.86	45.41	0.65	BDL*	BDL*
50	22/09/2017	94.20	55.40	13.85	38.54	0.55	BDL*	BDL*
51	26/09/2017	74.20	40.40	21.76	26.29	0.24	BDL*	BDL*
52	29/09/2017	84.50	36.66	19.24	37.28	0.30	BDL*	BDL*
	TEST METHOD	IS:5182(Part 23):Gravimetric CPCB - Method (Vol.I,May-2011)	Gravimetric-CPCB - Method (Vol.I,May-2011)	IS:5182(Part II):Improved West and Gaeke	IS:5182(Part VI):Modified Jacob & Hochheiser (NaOH-NaAsO2)	NDIR Digital Gas Analyzer	SOP: HC: GC/GCMS/Gas analyzer	IS 5182 (Part XI):2006/CPCB Method

*Below detection limit

SURAT-3 POLLUCON LABORATORIES PVT. LTD.

H. T. Shah
Lab Manager

Dr. ArunBajpai
Lab Manager (Q)

RESULT OF AMBIENT AIR QUALITY MONITORING

ADANI HOUSE								
Sr. No.	Date of Sampling	Particulate Matter (PM10) µg/m³	Particulate Matter (PM 2.5) µg/m³	Sulphur Dioxide (SO2) µg/m³	Oxides of Nitrogen (NO2) µg/m³	Carbon Monoxide as CO mg/m³	Hydrocarbon as CH_4 mg/m³	Benzene as C_6H_6 µg/m³
1	04/04/2017	57.59	22.49	18.97	38.58	0.37	BDL*	BDL*
2	07/04/2017	62.61	28.73	22.04	29.64	0.44	BDL*	BDL*
3	11/04/2017	76.49	36.64	6.33	17.20	0.62	BDL*	BDL*
4	14/04/2017	74.49	41.57	9.60	30.46	0.82	BDL*	BDL*
5	18/04/2017	63.60	34.56	19.40	24.85	0.25	BDL*	BDL*
6	21/04/2017	50.71	20.40	8.79	19.88	0.57	BDL*	BDL*
7	25/04/2017	71.47	38.73	13.07	28.83	0.15	BDL*	BDL*
8	28/04/2017	60.50	30.40	11.62	21.45	0.60	BDL*	BDL*
9	02/05/2017	53.50	28.73	8.73	21.53	0.64	BDL*	BDL*
10	05/05/2017	66.20	26.65	20.91	26.53	0.24	BDL*	BDL*
11	09/05/2017	75.81	33.73	13.80	30.58	0.11	BDL*	BDL*
12	12/05/2017	63.23	30.40	10.95	25.14	0.68	BDL*	BDL*
13	16/05/2017	72.40	31.65	17.52	27.76	0.39	BDL*	BDL*
14	19/05/2017	61.18	24.57	21.50	42.48	0.30	BDL*	BDL*
15	23/05/2017	80.40	41.64	9.59	33.52	0.95	BDL*	BDL*
16	26/05/2017	58.58	29.57	18.64	29.85	0.53	BDL*	BDL*
17	30/05/2017	81.58	37.48	6.17	19.38	0.70	BDL*	BDL*
18	02/06/2017	74.51	37.48	8.89	30.88	1.02	BDL*	BDL*
19	06/06/2017	55.42	27.48	11.82	19.80	0.56	BDL*	BDL*
20	09/06/2017	49.53	19.57	10.51	26.73	0.13	BDL*	BDL*
21	13/06/2017	73.39	34.56	5.61	17.53	0.70	BDL*	BDL*
22	16/06/2017	59.32	22.49	18.45	28.06	0.26	BDL*	BDL*
23	20/06/2017	68.37	36.64	14.97	38.08	0.31	BDL*	BDL*
24	23/06/2017	82.38	30.40	9.63	29.40	0.14	BDL*	BDL*
25	27/06/2017	63.41	26.65	15.13	25.54	0.41	BDL*	BDL*
26	30/06/2017	45.62	29.57	7.16	22.45	0.72	BDL*	BDL*
27	04/07/2017	76.37	37.48	16.63	30.41	0.70	BDL*	BDL*
28	07/07/2017	66.89	32.48	11.95	27.42	1.02	BDL*	BDL*
29	11/07/2017	70.17	26.65	13.46	18.34	0.56	BDL*	BDL*
30	14/07/2017	61.20	28.68	12.72	24.52	0.62	BDL*	BDL*

Continue …

H. T. Shah
Lab Manager

SURAT-3 POLLUCON LABORATORIES PVT. LTD.

Dr. ArunBajpai
Lab Manager (Q)

RESULT OF AMBIENT AIR QUALITY MONITORING

ADANI HOUSE								
Sr. No.	Date of Sampling	Particulate Matter (PM10) μg/m^3	Particulate Matter (PM 2.5) μg/m^3	Sulphur Dioxide (SO2) μg/m^3	Oxides of Nitrogen (NO2) μg/m^3	Carbon Monoxide as CO mg/m^3	Hydrocarbon as CH_4 mg/m^3	Benzene as C_6H_6 μg/m^3
31	18/07/2017	59.57	23.74	17.59	31.21	0.12	BDL*	BDL*
32	21/07/2017	52.63	20.40	10.63	23.14	0.27	BDL*	BDL*
33	25/07/2017	69.18	33.73	15.89	33.38	0.31	BDL*	BDL*
34	28/07/2017	74.20	39.56	9.90	26.45	0.40	BDL*	BDL*
35	01/08/2017	54.61	30.40	10.19	33.76	0.45	BDL*	BDL*
36	04/08/2017	66.70	38.73	19.55	36.18	0.50	BDL*	BDL*
37	08/08/2017	59.32	33.73	12.83	26.53	0.85	BDL*	BDL*
38	11/08/2017	62.30	29.57	15.94	31.26	0.52	BDL*	BDL*
39	15/08/2017	78.60	37.48	17.48	23.06	0.33	BDL*	BDL*
40	18/08/2017	69.92	28.73	14.86	41.38	0.87	BDL*	BDL*
41	22/08/2017	49.59	19.57	11.44	24.60	0.23	BDL*	BDL*
42	25/08/2017	52.50	24.57	13.42	35.27	0.32	BDL*	BDL*
43	29/08/2017	46.31	21.65	9.71	29.30	0.25	BDL*	BDL*
44	01/09/2017	55.42	21.65	12.32	26.89	0.18	BDL*	BDL*
45	05/09/2017	78.42	40.39	24.31	37.44	0.26	BDL*	BDL*
46	08/09/2017	60.50	27.48	10.63	35.49	0.40	BDL*	BDL*
47	12/09/2017	71.91	38.73	26.14	39.15	0.46	BDL*	BDL*
48	15/09/2017	65.58	30.40	15.84	25.54	0.29	BDL*	BDL*
49	19/09/2017	56.22	25.40	20.59	30.11	0.60	BDL*	BDL*
50	22/09/2017	89.57	42.47	18.94	27.53	0.32	BDL*	BDL*
51	26/09/2017	68.19	37.48	14.90	33.61	0.54	BDL*	BDL*
52	29/09/2017	58.58	24.57	11.33	43.50	0.79	BDL*	BDL*
	TEST METHOD	IS:5182(Part 23):Gravimetric CPCB - Method (Vol.I,May-2011)	Gravimetric-CPCB - Method (Vol.I,May-2011)	IS:5182(Part II):Improved West and Gaeke	IS:5182(Part VI):Modified Jacob & Hochheiser (NaOH-NaAsO2)	NDIR Digital Gas Analyzer	SOP: HC: GC/GCMS/Gas analyzer	IS 5182 (Part XI):2006/CPCB Method

*Below detection limit

H. T. Shah
Lab Manager

SURAT-3
POLLUCON LABORATORIES PVT. LTD.

Dr. ArunBajpai
Lab Manager (Q)

RESULT OF AMBIENT AIR QUALITY MONITORING

NEAR SHANTIVAN COLONY'S STP					
Sr. No.	Date of Sampling	Particulate Matter (PM10) µg/m^3	Particulate Matter (PM 2.5) µg/m^3	Sulphur Dioxide (SO_2) µg/m^3	Oxides of Nitrogen (NO_2) µg/m^3
1	03/04/2017	49.62	27.44	8.83	23.41
2	06/04/2017	76.22	42.40	14.49	21.51
3	10/04/2017	45.50	22.45	5.31	25.31
4	13/04/2017	52.70	18.71	11.20	31.63
5	17/04/2017	62.80	32.43	9.63	11.60
6	20/04/2017	58.61	26.61	13.28	26.36
7	24/04/2017	72.59	41.57	10.53	29.52
8	27/04/2017	42.48	16.63	7.13	15.39
9	01/05/2017	56.21	19.54	7.17	18.58
10	04/05/2017	64.21	35.75	17.42	35.68
11	08/05/2017	72.40	39.49	20.51	27.21
12	11/05/2017	61.38	25.77	5.60	20.64
13	15/05/2017	76.77	23.70	12.67	29.35
14	18/05/2017	58.18	20.37	10.47	23.22
15	22/05/2017	45.50	27.44	15.11	32.61
16	25/05/2017	69.82	32.43	9.78	19.21
17	29/05/2017	55.47	29.52	13.42	25.34
18	01/06/2017	45.50	23.70	15.15	33.52
19	05/06/2017	72.40	34.50	20.43	27.29
20	08/06/2017	56.27	31.59	9.62	25.64
21	12/06/2017	61.38	25.36	16.76	32.54
22	15/06/2017	76.40	33.67	12.52	29.45
23	19/06/2017	58.61	26.61	10.32	30.17
24	22/06/2017	69.38	38.66	17.53	23.49
25	26/06/2017	55.59	29.52	13.37	28.44
26	29/06/2017	49.50	19.54	7.10	21.31
27	03/07/2017	76.40	41.57	21.94	27.72
28	06/07/2017	67.23	34.50	8.89	25.59
29	10/07/2017	58.61	29.52	19.34	34.54
30	13/07/2017	65.63	27.44	14.23	36.49

Continue …

H. T. Shah
Lab Manager

SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

RESULT OF AMBIENT AIR QUALITY MONITORING

NEAR SHANTIVAN COLONY'S STP					
Sr.No.	**Date of Sampling**	**Particulate Matter (PM10) µg/m^3**	**Particulate Matter (PM 2.5) µg/m^3**	**Sulphur Dioxide (SO2) µg/m^3**	**Oxides of Nitrogen (NO2) µg/m^3**
31	20/07/2017	63.41	28.68	15.80	33.48
32	24/07/2017	55.59	45.31	11.89	18.12
33	27/07/2017	47.78	18.71	13.16	21.11
34	31/07/2017	69.38	25.36	16.81	30.09
35	03/08/2017	67.23	42.40	14.14	31.50
36	07/08/2017	55.22	31.59	17.73	35.49
37	10/08/2017	62.43	33.67	11.53	29.41
38	14/08/2017	76.77	40.74	15.96	26.47
39	17/08/2017	69.38	32.43	13.61	33.47
40	21/08/2017	52.27	22.45	7.21	21.15
41	24/08/2017	84.53	39.49	16.70	25.52
42	28/08/2017	70.49	29.52	10.74	32.33
43	31/08/2017	49.19	20.37	12.64	24.50
44	04/09/2017	82.62	45.73	14.19	34.69
45	07/09/2017	56.21	34.50	9.75	28.40
46	11/09/2017	65.32	25.36	11.41	25.36
47	14/09/2017	72.40	28.68	7.95	22.64
48	18/09/2017	59.23	31.59	19.51	35.65
49	21/09/2017	67.23	23.70	16.85	26.50
50	25/09/2017	80.59	29.52	5.59	31.43
51	28/09/2017	71.17	27.44	8.90	33.60
	TEST METHOD	**IS:5182(Part 23):Gravimetric CPCB - Method (Vol.I,May-2011)**	**Gravimetric- CPCB - Method (Vol.I,May-2011)**	**IS:5182(Part II):Improved West and Gaeke**	**IS:5182(Part VI):Modified Jacob & Hochheiser (NaOH-NaAsO2)**

*Below detection limit

H. T. Shah
Lab Manager

SURAT-3 POLLUCON LABORATORIES PVT. LTD.

Dr. ArunBajpai
Lab Manager (Q)

RESULTS OF NOISE LEVEL MONITORING

Result of Noise level monitoring [Day Time]

SR. NO.	Name of Location	T1 TERMINAL NR.MARINE BUILDING					
		Result [Leq dB(A)]					
	Sampling Date & Time	11/04/2017	15/05/2017	23/06/2017	14/07/2017	18/08/2017	15/09/2017
1	6:00-7:00	61.4	62.0	68.4	63.1	64.1	68.1
2	7:00-8:00	68.4	68.4	62.4	68.7	70.46	62.8
3	8:00-9:00	62.5	65.4	68.1	69.1	68.2	63.4
4	9:00-10:00	63.4	62.1	62.8	62.8	65.1	69.9
5	10:00-11:00	65.4	69.7	63.4	65.8	67.9	72.4
6	11:00-12:00	68.1	62.5	68.4	70.4	62.4	74.1
7	12:00-13:00	62.7	71.5	67.1	69.7	70.1	70.1
8	13:00-14:00	67.4	70.2	69.4	65.7	60.7	66.4
9	14:00-15:00	65.7	70.6	67.4	63.1	68.5	68.4
10	15:00-16:00	62.1	69.4	66.4	62.8	68.7	62.8
11	16:00-17:00	62.8	65.2	63.4	68.4	64.3	65.6
12	17:00-18:00	62.4	68.2	65.8	65.5	70.6	68.8
13	18:00-19:00	69.4	63.1	70.4	69.1	67.9	64.1
14	19:00-20:00	68.7	62.8	68.4	62.8	69.5	63.4
15	20:00-21:00	68.1	62.9	68.4	65.0	67.3	68.9
16	21:00-22:00	65.4	69.4	68.2	66.7	61.3	66.8
Day Time Limit*		75 Leq dB(A)					

Result of Noise level monitoring [Night Time]

SR. NO.	Name of Location	T1 TERMINAL NR.MARINE BUILDING					
		Result [Leq dB(A)]					
1	Sampling Date & Time	11/04/2017 & 12/04/2017	15/05/2017 & 16/05/2017	23/06/2017 & 24/06/2017	14/07/2017 & 15/08/2017	18/08/2017 & 19/08/2017	15/09/2017 & 16/09/2017
2	22:00-23:00	65.1	64.1	63.1	63.8	61.4	65.1
3	23:00-00:00	62.7	61.4	61.8	65.7	67.6	60.8
4	00:00-01:00	66.4	57.1	65.1	64.1	62.1	68.4
5	01:00-02:00	66.9	56.4	68.7	62.8	60.4	68.4
6	02:00-03:00	60.1	60.1	65.4	63.7	61.5	68.8
7	03:00-04:00	62.4	65.1	62.9	63.9	65.8	65.1
8	04:00-05:00	62.8	62.8	69.4	69.8	67.3	62.5
9	05:00-06:00	63.7	61.9	70.5	62.7	65.0	66.1
Night Time Limit*		70 Leq dB(A)					

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

RESULTS OF NOISE LEVEL MONITORING

Result of Noise level monitoring [Day Time]

SR. NO.	Name of Location	NEAR FIRE STATION					
		Result [Leq dB(A)]					
	Sampling Date & Time	18/04/2017	19/05/2017	06/09/2017	21/07/2017	11/08/2017	26/09/2017
1	6:00-7:00	68.4	68.1	68.1	63.7	61.2	68.4
2	7:00-8:00	65.1	62.7	65.4	61.8	63.8	65.1
3	8:00-9:00	65.2	65.1	63.1	65.4	64.7	63.4
4	9:00-10:00	69.4	65.9	70.4	69.4	67.8	65.1
5	10:00-11:00	73.4	68.2	73.1	74.1	70.4	72.1
6	11:00-12:00	72.4	63.7	65.1	72.5	65.5	68.8
7	12:00-13:00	71.5	65.4	69.4	68.4	63.4	65.1
8	13:00-14:00	69.4	62.8	68.4	65.4	70.2	69.8
9	14:00-15:00	70.4	69.1	63.1	61.5	72.1	67.2
10	15:00-16:00	67.4	67.1	62.4	60.4	68.8	65.3
11	16:00-17:00	65.1	63.4	65.1	69.1	61.2	62.1
12	17:00-18:00	62.5	69.1	68.4	62.4	63.4	63.4
13	18:00-19:00	63.8	71.1	68.1	62.9	68.5	65.8
14	19:00-20:00	68.4	68.1	62.4	67.1	67	66.9
15	20:00-21:00	62.8	65.2	61.8	62.8	64.3	71.4
16	21:00-22:00	66.1	68.1	62.4	65.1	63.8	72.8
Day Time Limit*		75 Leq dB(A)					

Result of Noise level monitoring [Night Time]

SR. NO.	Name of Location	NEAR FIRE STATION					
		Result [Leq dB(A)]					
1	Sampling Date & Time	18/04/2017 & 19/04/2017	19/05/2017 & 20/05/2017	09/06/2017 & 10/06/2017	21/07/2017 & 22/07/2017	11/08/2017 & 12/08/2017	26/09/2017 & 27/09/2017
2	22:00-23:00	64.1	65.1	63.7	69.4	68.8	61.5
3	23:00-00:00	63.4	68.7	65.1	66.2	62.4	68.4
4	00:00-01:00	62.1	59.4	69.4	68.1	65.4	65.1
5	01:00-02:00	60.4	60.8	64.1	62.8	58.4	60.4
6	02:00-03:00	68.4	63.1	66.1	68.4	59.3	69.4
7	03:00-04:00	63.4	62.4	62.8	62.8	63.4	62.8
8	04:00-05:00	65.4	60.4	68.4	66.7	66.8	66.1
9	05:00-06:00	67.1	60.8	62.7	62.8	61.7	68.7
Night Time Limit*		70 Leq dB(A)					

POLLUCON LABORATORIES PVT. LTD. SURAT-3

H. T. Shah
Lab Manager

Dr. ArunBajpai
Lab Manager (Q)

RESULTS OF NOISE LEVEL MONITORING

Result of Noise level monitoring [Day Time]

SR. NO.	Name of Location	ADANI HOUSE					
		Result [Leq dB(A)]					
	Sampling Date & Time	14/04/2017	05/12/2017	13/06/2017	18/07/2017	01/08/2017	19/09/2017
1	6:00-7:00	62.5	65.4	65.4	67.2	64.3	65.4
2	7:00-8:00	68.4	62.8	62.7	65.9	68.8	68.1
3	8:00-9:00	68.1	68.1	64.7	68.1	65.7	62.5
4	9:00-10:00	63.4	72.1	70.4	62.4	70.1	73.1
5	10:00-11:00	72.4	71.5	68.1	62.8	72.4	70.5
6	11:00-12:00	70.4	69.4	65.4	61.8	63.4	69.9
7	12:00-13:00	70.9	65.2	68.2	68.4	60.4	66.4
8	13:00-14:00	68.1	62.8	63.4	68.7	67.9	62.1
9	14:00-15:00	62.4	62.8	65.1	68.2	67.4	68.4
10	15:00-16:00	65.1	62.1	62.4	64.1	62.4	63.4
11	16:00-17:00	62.8	65.1	68.1	69.1	70.3	68.1
12	17:00-18:00	66.8	69.1	63.8	73.1	71.9	66.8
13	18:00-19:00	69.4	63.4	65.1	70.4	68.8	63.1
14	19:00-20:00	62.1	65.1	62.9	64.1	62.1	62.9
15	20:00-21:00	68.4	61.8	68.4	62.8	60.1	65.4
16	21:00-22:00	68.2	60.4	67.1	60.8	64.1	66.7
Day Time Limit*		75 Leq dB(A)					

Result of Noise level monitoring [Night Time]

SR. NO.	Name of Location	ADANI HOUSE					
		Result [Leq dB(A)]					
1	Sampling Date & Time	14/04/2017 & 15/04/2017	12/05/2017 & 13/05/2017	13/06/2017 & 14/06/2017	18/07/2017 & 19/07/2017	01/08/2017 & 02/08/2017	19/09/2017 & 20/09/2017
2	22:00-23:00	60.4	62.5	65.1	63.4	62.3	63.4
3	23:00-00:00	65.1	65.1	61.4	65.1	64.5	69.7
4	00:00-01:00	65.4	65.7	61.8	68.7	67.2	65.1
5	01:00-02:00	61.8	60.8	68.4	66.2	67.0	62.4
6	02:00-03:00	63.4	60.7	66.1	66.4	62.8	69.8
7	03:00-04:00	62.4	62.4	65.8	62.9	63.5	60.4
8	04:00-05:00	65.7	58.1	69.4	68.1	65.4	62.8
9	05:00-06:00	67.1	61.8	62.8	62.8	60.7	63.8
Night Time Limit*		70 Leq dB(A)					

H. T. Shah
Lab Manager

SURAT-3
POLLUCON LABORATORIES PVT. LTD.

Dr. ArunBajpai
Lab Manager (Q)

RESULTS OF NOISE LEVEL MONITORING

Result of Noise level monitoring [Day Time]

SR. NO.	Name of Location	AIRSTRIP					
		Result [Leq dB(A)]					
	Sampling Date & Time	12/04/2017	17/05/2017	06/02/2017	19/07/2017	23/08/2017	06/09/2017
1	6:00-7:00	52.1	57.1	54.1	52.1	49.5	55.2
2	7:00-8:00	56.4	56.1	58.1	59.7	47.7	60.1
3	8:00-9:00	63.1	60.1	60.4	60.4	58.5	59.4
4	9:00-10:00	62.4	59.8	62.4	55.1	53.4	63.1
5	10:00-11:00	68.4	59.1	68.4	63.8	59.1	54.1
6	11:00-12:00	61.4	62.4	59.4	65.8	62.4	63.1
7	12:00-13:00	60.4	63.1	60.4	65.4	63.1	60.4
8	13:00-14:00	58.4	66.4	62.1	63.9	57.3	60.9
9	14:00-15:00	60.4	64.1	58.7	68.2	52.1	63.2
10	15:00-16:00	60.9	62.7	56.1	62.9	56.4	62.8
11	16:00-17:00	63.1	62.8	58.4	60.8	64.8	65.1
12	17:00-18:00	61.4	60.4	60.4	59.7	58.8	60.8
13	18:00-19:00	65.4	65.1	55.8	62.7	60.0	60.6
14	19:00-20:00	62.4	62.7	59.8	62.8	58.4	57.2
15	20:00-21:00	60.4	60.8	56.4	60.8	65.2	59.1
16	21:00-22:00	60.7	63.4	58.4	60.4	63.3	62.4
Day Time Limit*		75 Leq dB(A)					

Result of Noise level monitoring [Night Time]

SR. NO.	Name of Location	AIRSTRIP					
		Result [Leq dB(A)]					
1	Sampling Date & Time	12/04/2017 & 13/04/2017	17/05/2017 & 18/05/2017	02/06/2017 & 03/06/2017	19/07/2017 & 20/08/2017	23/08/2017 & 24/08/2017	06/09/2017 & 07/09/2017
2	22:00-23:00	62.4	58.1	59.4	55.7	55	56.1
3	23:00-00:00	60.1	55.1	51.4	59.4	51.4	47.1
4	00:00-01:00	55.4	50.4	50.4	56.1	50.6	52.1
5	01:00-02:00	59.7	53.1	58.7	60.8	49.8	51.8
6	02:00-03:00	56.1	57.1	56.4	62.8	57.6	58.4
7	03:00-04:00	52.4	60.4	52.4	57.1	54.9	53.1
8	04:00-05:00	53.7	56.1	60.4	53.8	49.0	52.8
9	05:00-06:00	59.7	62.8	58.7	59.7	53.4	56.8
Night Time Limit*		70 Leq dB(A)					

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

Dr. ArunBajpai
Lab Manager (Q)

RESULTS OF NOISE LEVEL MONITORING

Result of Noise level monitoring [Day Time]

SR. NO.	Name of Location	NEAR SHANTIVAN STP					
		Result [Leq dB(A)]					
	Sampling Date & Time	13/04/2017	04/05/2017	26/06/2017	03/07/2017	21/08/2017	21/09/2017
1	6:00-7:00	60.4	59.7	60.4	57.1	60.1	63.1
2	7:00-8:00	63.4	63.4	62.1	60.4	58.8	65.4
3	8:00-9:00	59.4	62.8	65.4	60.8	62.7	61.5
4	9:00-10:00	62.4	67.1	68.1	65.1	68.5	69.9
5	10:00-11:00	68.1	63.9	66.1	62.8	61.9	72.4
6	11:00-12:00	67.1	68.1	65.1	68.4	65.4	63.4
7	12:00-13:00	62.5	62.8	62.4	65.5	61.1	65.8
8	13:00-14:00	66.4	66.1	68.4	64.1	65.4	68.1
9	14:00-15:00	69.1	63.5	62.8	62.8	61.9	62.8
10	15:00-16:00	67.1	65.1	68.7	69.1	62.1	65.1
11	16:00-17:00	71.5	65.8	65.1	62.4	68.0	63.8
12	17:00-18:00	68.1	68.7	62.8	61.8	69.1	68.4
13	18:00-19:00	65.4	69.1	69.1	62.8	60.4	67.1
14	19:00-20:00	65.1	62.8	65.4	65.1	63.4	69.1
15	20:00-21:00	62.8	70.4	62.4	63.1	65.9	62.8
16	21:00-22:00	63.7	69.7	66.1	60.8	62.8	58.1
Day Time Limit*		75 Leq dB(A)					

Result of Noise level monitoring [Night Time]

SR. NO.	Name of Location	NEAR SHANTIVAN STP					
		Result [Leq dB(A)]					
1	Sampling Date & Time	13/04/2017 & 14/04/2017	04/05/2017 & 05/05/2017	26/06/2017 & 27/06/2017	03/07/2017 & 04/07/2017	21/08/2017 & 22/08/2017	21/09/2017 & 22/09/2017
2	22:00-23:00	62.4	62.4	58.4	67.1	64	60.8
3	23:00-00:00	59.4	61.8	54.1	65.2	65.1	63.4
4	00:00-01:00	56.2	59.7	62.4	62.8	62.4	60.8
5	01:00-02:00	60.4	55.1	61.4	67.1	68.8	65.4
6	02:00-03:00	59.4	60.4	60.4	65.3	63.4	62.8
7	03:00-04:00	63.1	58.2	60.8	63.9	61.8	66.4
8	04:00-05:00	62.4	59.1	63.4	68.4	64.5	69.7
9	05:00-06:00	64.1	56.2	64.7	65.6	67.3	65.4
Night Time Limit*		70 Leq dB(A)					

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RESULT OF STACK MONITORING

SR. NO.	TEST PARAMETERS	UNIT	STD. LIMIT	THERMIC FLUID HEATER (BITUMEN-01)	THERMIC FLUID HEATER (BITUMEN-02)	HOT WATER SYSTEM-1	HOT WATER SYSTEM-2	TEST METHOD
				APRIL 17				
1	Particulate Matter	mg/Nm^3	**150**	14.57	--	27.55	21.73	IS:11255 (Part-I):1985
2	Sulfur dioxide	ppm	**100**	5.07	--	7.69	7.11	IS:11255 (Part-II):1985
3	Oxides of Nitrogen	ppm	**50**	34.04	--	32.75	40.61	IS:11255 (Part-VII):2005
				MAY 17				
1	Particulate Matter	mg/Nm^3	**150**	18.84	--	32.74	28.61	IS:11255 (Part-I):1985
2	Sulfur dioxide	ppm	**100**	5.72	--	6.85	8.89	IS:11255 (Part-II):1985
3	Oxides of Nitrogen	ppm	**50**	32.29	--	38.00	39.44	IS:11255 (Part-VII):2005
				JUNE 17				
1	Particulate Matter	mg/Nm^3	**150**	13.84	--	26.71	21.75	IS:11255 (Part-I):1985
2	Sulfur dioxide	ppm	**100**	4.35	--	8.75	6.77	IS:11255 (Part-II):1985
3	Oxides of Nitrogen	ppm	**50**	28.28	--	33.80	35.69	IS:11255 (Part-VII):2005
				JULY 17				
1	Particulate Matter	mg/Nm^3	**150**	10.82	--	20.25	15.52	IS:11255 (Part-I):1985
2	Sulfur dioxide	ppm	**100**	3.49	--	6.61	5.79	IS:11255 (Part-II):1985
3	Oxides of Nitrogen	ppm	**50**	25.40	--	38.30	33.60	IS:11255 (Part-VII):2005
				AUGUST 17				
1	Particulate Matter	mg/Nm^3	**150**	18.55	15.45	28.75	22.61	IS:11255 (Part-I):1985
2	Sulfur dioxide	ppm	**100**	4.62	5.19	5.59	6.47	IS:11255 (Part-II):1985
3	Oxides of Nitrogen	ppm	**50**	30.30	33.30	40.07	36.16	IS:11255 (Part-VII):2005
				SEPTEMBER 17				
1	Particulate Matter	mg/Nm^3	**150**	12.42	--	20.55	16.66	IS:11255 (Part-I):1985
2	Sulfur dioxide	ppm	**100**	3.87	--	5.75	7.28	IS:11255 (Part-II):1985
3	Oxides of Nitrogen	ppm	**50**	25.39	--	33.52	29.83	IS:11255 (Part-VII):2005

*Below detection limit
Results on 11 % O2 Correction when Oxygen is greater than 11 %.

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MINIMUM DETECTION LIMIT [MDL]

Water parameter(mg/L)

Sr. No.	Test parameter	MDL
1	Total Suspended Solids	1
2	Oil & Grease	1
3	BOD	3
4	COD	5
5	Total Dissolved Solids	3
6	Sulphate	0.3
7	Ammonical Nitrogen	0.05
8	Nickel	0.01
9	Phenolic Compound	0.001
10	Fluoride	0.01
11	Copper	0.013
12	Sulphide	0.01
13	Cyanide	0.0001
14	Residual Chlorine	0.1
15	Boron	0.02
16	Insecticides/Pesticides	0.01
17	Nitrate Nitrogen	0.15
18	Phosphorous	0.15
19	Petroleum Hydrocarbon	0.01
20	Lead	0.005
21	Mercury	0.0005
22	Zinc	0.022
23	Cadmium	0.001
24	Arsenic	0.00015
Sediment parameter(mg/kg)		
1	Petroleum Hydrocarbon	0.2

Stack parameter		
Sr. No.	**Test parameter**	**MDL**
1	Particulate Matter (mg/Nm3)	10
2	Sulphur Dioxide(ppm)	1.52
3	Oxides of Nitrogen (ppm)	2.65

Ambient Air Parameter		
1	Particulate Matter (PM10)	10
2	Particulate Matter (PM 2.5)	10
3	Sulphur Dioxide (SO_2) (µg/m3)	5
4	Oxides of Nitrogen (NO_2) (µg/m3)	5
5	Benzene as C_6H_6 (µg/m3)	2
6	Carbon Monoxide as CO (mg/m3)	0.1
7	Hydrocarbon as CH_4 (mg/m3)	0.15
8	Hydrogen Sulphide (H_2S) (µg/m3)	6

H. T. Shah
Lab Manager

POLLUCON LABORATORIES PVT. LTD. SURAT-3

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Lab Manager (Q)

Annexure – 2

Creek System (before & after)

As per Marine EIA of Waterfront Development project, prominent creek system in the study region are

1. Kotdi
2. Baradimata
3. Navinal
4. Bocha
5. Mundra (Oldest port (Juna Bandar) leading to bhukhi river)

All above creeks are in existence and well functioning as on date.

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Culverts & Bridge

APSEZL has so far constructed 19 culverts having total length of approx. 1100 m and total cost of Rs. 20 Crores.

Culverts & Bridge






Three RCC Bridges have been constructed over Kotdi creek with total length of 230 m and cost of Rs. 10 Crores.

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Kotdi Creek

Outfall of APSEZL

Outfall of APSEZ and free flowing Kotdi Creek

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Annexure – 3

Details of Greenbelt development at APSEZ, Mundra

LOCATION	Total Green Zone Detail				
	Area (In Ha.)	Trees (Nos.)	Palm (Nos.)	Shrubs (SQM)	Lawn (SQM)
SV COLONY	65.34	30051.00	6965.00	51138.00	80069.00
PORT & NON SEZ	77.52	131942.00	18613.00	68166.78	58455.18
SEZ	99.52	227135.00	15924.00	220449.60	27462.03
MITAP	2.48	8168.00	33.00	1670.00	4036.00
WEST PORT	83.20	182118.00	50221.00	24112.00	22854.15
AGRO- PARK	7.52	17244.00	1332.00	5400.00	2121.44
SOUTH PORT	14.08	25150.00	3430.00	3882.00	4826.97
Samudra Township	38.67	28252.00	11818.00	19978.07	35071.67
Productive Farming	15.69	19336.00	0.00	0.00	0.00
TOTAL (APSEZL)	**404.02**	**669396.00**	**108336.00**	**394796.45**	**234896.44**
		7,77,732			

Details of Mangrove Afforstation done by APSEZ

Sl. no.	Location	Area (ha)	Duration	Species	Implementation agency
1	Mundra Port	24.0	-	Avicennia marina	Dr. Maity, Mangrove consultant of India
2	Mundra Port	25.0	-	Avicennia marina	Dr. Maity, Mangrove consultant of India
3	Luni/Hamirmora (Mundra, Kutch)	160.8	2007 - 2015	Avicennia marina, Rhizophora mucronata, Ceriops tagal	GUIDE, Bhuj
4	Kukadsar (Mundra, Kutch)	66.5	2012 - 2014	Avicennia marina	GUIDE, Bhuj
5	Forest Area (Mundra)	298.0	2011 - 2013	Avicennia marina	-
6	Jangi Village (Bhachau, Kutch)	50.0	2012 - 2014	Avicennia marina	GUIDE, Bhuj
7	Jakhau Village (Abdasa, Kutch)	310.6	2007-08 & 2011-13	Avicennia marina, Rhizophora mucronata, Ceriops tagal	GUIDE, Bhuj
8	Sat Saida Bet (Kutch)	255.0	2014-15 & 2016-17	Avicennia marina & Bio diversity	GUIDE, Bhuj
9	Dandi Village (Navsari)	800.0	2006 - 2011	Avicennia marina, Rhizophora mucronata, Ceriops tagal	SAVE, Ahmedabad
10	Talaza Village (Bhavnagar)	50.0	2011-12	Avicennia marina	SAVE, Ahmedabad
11	Narmada Village (Bhavnagar)	250.0	2014 - 2015	Avicennia marina	SAVE, Ahmedabad
12	Malpur Village (Bharuch)	200.0	2012-14	Avicennia marina	SAVE, Ahmedabad
13	Kantiyajal Village (Bharuch)	50.0	2014-15	Avicennia marina	SAVE, Ahmedabad
14	Devla Village (Bharuch)	150.0	210-16	Avicennia marina	SAVE, Ahmedabad
15	Village Tala Talav (Khambhat, Anand)	100.0	2015 - 2016	Avicennia marina	SAVE, Ahmedabad
16	Village Tala Talav (Khambhat, Anand)	38.0	2015 - 2016	Avicennia marina	GEC, Gandhinagar
	Total Mangrove Plantation:	**2827.90 Ha**			

A. Green Development at APSEZL,Mundra (Till Nov.2017) as per EC

Green Belt Developed as per EC Condition

Sr No	Symbol	EC	EC Details	Locations	Green Belt (ha.)	Trees (No.)	Average Tree Density (ha.)
GB1		[illegible] 1995	Handling facility of General cargo [illegible]	[illegible]	15.15	[illegible]	[illegible]
GB2		20 Sept.2000	Port Expansion project including [illegible]	[illegible]	13.55	[illegible]	[illegible]
GB3		21.11.2004	SPM/COT and connecting pipeline at Mundra port	[illegible]	9.1875	7607	1250
GB4		05.Feb.2007	Development of Multipurpose Berths (2),Mundra	Terminal 2	4.37	5366	1370
GB5		12 Jan.2009	Waterfront Development Project at Mundra	Waterfront area [illegible]	122.56	281215	2293
GB6		20 Feb 2013	Establishment of CETP [illegible] capacity at survey no 141 [illegible] Mundra	CETP area and treated water utilization area	16.56	[illegible]	[illegible]
GB7		[illegible]	Township and area Development [illegible]	[illegible]	45.55	[illegible]	[illegible]
			(A.)Total		222.26	455342	2049

Additional Green Belt Developed

B. Additional Green Development at APSEZL,Mundra (Till Nov.2017)

Sr No	Symbol	Area Details	Green Belt (ha.)	Trees(No.)	Tree Density (ha.)
GB8		Shantivan [illegible] Adani School [illegible] Mundra	[illegible]	[illegible]	621
GB9		[illegible] and nearby area	2.4	[illegible]	[illegible]
GB10		Airport area	7.52	[illegible]	[illegible]
GB11		Area [illegible]	[illegible]	243066	[illegible]
GB12		New Development area [illegible]	[illegible]	[illegible]	481
		(B.)Total	190.09	347850.00	1828.97

Total Green Development at APSEZL,Mundra (Till Nov.2017)

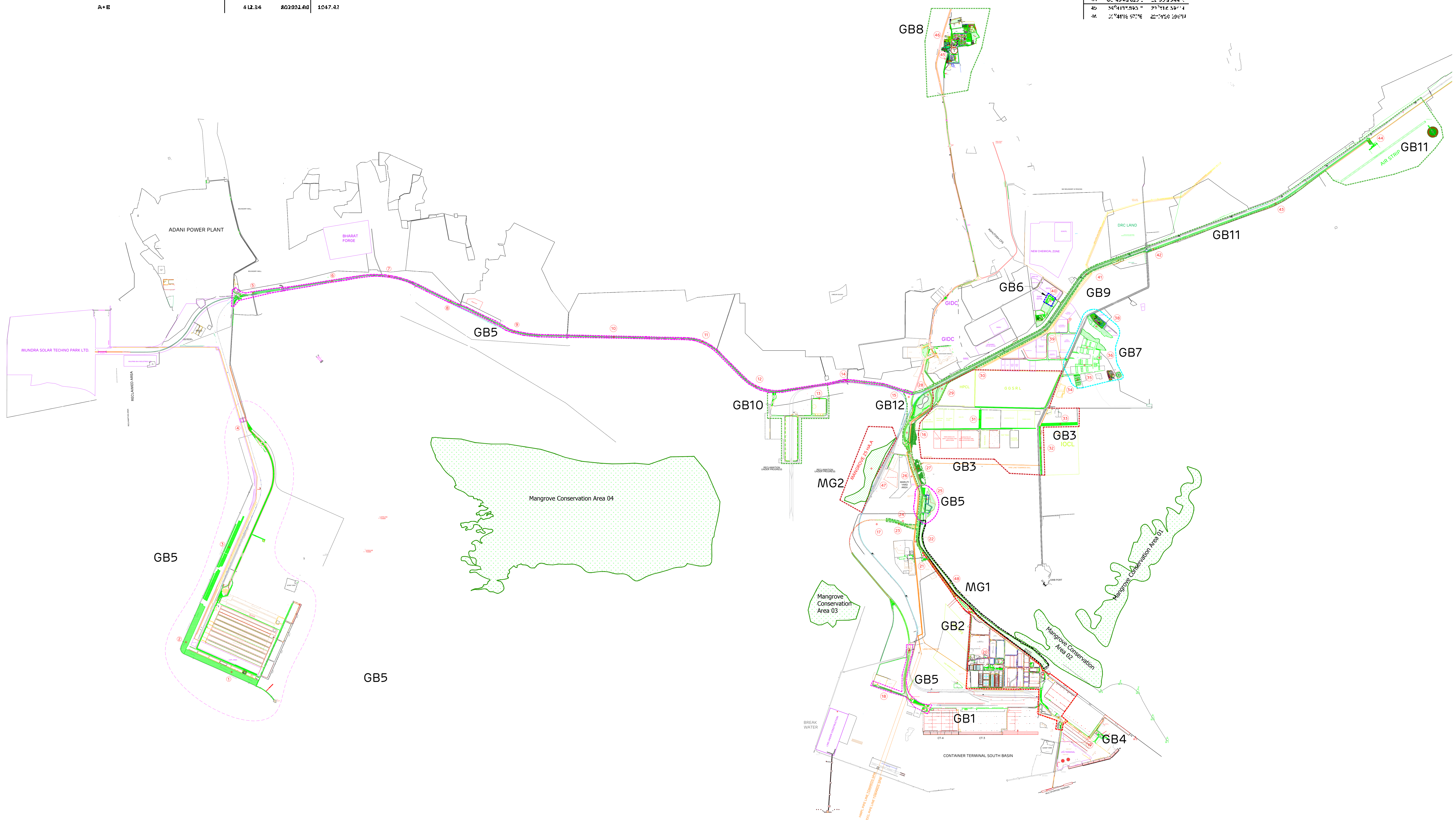
Sr No	Area Details	Green Belt (ha.)	Trees (No.)	Tree Density (ha.)
	A+B	412.34	803091.00	1047.42

Lat Long Of Green Belt Area

Sr. No.	Latitude	Longitude
1	[illegible]	[illegible]
2	[illegible]	[illegible]
3	[illegible]	[illegible]
4	[illegible]	[illegible]
5	[illegible]	[illegible]
6	[illegible]	[illegible]
7	[illegible]	[illegible]
8	[illegible]	[illegible]
9	[illegible]	[illegible]
10	[illegible]	[illegible]
11	[illegible]	[illegible]
12	[illegible]	[illegible]
13	[illegible]	[illegible]
14	[illegible]	[illegible]
15	[illegible]	[illegible]
16	[illegible]	[illegible]
17	[illegible]	[illegible]
18	[illegible]	[illegible]
19	[illegible]	[illegible]
20	[illegible]	[illegible]
21	[illegible]	[illegible]
22	[illegible]	[illegible]
23	[illegible]	[illegible]
24	[illegible]	[illegible]
25	[illegible]	[illegible]
26	[illegible]	[illegible]
27	[illegible]	[illegible]
28	[illegible]	[illegible]
29	[illegible]	[illegible]
30	[illegible]	[illegible]
31	[illegible]	[illegible]
32	[illegible]	[illegible]
33	[illegible]	[illegible]
34	[illegible]	[illegible]
35	[illegible]	[illegible]
36	[illegible]	[illegible]
37	[illegible]	[illegible]
38	[illegible]	[illegible]
39	[illegible]	[illegible]
40	[illegible]	[illegible]
41	[illegible]	[illegible]
42	[illegible]	[illegible]
43	[illegible]	[illegible]
44	[illegible]	[illegible]
45	[illegible]	[illegible]
46	[illegible]	[illegible]

Lat Long Of Mangrove Area

Sr. No.	Latitude	Longitude
47	[illegible]	[illegible]
48	[illegible]	[illegible]



DRG NO. HORTI/APSEZL

Implemented Green Zone Development In APSEZL Area
(Mangrove afforestation and Conservation, Green Zone area & Additional Green Belt Development)

DRG. TITLE:

Landscape Drawing

SCALE :- N.T.S.

DATE : 14.11.2017

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DEPT.OF HORTICULTURE
ADANI PORTS & SPECIAL ECONOMIC ZONE LIMITED, MUNDRA .

Annexure – 4

QUANTITATIVE RISK ASSESSMENT REPORT FOR JETTY AREA

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MUNDRA PORT – NEW LPG FACILITIES

Technip
take it further.

HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD.

EC

PMC

iFluids ENGINEERING

http://ifluids.com

Document Title	:	Quantitative Risk Assessment Report for Jetty area
Project Title	:	Mundra Port - New LPG Facilities
Client Company Name	:	Adani
Engineering consultant	:	Technip India Limited
PMC	:	HOWE Engineering Projects (India) Pvt. Ltd.
Consultant	:	iFluids Engineering

DISCLAIMER

The report rendered by consultants is in the nature of guidelines based on good engineering practices and generally accepted safety procedures. The recommendations shown in the report shall be considered as a Technical professional opinion and not binding on the parties involved viz. Technip and iFluids Engineering.

The technical recommendations and the conclusions thus expressed may have to be re-considered in light of any modifications or alterations that would invalidate the data shown in the documents which are referred to therein.

These recommendations and conclusions would become null and void should the consultants not be kept informed of such modifications or alterations with specific reference to the present report.

Rev	Date	Description	Prepared by	Reviewed by	Approved by
A	28-Nov-16	Final Report	VP	JS	

LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
EA	Environmental Assessment
ERP	Emergency Response Plan
ESD	Emergency Shutdown
HAZID	Hazard Identification
HAZOP	Hazard & Operability Study
HC	Hydrocarbon
HSE	Health Safety & Environment
IRPA	Individual Risk Per Annum
LFL/LEL	Lower Flammability Limit / Lower Explosive Limit
LOC	Loss of Containment
P&ID	Piping and Instrument Diagram
PLL	Potential Loss of Life
QRA	Quantitative Risk Assessment
SOP	Standard Operating Procedure

EXECUTIVE SUMMARY

Adani group intends to expand its current port facility at Adani Mundra Port Pvt Ltd. ADANI is developing LPG, Propane, Butane handling and storage facility at their Port in Mundra. Propylene and propane will be stored and handled in the terminal in a scenario where LPG business subsides. The Adani group has appointed iFluids engineering to carry out Quantitative Risk Assessment and recommend cost effective measures to address the hazardous scenarios.

Overall Facility Description

ADANI is developing LPG, Propane, Butane handling and storage facility at their Port in Mundra. Propylene and propane will be stored and handled in the terminal in a scenario where LPG business subsides.

ADANI has envisaged the following services for set up in Import/Export terminal at Mundra,

- Import of Propane / Butane in cryogenic state in jetties through ship tankers and transferring through unloading arms and pipelines.
- Transfer of product through the unloading line and storing in dedicated refrigerated / cryogenic tanks.
- Transfer of products from tanks through pumps to heating train and then to online blending system for mix of Domestic, Auto & Industrial LPG
- Mercaptan dosing of the LPG, Propane and Butane
- Transfer to loading gantry for loading in to road tankers for dispatch of following products through Tanker loading facility.
    - LPG (AUTOMOTIVE)/ (INDUSTRIAL)
    - LPG (DOMESTIC)
    - LPG PROPANE
    - BUTANE
    - PROPYLENE (In future when LPG demand subside BUTANE import would stop and PROPYLENE shall be imported and stored in Storage tank).
- Simultaneous operation of Berth 1 with Berth 2, 3 & 4 respectively

STUDY RESULTS

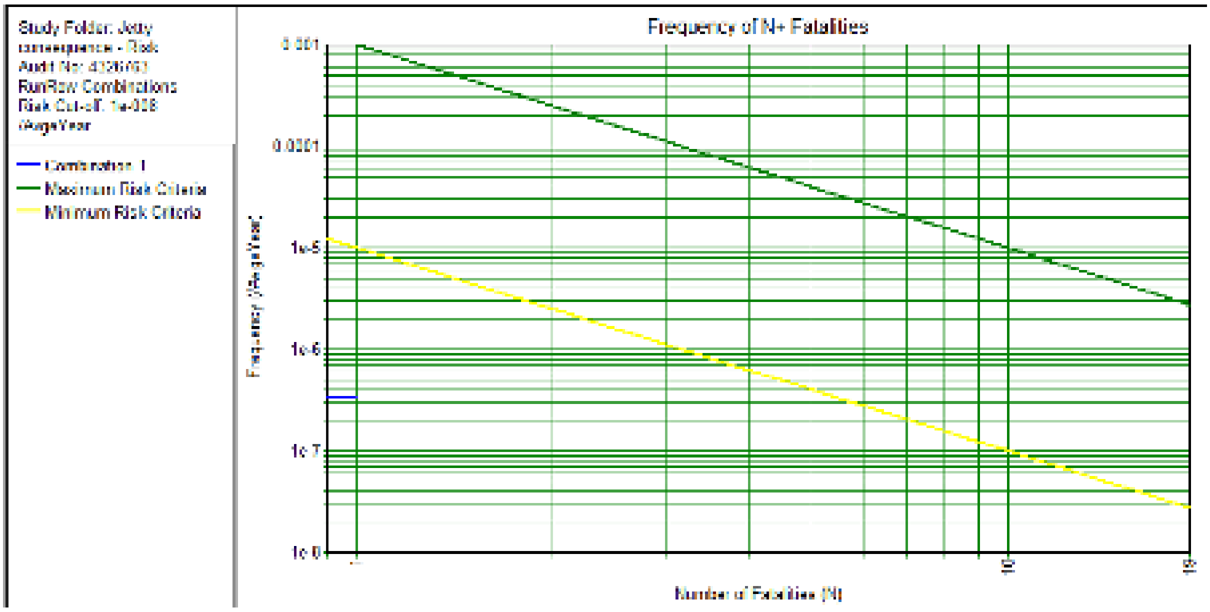
Risk Analysis

The risk estimated due to the activities conducted at the Mundra port is shown in the risk contour map provided **Figure 1**.

The F-N curve demonstrates the societal risk is within As Low as Reasonably Practicable (ALARP) level shown in the **Figure 2**.

Figure 1: Risk Contours

Figure 2: FN Curve



Individual & Societal Risk per Annum

Individual Risk per Annum	2.96E-07
Societal Risk per Annum	3.27E-07

Recommendations

Propane and butane Unloading arm rupture has maximum consequence effect in jetty operations at Mundra port

The Following measures shall be implemented for safe operation

- Selection of the loading arms and commissioning checks to ensure proper operation of the PERC in the event of ESD actuation (maximum time shall not exceed more than 2 min for complete isolation, loading arm release and ship pumps stop in case of hydrocarbon leak)

- Provide trip interlocks (ESD) in berth 2 to ensure isolation/tripping of the ship unloading pumps based on suitable leak detection system (LFL) in berth 2. Ensure unloading hose are designed for hydraulic surges in the event of ESD actuation.

- Mechanical interlocking systems to ensure complete closure of the valves before releasing of coupling (PERC)

- Two independent level indicators. High level alarms (1oo2) shall be set at not more than 85% level of the volumetric capacity of the drain vessel. Audio visual indication shall be at local panel & control room

- Provision for stopping the transfer operation on high level of the drain system and low level permissive for unloading operation

- Drain drum shall have at least two safety relief valves with isolation arrangement, set at different values and at not more than 110% operating pressure of the vessel and each having 100 % relieving capacity adequate for limiting the pressure build up in the vessel not more than 120% of operating pressure

- Drain system to be designed to accommodate the capacity of the drain contents of both unloading arms

- Surge analysis for the unloading arm and unloading line to be done to ensure proper design considerations in the event of ESD actuation bypassing of hydraulic surge protection systems to be done only after satisfactory protection measures implemented and with management clearance only

- Selection of electrical and other instruments based on hazardous area classification (IS 5572:2008)

- All flanges shall be connected for bonding for electrical continuity

- Lightning protection shall be provided as per the requirements of IS: 2309. (High mast towers)

- Periodical maintenance schedule should be implemented and meticulously followed

- F&G systems management to be inspected periodically and availability ensured

- Periodical inspection of pipeline and drain systems

- SOP for critical operations to be developed and displayed at critical locations in local/English languages.

- SIL verification of the SIFs selected

Mitigation measures

- Water curtains shall be provided for segregation of unloading arms/piping manifold and ship tanker in the event of fire on either of these facilities.

- Kerb wall shall be provided around all sides of the unloading arm with concrete flooring of the ground under and extending up to minimum distance of at least 5 M (min.) from the edge of the unloading arm with a slope of 1:100 (min.). Grading of the ground underneath should be levelled and directed to an safe area connected with water seal

- Kerb wall height shall be minimum 30 cm but shall not exceed 60 cm.

Other recommendations

- During ship berthing/de-berthing conditions in berth 2, unloading operations in berth 1 to be stopped

- Ship power generation systems and other electrical systems should be verified for possible ignition source, if safety measures are in place which eliminates ignition source (for all the ships), unloading activity in berth 1,2,3,4 can be done simultaneously after stabilization of LPG unloading operation

- If Motor spirit/SKO/HSD/ethanol/methanol unloading operations are in progress in berth 2/3, unloading operations to be stopped until LPG tanker secured and ignition sources eliminated.

- Hot works jobs for Berth 1 to be avoided during unloading in Berth 2

- Berth 3/4 can be used for unloading operation during construction and commissioning activities in Berth 1

- Any Hot work in the pipe corridor to be covered under PTW systems with continuous monitoring of LFL, running fire water hose (to avoid sparks), area barricading, proper hood to avoid spark spillage

- Continuous LFL monitors with audible alarms near the vessel being unloaded to identify any hydrocarbon leak

Table of Contents

LIST OF FIGURES

LIST OF TABLES:

1 INTRODUCTION

Adani group intends to expand its current port facility at Adani Mundra Port Pvt Ltd. ADANI is developing LPG, Propane, Butane handling and storage facility at their Port in Mundra. Propylene and propane will be stored and handled in the terminal in a scenario where LPG business subsides. The report prepared addresses risk assessment of unloading and transportation facilities to provide a better understanding of the risk posed to the plant and surrounding population.

This document describes the results after the completion of Quantitative Risk Assessment study for the Adani Mundra port-New LPG facility.

1.1 Project Objective

The objective of the QRA is to assess the risk levels associated with the facilities under scope; evaluate those risks based on the HSE UK Risk Acceptance Criteria, and if risks are outside the tolerable region, then risk reduction measures shall be proposed to bring the risks into tolerable or As Low As Reasonably Practicable (ALARP) Levels and lower levels.

1.2 Scope of Work

IFluids Engineering has been awarded the Project to carry out the QRA study to assess risks at the following in the Mundra port;

- Berth 2 (White oil-Motor Spirit representing worst case scenario) Pipeline transfer Facilities in the jetty area
- Berth 1 (Propane/Butane) Pipeline Transfer facilities in the jetty area
- Berth 3 & 4 - Berth 3 handling LPG (typical as Berth 1 in terms of inventory and process conditions) and Berth 4 (White oil-Motor Spirit representing worst case scenario)
- To study the impact of LPG pipeline on existing pipelines in the jetty area.
- To study the impact of Simultaneous berth operations of berth 1 with berth 2, 3 & 4 respectively.

2 FACILITIES OVERVIEW

2.1 Propane/Butane Unloading and Storage Tank

Storage tank (2000-FB-01 and 2000-FB-02) is vertical flat bottom, double wall, full containment refrigerated storage tank, which is designed to store Propane/Butane/Propylene from jetty. The function of these tanks is to store Propane/Butane/Propylene. Both these tanks are identical in all respect and Propane/Butane/Propylene can be stored in any of these tanks. The capacity of each tank is 25000 MT.

Propane/Butane/Propylene is pumped by shipping pump through marine unloading arm to storage tanks through two marine unloading arms at the rate of 500 MT/hr each.

The tank operating pressure is 500 mm WC & temperature of approximately -45°C in case of propane, - 5°C in case of Butane and -47°C in case of Propylene will be maintained in Propane/Butane Storage Tank (2000-FB-01 and 2000-FB-02).

2.2 Precooling Operation

The pre-cooling operation is one of the requirements prior to the ship unloading operation. During precooling operation, cold Propane/ Butane from the Storage Tank I & II is pumped into one of the unloading line going to the Jetty Area, from where it flows towards the Propane/Butane Storage Area and returns into the tank through the other unloading line. Flash compressor will cater the flash gas generated during this operation.

For precooling during propylene/propane unloading scenario two additional lines shall be installed (in future) from storage tank till jetty to avoid any contamination of propylene and Propane inventory.

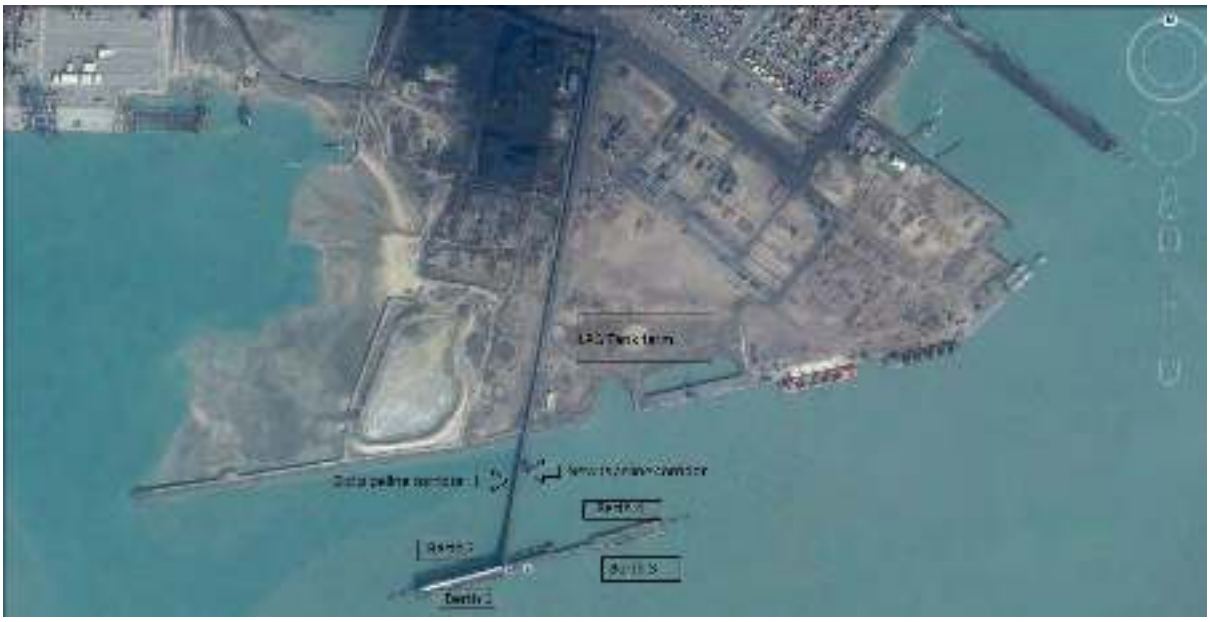


Figure 3: Google Earth image of the facility

3 RISK TOLERABILITY CRITERIA

The assessment and control of risk are essential requirements for a proactive HSE management system. In order to make a valued judgment and to decide on what risks are acceptable, an easily understood set of criteria should be set and followed rigorously. Risk criteria are required to promote consistency in evaluating the results of relevant studies and to formulate a proactive approach to incident prevention. The Risk Acceptance Criteria used in this assessment is from the UK HSE guidelines.

3.1 Individual Risk Criteria

Individual Risk Criteria is a measure of the risk to a person within an occupied area or building. This includes the nature of the injury to the individual, the likelihood of the injury occurring, and the time over which the injury might occur. It is the probability of death occurring because of accidents at a plant facility, installation or a transport route expressed as a function of the distance from such an activity. It is the frequency at which an individual or an individual within a group who may be expected to sustain a given level of harm (typically death) from the realization of specific hazards.

Occupancy is the proportion of exposure time of the individual to the hazard.

The exposure of an individual is related to:

- The likelihood of occurrence of an event involving a release and Ignition of hydrocarbon;
- The vulnerability of the person to the event; and
- The proportion of time the person will be exposed to the event (which is termed 'occupancy' in the QRA terminology).

There is a need to determine the limits for IR, based on numeric values (which would be regarded as intolerable. Figure 4 shows the principle of this framework.

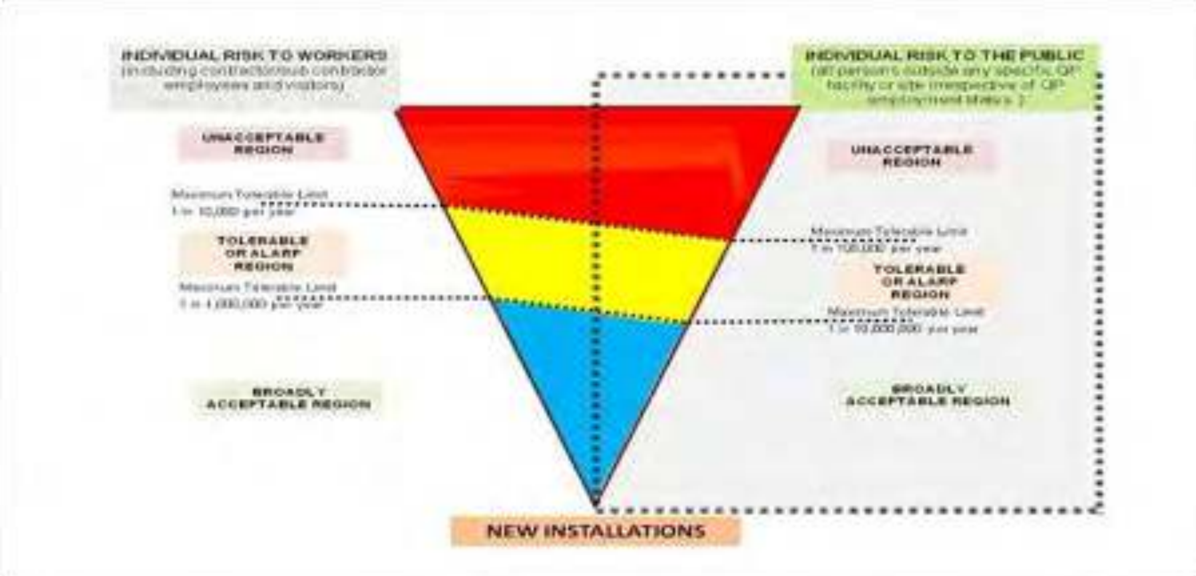


Figure 4: Risk Acceptance graph

3.2 Societal Risk Criteria

Assessment of societal risks is even more important than assessment of individual risk because they involve the likelihood of multiple fatalities. Societal risk is the risk to any person or group of persons who are not connected to project facilities and are outside the facility fence line.

F-N Curve

It is helpful to consider group risk in the demonstration that risks are ALARP. This allows consideration to be given to events, which, although low in frequency, may cause multiple injuries or fatalities. Group risk can be presented in the form of a plot of cumulative frequency versus number of fatalities (F-N curve).

F = Frequency (experienced or predicted)

N = No. of multiple fatalities.

'N' includes indirect deaths caused because of the main event occurring and can therefore be difficult to predict e.g. many people may die years after exposure to a toxic chemical. F-N Curve is generated for customers and benchmarked against risk acceptance criteria. The risk acceptance criteria used to compare the predicted risks for this proposed project can be understood from Figure 5.

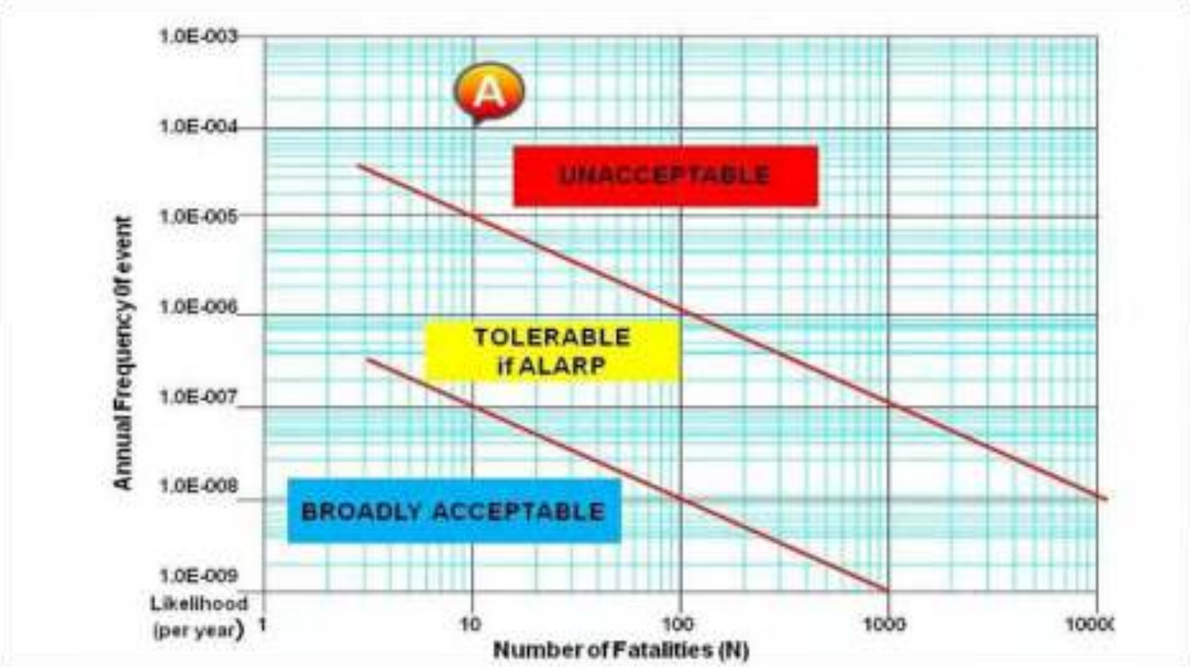


Figure 5: Risk acceptance criteria- FN Curve

4 METROLOGICAL CONDITIONS

This chapter describes the meteorological data, used for the risk assessment study of Adani Mundra Port.

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

4.1 Wind Direction

N	NE	E	SE	S	SW	W	NW
0.0148	0.1211	0.1374	0.0404	0.0179	0.559	0.087	0.0225

4.2 Ambient Conditions

Maximum Ambient temperature	:	35°C
Minimum Ambient temperature	:	7°C
Relative humidity	:	70%
Atmospheric Pressure	:	1.013 Bar
Incident solar radiation	:	0.215 kW/m2
Surface roughness parameter	:	0.3 m

4.3 Atmospheric Stability

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

Pasquill has defined six stability classes ranging from 'A' (extremely unstable) to 'F' (very stable). Wind speeds, intensity of solar radiation (daytime insulation) at night time sky cover have beam identified as prime factors defining these stability categories. Below table indicates the various Pasquill stability classes.

Table 1: Pasquill's Stability Class

Wind Speed (m/s)	Day: Solar Radiation			Night: cloud Cover		
	Strong	Moderate	Slight	Thinly < 40%	Moderate	Overcast > 80%
<2	A	A-B	B	-	-	D
2-3	A-B	B	C	E	F	D
3-5	B	B-C	C	D	E	D
5-6	C	C-D	D	D	D	D
>6	C	D	D	D	D	D

A – Very Unstable

B – Unstable

C – Slightly Unstable

D – Neutral

E – Stable

F – Very Stable

When the atmosphere is unstable and wind speeds are moderate or high or gusty, rapid dispersion of pollutants will occur. Under these conditions, pollutant concentrations in air will be moderate or low and the material will be dispersed rapidly. When the atmosphere is stable and wind speed is low, dispersion of material will be limited and pollutant concentration in air will be high. In general, worst dispersion conditions (i.e. contributing to greater hazard distances) occur during low wind speed and very stable weather conditions, such as that at 1F weather condition (i.e. 1 m/s wind speed and Pasquill stability F).

Stability category for the present study is identified based on the cloud amount and wind speed.

Based on the weather analysis, predominant weather stability of "F" and "D" was selected with wind speed 1.5m/s, 2 m/s and 5m/s for consequence analysis, respectively. 2F is the most prevalent weather condition for this location.

Table 2: Weather Conditions

Wind Speed in m/s	Pasquill Stability
1.5	F
2	F
5	D

5 QUANTITATIVE RISK ASSESSMENT METHODOLOGY

5.1 General Overview

Quantitative Risk Assessment (QRA) is used for risk management and safety improvement in many industries. It provides a quantitative assessment of potential risks identified and provides a basis for evaluating process safety with respect to a predetermined risk acceptance criterion. The usefulness of the QRA results is highly dependent on the availability and accuracy of the input data, with more complete input data providing a higher confidence on the validity and robustness of the results obtained.

In most practical applications, there will be uncertainties in both the key parameters used and the QRA model itself. The effect of these uncertainties should be evaluated to confirm there is no impact on the conclusion. The QRA model will include:

- Examination of flammable/toxic material related to Major Accident Hazards;
- Quantification of the likelihood of flammable/toxic Major Accident Hazardous events;
- Quantification of the consequences of flammable/toxic Major Accident Hazardous events;
- Combination of consequences and likelihood of Major Accident Hazard events to assess risk profiles for individuals, and assets;
- Identification of the predicted levels of risk with regard to Individual Risk (IR) levels and Societal Risk (SR);
- Identification and assessment of risk reduction solutions (to the extent required to reduce predicted risks to acceptable levels); and
- Demonstration that the risks have been reduced to As Low As Reasonably Practicable (ALARP), when risks cannot be reduces to acceptable levels).

The following schematic (**Figure 6**) displays the methodology used to perform the Quantitative Risk Assessment Study for the Adani Mundra Port – New LPG Facilities.

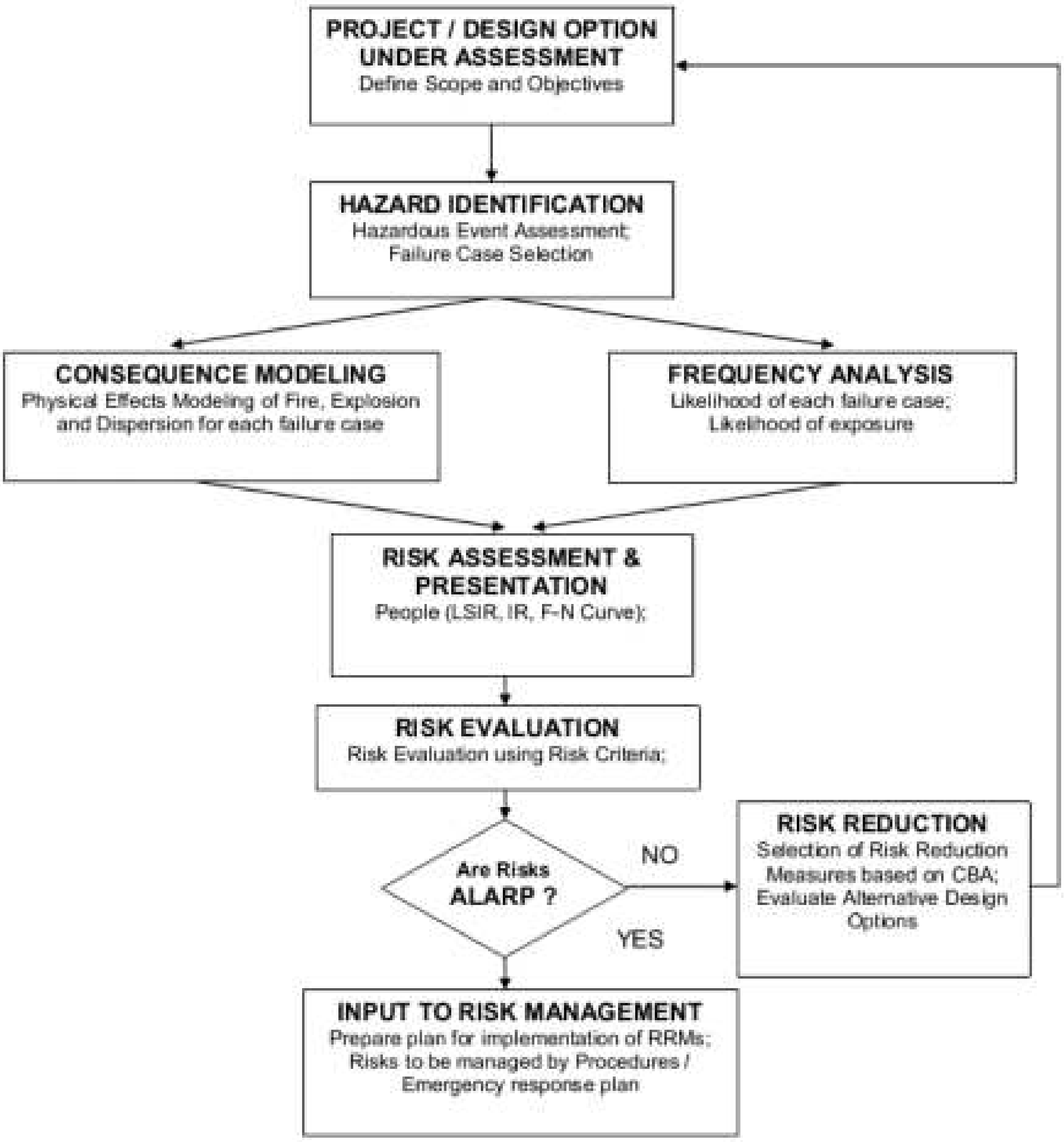


Figure 6: Quantitative Risk Assessment Methodology

5.2 Scenario Description and Operating Conditions

To carry out the QRA study the following basic data were used:

- Process parameters such as operating pressure, temperature & flow rate of equipment and process pipelines as well as the composition of the process streams etc.
- Manning details at strategic locations at site and meteorological details of Adani Mundra port area;
- Failure frequencies of leak sources, Ignition probabilities, operating probabilities etc. and

- Isolation and detection time, Impact criteria for consequences such as fire, explosion and toxic concentration.

5.3 QRA Approach

The QRA was carried out using the standard, internationally accepted approach consisting of the steps shown below:

Data used for the QRA were project and site specific; however, where this was not possible, the use of generic data was documented in the assumptions register prior to being applied within the study. As such, the QRA results was also specific to the planned operations, building design and personnel and general population occupancy levels expected at the time of data collection. Given the above, the consequence and risk results are only applicable to the site under study in this QRA and cannot be applied to any other location.

The following information was considered in the QRA:

- Facility design, function, location, capacity and layout;
- Environmental weather data e.g. wind rose, cloud coverage, stability class;
- Process engineering details e.g. composition, heat and mass balance, equipment items, process parameters - pressure and temperature regimes, inventories, flow schemes;
- Facility operation e.g. operational and emergency procedures; and
- Work force deployment, estimated occupancy and exposure.

5.4 Hazard Identification

A technique commonly used to generate an incident list is to consider potential leaks and major releases from fractures of all process pipelines and vessels. This compilation includes all pipe work and vessels in direct communication, as these may share a significant inventory that cannot be isolated in an emergency. The following data were collected to envisage scenarios:

- Composition of materials stored in vessels / flowing through pipeline;
- Inventory of materials stored in vessels;
- Flow rate of materials passing through pipelines;
- Vessels / Pipeline conditions (phase, temperature, pressure); and Connecting piping and piping dimensions.

Accidental release of flammable liquids / gases has the potential for severe consequences. Delayed ignition of flammable gases can result in blast overpressures covering large areas. This may lead to extensive loss of life and property. In contrast, fires have localized consequences. Fires can be extinguished or contained in most cases; there are few mitigating actions one can take once a flammable gas or a vapour cloud gets released.

5.4.1 Factors for Hazard Identification

In any installation, main hazards arise due to loss of containment during handling of flammable liquids / gases. To formulate a structured approach to the identification of hazards, a list of contributory factors is provided below:

Blast over Pressures

Blast Overpressures depend upon the reactivity class of material and the amount of gas between two explosive limits. For example, Motor spirit/Gasoline once released and not ignited immediately is expected to give rise to a gas cloud. These gases in general have medium reactivity and in case of confinement of the gas cloud, on delayed ignition may result in an explosion and overpressures.

Operating Parameters

Potential gas release for the same material depends significantly on the operating conditions. The gases are likely to operate at atmospheric temperature (and hence high pressures). This operating range is enough to release a large amount of gas in case of a leak / rupture, therefore the pipeline leaks and ruptures need to be considered in the risk analysis calculations.

Inventory

Inventory Analysis is commonly used in understanding the relative hazards and short listing of release scenarios. Inventory plays an important role when considering a potential hazard. The large inventory of a vessel or a system can lead to a large quantity of potential release. A practice commonly used to generate an incident list is to consider potential leaks and major releases from fractures of pipelines and vessels/tanks containing sizable inventories.

Range of Incidents

Both the complexity of study and the number of incident outcome cases are affected by the range of initiating events and incidents covered. This not only reflects the inclusion of accidents and / or non-accident-initiated events, but also the size of those events. For instance, studies may evaluate one or more of the following:

- Catastrophic failure of container;
- Large hole (large continuous release);
- Smaller holes (continuous release); and
- Leaks at fittings or valves (small continuous release).

In general, quantitative studies do not include very small continuous releases or short duration small releases if past experience or preliminary consequence modelling shows that such releases do not contribute to the overall risk levels.

5.5 Isolatable Sections

The following table describes the isolatable section considered for the study:

Table 3: Isolatable Sections

Isolatable section identification	Description	Scenario	Diameter m	Pressure barg	Temperature C	Isolation time s	Total Inventory, kg
Berth 1							
IS-1	Propane unloading line	7	0.406	8	-42.67	120	1593
IS-2		25	0.406	8	-42.67	120	2615
IS-3		150	0.406	8	-42.67	120	18173
IS-4	Butane unloading line	7	0.406	8	-2.9	120	1637
IS-5		25	0.406	8	-2.9	120	2687
IS-6		150	0.406	8	-2.9	120	18215
IS-7	Propylene unloading line	7	0.406	8	-45	120	1422
IS-8		25	0.406	8	-45	120	2464
IS-9		150	0.406	8	-45	120	17999
Berth 2							
IS-10	Methanol Pipelines	10	0.305	10	35	120	11809
IS-11		150	0.305	10	35	120	24885
IS-12	MS Pipelines	10	0.406	10	35	120	18894
IS-13		150	0.406	10	35	120	35336
IS-14	HSD Pipelines	10	0.610	10	35	120	48967
IS-15		150	0.610	10	35	120	82050
IS-16	SKO Pipelines	10	0.305	10	35	120	12058
IS-17		150	0.305	10	35	120	21814
IS-18	Furnace Oil Pipelines	10	0.305	10	55	120	13848
IS-19		150	0.305	10	55	120	21916
IS-20	Crude Pipelines	10	0.9144	10	35	120	121023
IS-21		150	0.9144	10	35	120	177890

6 CONSEQUENCE ANALYSIS

6.1 Overview

Consequence is the measure of the expected outcomes for a given accidental release. For this project, consequence is defined as the hazard distance or hazard zone to various fatality endpoints. During the execution of site-specific consequence analysis, it is essential to accurately model the release, dilution, and dispersion of gases and aerosols if a precise assessment of potential exposure is to be attained. Consequence modelling, also known as physical effects modelling, is a technique in which computer based mathematical modelling is used to predict physical behaviour under accident conditions in order to make a quantitative estimation of risk. Internationally accepted and validated software PHAST v6.7 and PHAST RISK v.6.7, (both developed by DNV GL) have been used for this project.

PHAST v6.7 contains a set of complex models that calculate release conditions, initial dilution of the vapour (dependent upon the release characteristics), and the subsequent dispersion of the vapour introduced into the atmosphere. It permits the user to evaluate the downwind dispersion of the chemical cloud based on the toxicological/physical characteristics of the released chemical, atmospheric conditions, and specific circumstances of the release.

PHAST v6.7 will be used to estimate threat zones associated with several types of hazardous chemical releases, including toxic gas clouds, fires, and explosions.

It is most important that the QRA model effectively reflect reality, thus those familiar with the facilities and their operation are required for proper evaluation. This is particularly true in relation to the preparation of input data and assumptions and the review of results from the evaluation. The QRA model must identify the major hazard contributors to the work force and third parties, quantify risks, and identify and assess any risk reduction methods that may be proposed. In addition to modelling the current situation within the field, the model shall be extendible to add additional facilities as development occurs and provide an active method of planning any proposed development.

6.2 Consequence Modelling

Discharge Rate

The initial rate of release through a leak depends mainly on the pressure inside the equipment, size of the hole and phases of the release (liquid, gas or two phases). The release rate decreases with time as the equipment depressurizes. The reduction mainly on the inventory and the actions taken to isolate the leak and blow-down the equipment

Dispersion

A vapour cloud may be formed when a vaporizing liquid is released for an extended duration. If the gas cloud does not immediately ignite, it disperses based on the prevalent wind direction, speed and stability category (i.e. degree of turbulence).

The cloud dispersion simulation is carried out to provide the distance (from the leak) at which the concentration of flammable material falls below the Lower Flammability Limit (LFL).

Consequence Events

The following describes the probabilities associated with the sequence of events which must take place for the incident scenarios to produce hazardous effects. Considering the present case, the outcomes expected are:

- Flash Fire (FF);
- Jet fires;
- Pool fire;
- Vapour Cloud Explosion.

Flash Fire

The vapour/gas release from a pool would disperse under the influence of the prevailing wind; with material concentration in air reducing with distance. At a particular location downwind, the concentration will drop below its lower flammable level (LFL) value. If ignited within the flammable envelope, the mass of the material available between the LFL and ½ LFL will be likely to burn as a flash fire; rapidly spreading through the cloud from the point of ignition back to the source of release.

Although flash fires are generally low intensity transitory events, the burning velocity is quite high and escape following ignition is not possible. Flash fires often remain close to the ground, where most ignition sources are present. It is assumed that personnel caught inside a flash fire will not survive while those outside suffer no significant harm. If other combustible material is present within the flash fire it is also likely to ignite and a secondary fire could result.

Jet Fire

Jet fire causes damage due to the resulting heat radiation. The working level heat radiation impact will vary widely depending on the angle of the flame to the horizontal plane, which in turn mainly depends on the location of the leak. The flame direction was considered horizontal for consequence analysis of leaks and ruptures from process equipment. Jet fire heat radiation impacts were estimated for the identified credible and worst case scenarios.

Upon accidental leakage, the pressurized fluid will disperse as a jet, initially moving forward in the spatial direction of the leak until the kinetic energy is lost and gravity slumping or lifting of the cloud occurs, dependent upon whether the fluid is heavier or lighter than air.

The primary hazard associated with jet fires is thermal radiation and potential for flame impingement on adjacent pipelines/equipment, resulting in escalation. High pressure releases have the potential to cover large areas due to its relatively large flame length. However, the effects of escalation are minimized if the flame length reduces to less than the separation distance between other equipment and the jet fire source.

Pool Fire

A liquid pool is formed during a prolonged leakage if the rate of leakage exceeds the rate of vaporization. On ignition, this would result in a pool fire whose size/radius would depend on the mass flow rate, ambient temperature, heat of vaporization of material released, vapour pressure, duration of discharge and effects of containment or dykes. The pool fire could cause damage to equipment or injury/fatality to personnel due to thermal radiation effects.

Vapour Cloud Explosion

Vapour cloud explosion is the result of flammable materials in the atmosphere, a subsequent dispersion phase, and after some delay an ignition of the vapour cloud. Turbulence is the governing factor in blast generation which could intensify combustion to the level that will result in an explosion. Turbulence is often created by obstacles in the path of vapour cloud or when the cloud finds a confined area, as under the bullets. Insignificant level of confinement will result in a flash fire. The VCE will result in overpressures.

6.3 Damage Criteria

Damage criteria give the relation between the extent of the physical effects (exposure) and the effect of consequences. For assessing the effects on humans, consequences are expressed in terms of injuries and the effects on equipment / property in terms of monetary loss. The consequences for release of toxic substances or fire can be categorized as:

- Damage caused by heat radiation on material and people;
- Damage caused by explosion on structure and people; and

In Consequence Analysis studies, three main types of exposure to hazardous effects are categorized as:

- Heat radiation due to fires.
- Jet fires and flash fires;
- Explosions;

The knowledge about these relations depends strongly on the nature of the exposure. The following discusses the criteria selected for damage estimation:

Heat Radiation:

The effect of fire on a human being is in the form of burns. There are three categories of burns: first degree, second degree and third degree burns being the most severe. The consequences caused by exposure to heat radiation are a function of:

- The radiation energy onto the human body [kW/m^2];
- The exposure duration [sec]; and
- The protection of the skin tissue (clothed or bare body).

The physical effects of hazard events are given in the table below:

Table 4: Effects due to Incident Radiation Intensity

Incident Radiation (kW/m^2)	Type of Damage
4.7	Sufficient to cause pain within 20 sec. Blistering of skin(first degree burns are likely)
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing's etc.
37.5	Sufficient to cause damage to the equipment

The actual results would be less severe due to the various assumptions made in the models arising out of the flame geometry, emissivity, angle of incidence, view factor and others. The radiation output of the flame would be dependent upon the fire size, extent of mixing with air and the flame temperature. Some fraction of the radiation is absorbed by carbon dioxide and water vapour in the intervening atmosphere. Finally, the incident flux at an observer location would depend upon the radiation view factor, which is a function of the distance from the flame surface, the observer's orientation and the flame geometry.

Blast Overpressure from Vapour cloud Explosion (VCE)

The assessment aims are to determine the impact of overpressure in the event that a flammable gas cloud is ignited. A Vapour cloud Explosion (VCE) results when a flammable vapour is released and mixes with the air to form a flammable vapour cloud. If ignited, the flame speed may accelerate to high velocities and produce significant blast overexposure.

The assessment goals are to determine the impact of overpressure in the event that a flammable gas cloud is ignited. The damage effects due to 0.01 bar, 0.1 bar & 0.3 bar are reported in terms of distance from the overpressure source.

In case of vapour cloud explosion, two physical effects may occur:

- A flash fire over the whole length of the explosive gas cloud;

- A blast wave, with typical peak overpressures circular around ignition source.

For the blast wave, the lethality criterion is based on:

- A peak overpressure of 0.1 bar will cause serious damage to 10% of the housing/structures;
- Falling fragments will kill one of each eight persons in the destroyed buildings.

The following damage criteria may be distinguished with respect to the peak overpressures resulting from a blast wave:

Table 5: Damages due to Blast Overpressure

Peak Overpressure	Damage Type	Description
0.30 bar	Heavy Damage	Major damage to plant equipment structure
0.10 bar	Moderate Damage	Repairable damage to plant equipment & structure
0.01 bar	Significant Damage	Shattering of glass

The summary of the consequence modelling is shown below in

Table 6: Impact Distance in meter

Isolatable Section	Description	Release category	Flash Fire Effects: 100% LFL Ellipse			Flash Fire Effects: 50% LFL Ellipse			Radiation Effects: Jet Fire Ellipse				Radiation Effects: Pool Fire				Overpressure			
			Distance in meters			Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Overpressure level bar	Distance in meters		
			1.5F	2F	5D	1.5F	2F	5D		1.5F	2F	5D		1.5F	2F	5D		1.5F	2F	5D
IS-1	**Propane Unloading line**	7	12.27	10.19	6.42	24.48	21.07	8.19	4	26.73	25.93	23.19	4	NR	NR	NR	0.01	74.95	70.11	NR
									12.5	21.34	20.46	17.59	12.5	NR	NR	NR	0.1	29.53	28.69	NR
									37.5	17.80	16.88	13.98	37.5	NR	NR	NR	0.3	24.76	24.34	NR
IS-2		25	59.61	54.52	35.64	73.68	68.08	52.16	4	84.21	81.90	73.89	4	NR	NR	NR	0.01	518.96	438.73	228.54
									12.5	67.27	64.69	56.26	12.5	NR	NR	NR	0.1	147.88	125.70	80.97
									37.5	56.64	53.96	45.55	37.5	NR	NR	NR	0.3	108.89	92.80	65.46
IS-3		150	255.99	227.90	175.34	342.85	308.57	249.72	4	410.32	400.22	364.35	4	225.82	226.55	210.65	0.01	1520.60	1481.14	1181.37
									12.5	323.38	311.98	274.04	12.5	147.83	151.34	149.79	0.1	408.53	398.63	395.03
									37.5	270.11	258.10	219.76	37.5	90.24	93.49	101.49	0.3	351.57	324.51	312.40
IS-4	**Butane Unloading line**	7	12.90	10.41	6.47	24.75	21.42	8.36	4	27.01	26.27	23.68	4	NR	NR	NR	0.01	77.70	71.73	NR
									12.5	21.31	20.48	17.75	12.5	NR	NR	NR	0.1	30.01	28.97	NR
									37.5	17.63	16.75	13.96	37.5	NR	NR	NR	0.3	25.00	24.48	NR
IS-5		25	61.17	55.27	35.91	74.85	68.90	52.50	4	85.31	83.17	75.62	4	NR	NR	NR	0.01	531.00	445.16	232.21
									12.5	67.28	64.85	56.81	12.5	NR	NR	NR	0.1	149.97	126.81	81.61
									37.5	56.20	53.65	45.54	37.5	NR	NR	NR	0.3	109.93	93.36	65.78
IS-6		150	248.45	220.10	170.78	318.19	285.38	239.34	4	417.21	407.89	374.03	4	240.76	241.15	225.00	0.01	1512.39	1460.54	1211.13
									12.5	324.58	313.85	277.69	12.5	157.30	160.70	158.92	0.1	408.43	390.08	400.19
									37.5	268.52	257.08	220.24	37.5	96.17	99.77	109.58	0.3	326.95	314.12	314.98
IS-7	**Propylene Unloading line**	7	12.80	10.41	6.47	25.11	21.62	8.48	4	26.96	26.14	23.32	4	NR	NR	NR	0.01	77.44	71.55	NR
									12.5	21.59	20.69	17.76	12.5	NR	NR	NR	0.1	29.96	28.94	NR
									37.5	18.07	17.11	14.15	37.5	NR	NR	NR	0.3	24.98	24.47	NR
IS-8		25	61.42	55.55	36.02	76.62	70.60	53.30	4	84.85	82.48	74.25	4	33.27	29.36	NR	0.01	514.46	443.04	231.31
									12.5	67.98	65.34	56.71	12.5	26.65	24.53	NR	0.1	147.10	134.71	81.45
									37.5	57.31	54.59	46.03	37.5	20.59	19.49	NR	0.3	108.50	102.31	65.70
IS-9		150	255.73	227.88	169.63	349.93	314.29	243.58	4	412.90	402.50	365.63	4	242.40	242.43	230.06	0.01	1529.10	1478.23	1132.59
									12.5	326.40	314.72	275.88	12.5	160.76	162.51	159.81	0.1	409.22	397.65	378.30
									37.5	273.18	260.91	221.81	37.5	105.49	108.88	116.15	0.3	351.92	333.41	299.04

Isolatable Section/	Description	Release category	Flash Fire Effects: 100% LFL Ellipse			Flash Fire Effects: 50% LFL Ellipse			Radiation Effects: Jet Fire Ellipse				Radiation Effects: Pool Fire				Overpressure			
			Distance in meters			Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Overpressure level bar	Distance in meters		
			1.5F	2F	5D	1.5F	2F	5D		1.5F	2F	5D		1.5F	2F	5D		1.5F	2F	5D
IS-10	Methanol P/L	10	11.40	11.05	6.84	23.45	21.08	13.29	4	44.0716	42.1378	35.979	4	44.3716	43.1432	NR	0.01	65.8894	64.6327	37.965
									12.5	37.1441	35.2776	29.5076	12.5	30.9147	30.7607	NR	0.1	27.96	27.7421	14.8509
									37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	23.9747	23.8659	12.4222
IS-11		150	70.62	69.21	50.04	121.93	107.00	76.68	4	235.718	226.635	209.858	4	136.037	136.988	142.032	0.01	294.232	298.903	226.029
									12.5	199.537	190.182	171.207	12.5	97.0531	99.1266	108.836	0.1	125.426	133.727	97.0651
									37.5	NR	NR	139.528	37.5	72.4929	72.3265	75.5624	0.3	109.603	116.841	83.5145
IS-12	MS P/L	10	26.40	23.59	15.23	32.67	29.67	23.22	4	37.5937	36.724	33.671	4	NR	NR	NR	0.01	225.457	172.851	98.5467
									12.5	29.3562	28.3433	24.9996	12.5	NR	NR	NR	0.1	63.9044	46.5137	33.6248
									37.5	24.3735	23.2947	19.8615	37.5	NR	NR	NR	0.3	46.9296	33.2392	26.8034
IS-13		150	169.59	148.07	113.80	207.40	185.21	155.25	4	326.379	321.139	303.961	4	136.482	142.569	168.27	0.01	1189.97	1184.48	818.819
									12.5	249.763	243.019	224.278	12.5	79.7338	79.518	82.0953	0.1	317.542	308.385	266.014
									37.5	204.073	196.518	177.003	37.5	NR	NR	NR	0.3	248.759	241.121	207.93
IS-14	HSD P/L	10	11.37	11.25	12.86	11.58	11.44	13.60	4	9.23875	9.2571	11.9794	4	70.0438	73.0102	85.1624	0.01	30.4035	31.4317	32.693
									12.5	7.02619	6.95779	8.73359	12.5	37.835	37.668	41.0876	0.1	13.5392	13.7176	13.9364
									37.5	5.43322	5.3477	6.71139	37.5	NR	NR	NR	0.3	11.7673	11.8563	11.9656
IS-15		150	29.56	29.44	33.04	29.56	29.45	33.09	4	28.7595	28.2825	29.4646	4	185.219	191.383	218.455	0.01	29.4186	29.6151	51.2393
									12.5	22.1526	21.5302	21.557	12.5	113.912	113.79	118.02	0.1	21.6338	21.6678	33.6842
									37.5	18.1956	17.4941	16.9013	37.5	NR	NR	NR	0.3	20.8158	20.8328	31.8397
IS-16	SKO P/L	10	11.43	11.29	12.93	17.30	15.67	13.95	4	26.8337	26.8878	33.6751	4	66.7752	69.687	77.6411	0.01	53.7609	55.9137	57.5866
									12.5	20.7828	20.5746	24.7386	12.5	35.1158	34.8127	36.4009	0.1	17.5908	17.9643	18.2545
									37.5	17.1296	16.783	19.4742	37.5	NR	NR	NR	0.3	13.7904	13.9768	14.1217
IS-17		150	29.25	29.14	32.75	37.39	37.77	39.80	4	88.3046	86.9503	90.2507	4	121.643	126.421	147.559	0.01	72.8802	73.4377	78.1448
									12.5	67.6656	65.8591	65.7575	12.5	73.4972	73.3811	78.5757	0.1	37.4381	37.5348	38.3513
									37.5	55.4211	53.3769	51.4125	37.5	NR	NR	NR	0.3	33.7141	33.7624	34.1701
IS-18	FURNACE OIL	10	NR	11.37	13.43	NR	11.70	14.80	4	NR	NR	NR	4	67.7607	70.0269	79.8512	0.01	NR	NR	NR
									12.5	NR	NR	NR	12.5	38.5883	38.4596	42.2865	0.1	NR	NR	NR
									37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	NR	NR	NR
IS-19		150	NR	NR	NR	NR	NR	NR	4	NR	NR	NR	4	94.4439	97.0658	109.734	0.01	NR	NR	NR
									12.5	NR	NR	NR	12.5	61.6346	61.5704	66.4692	0.1	NR	NR	NR
									37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	NR	NR	NR

Isolatable Section/	Description	Release category	Flash Fire Effects: 100% LFL Ellipse Distance in meters			Flash Fire Effects: 50% LFL Ellipse Distance in meters			Radiation Effects: Jet Fire Ellipse				Radiation Effects: Pool Fire				Overpressure			
									Radiation Levels (kW/m2)	Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Overpressure level bar	Distance in meters		
			1.5F	2F	5D	1.5F	2F	5D		1.5F	2F	5D		1.5F	2F	5D		1.5F	2F	5D
IS-20	**CRUDE**	10	28.69	25.89	16.60	35.84	32.52	24.92	4	34.6209	34.0991	29.749	4	NR	NR	NR	0.01	237.787	206.342	104.653
									12.5	25.8094	25.124	21.3767	12.5	NR	NR	NR	0.1	66.043	60.5885	34.6841
									37.5	20.6567	19.8868	16.4918	37.5	NR	NR	NR	0.3	47.9976	45.2739	27.3323
IS-21		150	332.30	283.90	202.34	403.72	348.47	269.54	4	325.533	314.373	268.919	4	164.136	170.158	163.372	0.01	2994.33	2733.84	1583.86
									12.5	247.302	236.963	198.353	12.5	96.7701	95.8433	81.2582	0.1	791.031	754.644	489.64
									37.5	200.903	191.054	156.56	37.5	NR	NR	NR	0.3	590.249	547.046	374.667

*NH- No Hazard, NR- Not Reached

7 FREQUENCY ANALYSIS

7.1 Overview

Frequency of occurrence of the representative hazardous events needs to be evaluated by referencing appropriate generic industry data. Both generic industry and company / vendor based information has been used, and particular care has been taken to ensure its validity. Generic failure data was applied where site specific or company / vendor data is not available.

Initiating event failure frequencies for each case developed have been estimated using various sources (listed in order of preference) including:

- TNO Guidelines for Quantitative Risk Assessment (Purple Book);
- OGP Risk Assessment Data Directory, Process Release Frequencies, 2010; and
- Health & Safety Executive (HSE) failure rates & event data for land use planning.

Given the potential for release from each of these scenarios, an event tree of possible outcomes has been developed using this individual component failure data. The table given below shows the frequency of failure of the selected isolatable sections calculated by parts count.

7.2 Event tree analysis

A release can result in several possible outcomes or scenarios (fire, explosions, un-ignited release etc.). A specific outcome for a release scenario may be dependent on other unrelated events following the initial release. Event tree analysis is used to identify potential outcomes of a release and to quantify the risk associated with each of these outcomes. The event tree for this QRA study is shown in **Figure 7**:

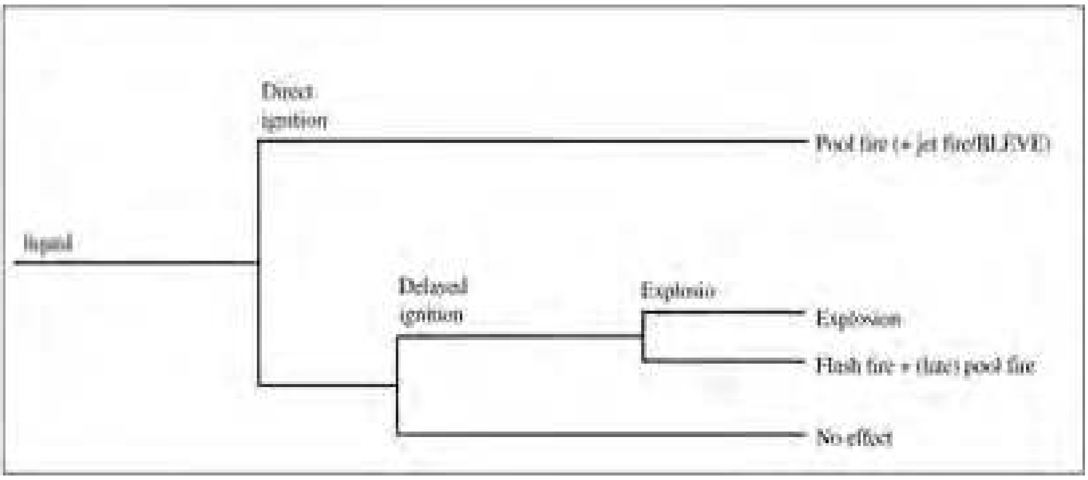


Figure 7: Event Tree

For calculating the frequency used for modeling, the following modification factors were taken into consideration:

- Design/Quality Maintenance
- Time is use

Table 7: Failure Frequency of an Event

Isolatable Sections	Description	Scenario	Total Frequency
IS-1	Propane unloading line	7	6.08E-06
IS-2		25	2.18E-06
IS-3		150	1.86E-07
IS-4	Butane unloading line	7	6.08E-06
IS-5		25	2.18E-06
IS-6		150	1.86E-07
IS-10	Methanol P/L	10	2.28E-06
IS-11		150	1.44E-08
IS-12	MS P/L	10	2.50E-06
IS-13		150	1.58E-08
IS-14	HSD P/L	10	7.03E-06
IS-15		150	4.56E-08
IS-16	SKO P/L	10	4.94E-06
IS-17		150	3.12E-08
IS-18	Furnace Oil	10	1.20E-05

Isolatable Sections	Description	Scenario	Total Frequency
IS-19		150	7.56E-08
IS-20	Crude	10	4.05E-07
IS-21		150	1.26E-08

8 RISK ASSESSMENT & PRESENTATION

8.1 Overview

Risk is often defined as a function of the likelihood that a specified undesired event will occur, and the severity of the consequences of that event. Risk is derived from the product of likelihood and potential consequence. Risk in general is a measure of potential economic loss or human injury in terms of the probability of the loss or injury occurring and magnitude of the loss or injury if it occurs.

$$Risk = f(\text{Severity}, \text{Frequency})$$

Quantification of effects of the hazardous event was done using the Event Tree approach in which all the possible outcomes of the hazardous event were considered and the likelihood of each type of end event determined. This step in the process involves the use of consequence modelling to predict both physical phenomena such as dispersion of gas, size and duration of fires, overpressures due to explosions, and the performance of equipment and systems such as availability of a fire & gas detection system, availability of emergency shutdown system, and availability of fire protection system. The end result of this phase of the assessment is a series of "end events", together with their estimated frequency of occurrence.

8.2 Risk Results

The risk modelling has been performed using DNV PHAST RISK 6.7 software. Thereby, the details of the input data used for the risk modelling such as vulnerability criteria, ignition probability and occupancy data are given in the QRA Assumption Register. The results of a QRA are expressed using Individual Risk Contours and Societal Risk Graphs.

The Individual Risk represents the frequency of an individual dying due to loss of containment events (LOCs). The individual is assumed to be unprotected and to be present during the total exposure time. The Individual Risk is presented as contour lines on a topographic map.

The Societal Risk represents the frequency of having an accident with N or more people being killed simultaneously. The people involved are assumed to have some means of protection. The Societal Risk is presented as an F-N curve, where N is the number of deaths and F the cumulative frequency of accidents with N or more deaths.

The Individual Risk estimated due to the activities being conducted at the Adani Mundra port is represented by a risk contour in the Figure 8 below.

Figure 8: Risk Contour

The Societal Risk pertaining to group of individuals is represented in **Figure 9**.

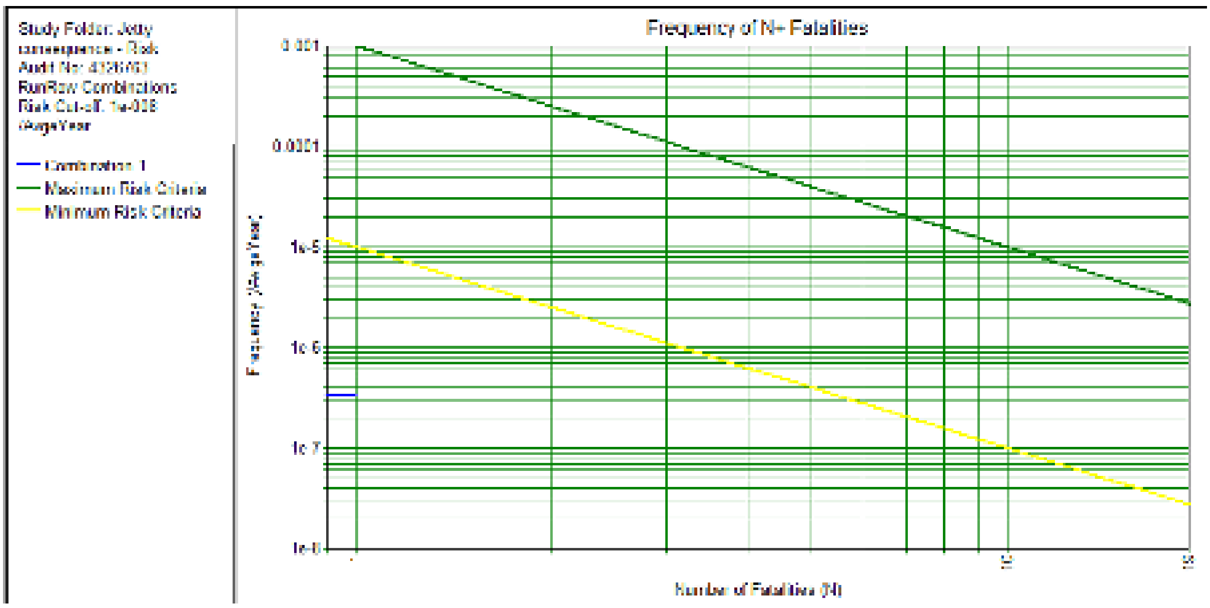


Figure 9: FN Curve

9 RECOMMENDATIONS

Propane and butane Unloading arm rupture has maximum consequence effect in jetty operations at Mundra port

The Following measures shall be implemented for safe operation

• Selection of the loading arms and commissioning checks to ensure proper operation of the PERC in the event of ESD actuation (maximum time shall not exceed more than 2 min for complete isolation, loading arm release and ship pumps stop in case of hydrocarbon leak)

• Provide trip interlocks (ESD) in berth 2 to ensure isolation/tripping of the ship unloading pumps based on suitable leak detection system (LFL) in berth 2. Ensure unloading hose are designed for hydraulic surges in the event of ESD actuation.

• Mechanical interlocking systems to ensure complete closure of the valves before releasing of coupling (PERC)

• Two independent level indicators. High level alarms (1oo2) shall be set at not more than 85% level of the volumetric capacity of the drain vessel. Audio visual indication shall be at local panel & control room

• Provision for stopping the transfer operation on high level of the drain system and low level permissive for unloading operation

• Drain drum shall have at least two safety relief valves with isolation arrangement, set at different values and at not more than 110% operating pressure of the vessel and each having 100 % relieving capacity adequate for limiting the pressure build up in the vessel not more than 120% of operating pressure

• Drain system to be designed to accommodate the capacity of the drain contents of both unloading arms

• Surge analysis for the unloading arm and unloading line to be done to ensure proper design considerations in the event of ESD actuation bypassing of hydraulic surge protection systems to be done only after satisfactory protection measures implemented and with management clearance only

• Selection of electrical and other instruments based on hazardous area classification (IS 5572:2008)

• All flanges shall be connected for bonding for electrical continuity

• Lightning protection shall be provided as per the requirements of IS: 2309. (High mast towers)

• Periodical maintenance schedule should be implemented and meticulously followed

• F&G systems management to be inspected periodically and availability ensured

• Periodical inspection of pipeline and drain systems

• SOP for critical operations to be developed and displayed at critical locations in local/English languages.

•SIL verification of the SIFs selected

Mitigation measures

• Water curtains shall be provided for segregation of unloading arms/piping manifold and ship tanker in the event of fire on either of these facilities.

• Kerb wall shall be provided around all sides of the unloading arm with concrete flooring of the ground under and extending up to minimum distance of at least 5 M (min.) from the edge of the unloading arm with a slope of 1:100 (min.). Grading of the ground underneath should be levelled and directed to an safe area connected with water seal

• Kerb wall height shall be minimum 30 cm but shall not exceed 60 cm.

Other recommendations

• During ship berthing/de-berthing conditions in berth 2, unloading operations in berth 1 to be stopped

• Ship power generation systems and other electrical systems should be verified for possible ignition source, if safety measures are in place that eliminates ignition source (for all the ships), unloading activity in berth 1,2,3,4 can be done simultaneously after stabilization of LPG unloading operation

• If Motor spirit/SKO/HSD/ethanol/methanol unloading operations are in progress in berth 2/3, unloading operations to be stopped until LPG tanker secured and ignition sources eliminated.

- Hot works jobs for Berth 1 to be avoided during unloading in Berth 2

- Berth 3/4 can be used for unloading operation during construction and commissioning activities in Berth 1

- Any Hot work in the pipe corridor to be covered under PTW systems with continuous monitoring of LFL, running firewater hose (to avoid sparks), area barricading, proper hood to avoid spark spillage

- Continuous LFL monitors with audible alarms near the vessel being unloaded to identify any hydrocarbon leak

APPENDIX 1 CONSEQUENCE CONTOURS

PROPANE PIPELINE FROM BERTH 1 - 25mm LEAK

FLASH FIRE

JET FIRE

EXPLOSION

BUTANE PIPELINE FROM BERTH 1- 25mm LEAK

FLASH FIRE

JET FIRE

EXPLOSION

PROPYLENE PIPELINE FROM BERTH 1-25 mm LEAK

FLASH FIRE

JET FIRE

POOL FIRE

EXPLOSION

METHANOL PIPELINE FROM BERTH 2-25 mm LEAK

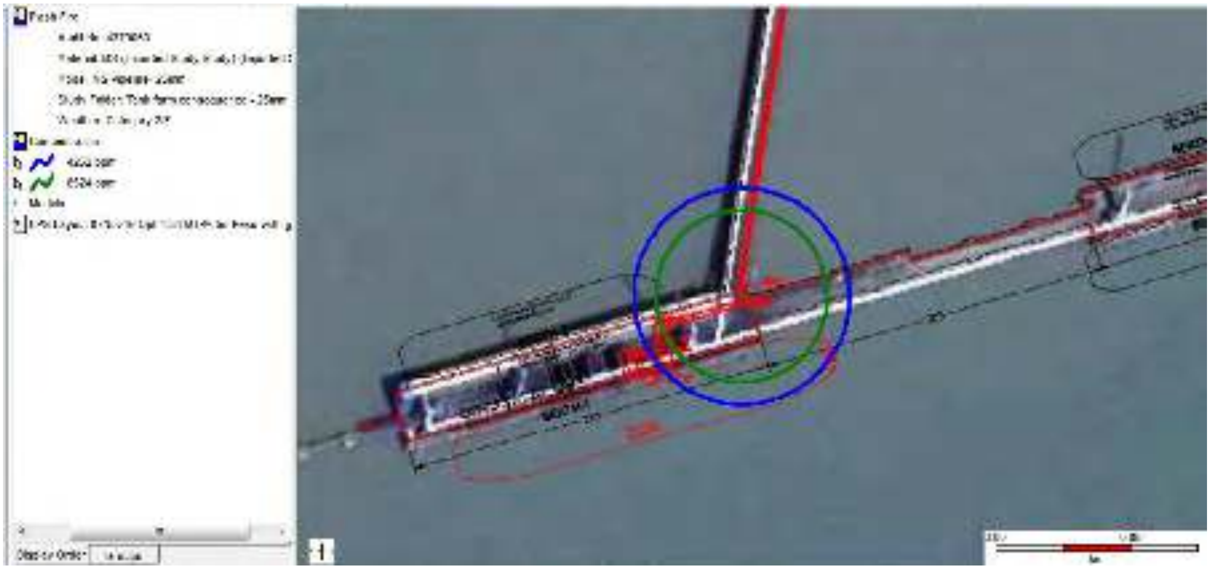
FLASH FIRE

JET FIRE

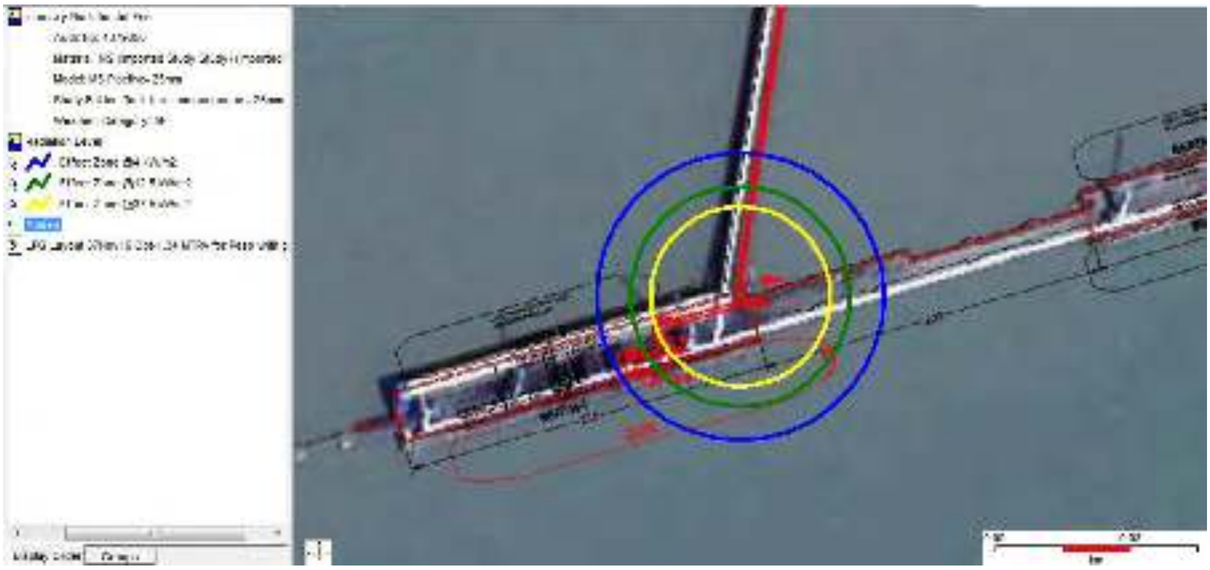
EXPLOSION

MS PIPELINE FROM BERTH 2-25 mm LEAK

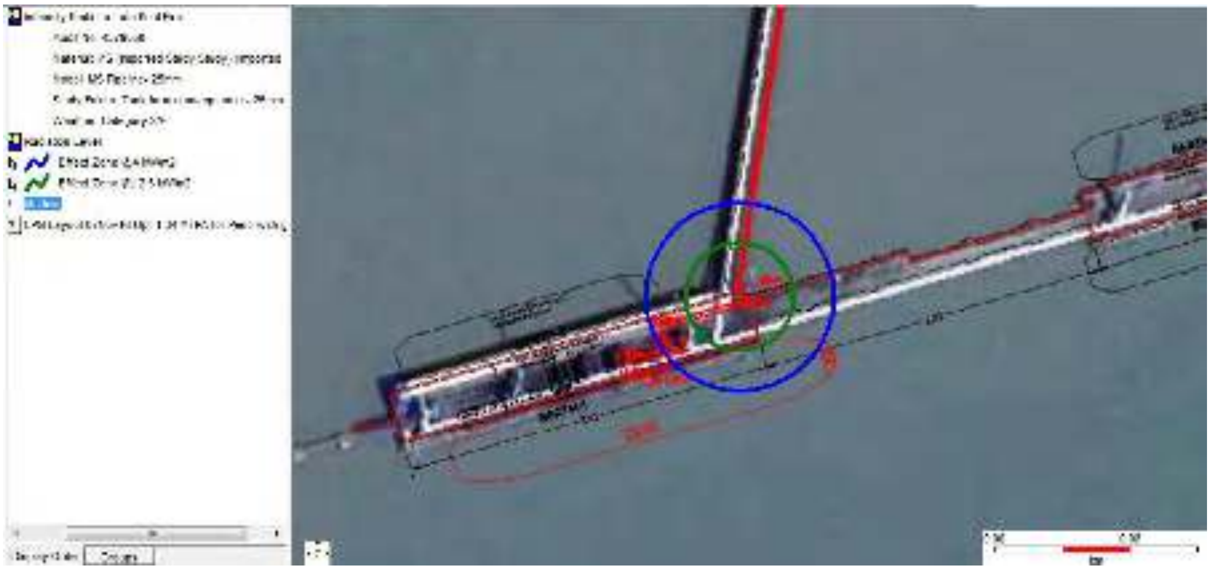
FLASH FIRE



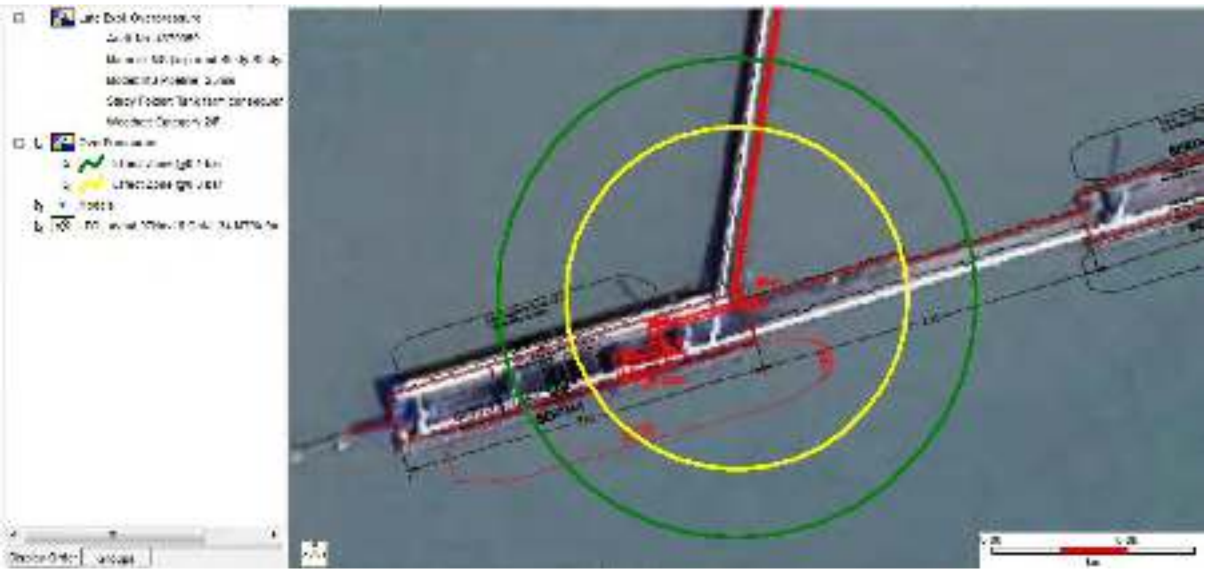
JET FIRE



POOL FIRE



EXPLOSION

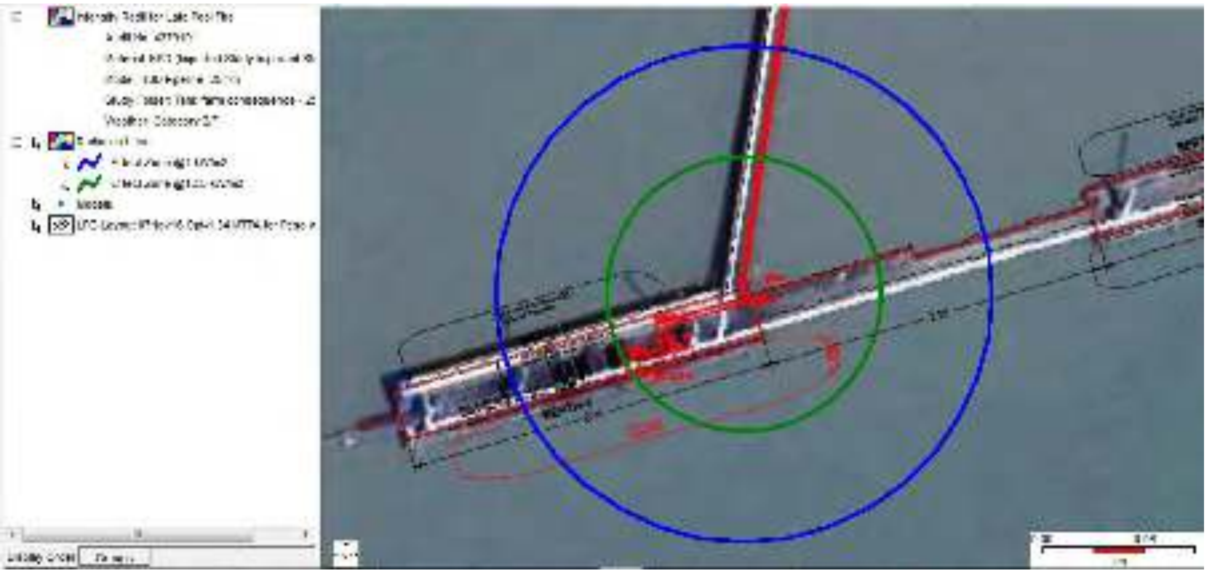


HSD PIPELINE FROM BERTH 2-25 mm LEAK

FLASH FIRE

JET FIRE

POOL FIRE



EXPLOSION

SKO PIPELINE FROM BERTH 2-25 mm LEAK

FLASH FIRE

JET FIRE

POOL FIRE

EXPLOSION

FURNACE OIL PIPELINE FROM BERTH 2-25 mm LEAK

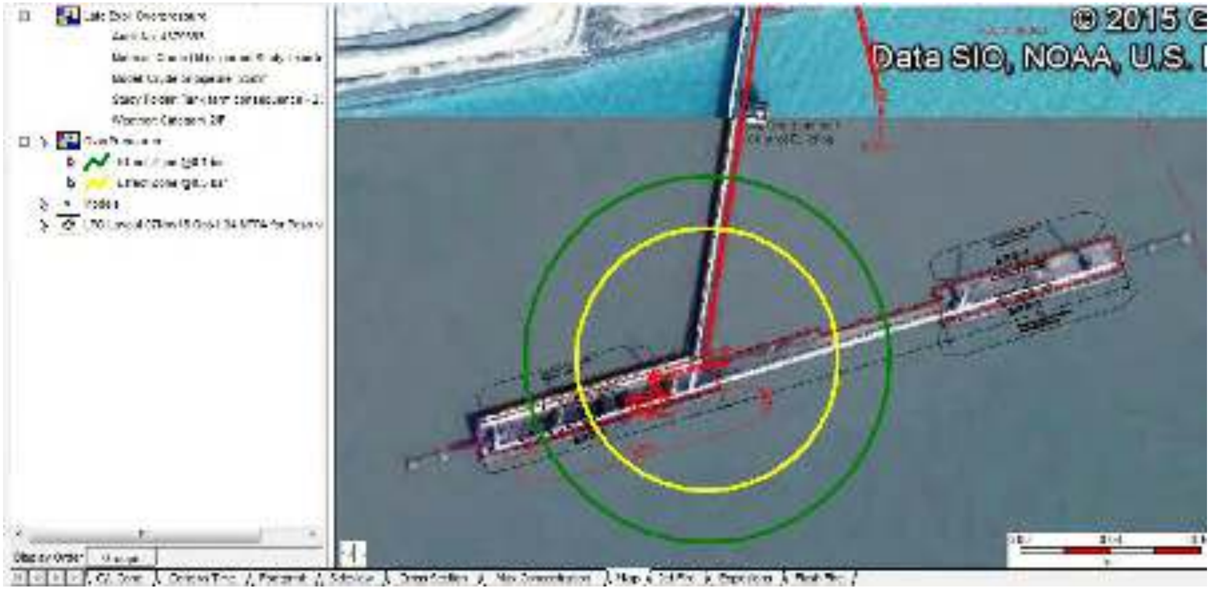
POOL FIRE

CRUDE PIPELINE FROM BERTH 2-25 mm LEAK

FLASH FIRE

JET FIRE

EXPLOSION



QUANTITATIVE RISK ASSESSMENT REPORT FOR PIPELINE AREA

MUNDRA PORT – NEW LPG FACILITIES

HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD.

EC

PMC

http://ifluids.com

Document Title : Quantitative Risk Assessment Report For Pipelines

Project Title : Mundra Port - New LPG Facilities

Client Company Name : Adani

Engineering consultant : Technip India Limited

PMC : HOWE Engineering Projects (India) Pvt. Ltd.

Consultant : iFluids Engineering

DISCLAIMER

The report rendered by consultants is in the nature of guidelines based on good engineering practices and generally accepted safety procedures. The recommendations shown in the report shall be considered as a Technical professional opinion and not binding on the parties involved viz. Technip and iFluids Engineering.

The technical recommendations and the conclusions thus expressed may have to be re-considered in light of any modifications or alterations that would invalidate the data shown in the documents which are referred to therein.

These recommendations and conclusions would become null and void should the consultants not be kept informed of such modifications or alterations with specific reference to the present report.

Rev	Date	Description	Prepared by	Reviewed by	Approved by
A	28-Nov-16	Final Report	VP	JS	

LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
EA	Environmental Assessment
ERP	Emergency Response Plan
ESD	Emergency Shutdown
HAZID	Hazard Identification
HAZOP	Hazard & Operability Study
HC	Hydrocarbon
HSE	Health Safety & Environment
IRPA	Individual Risk Per Annum
LFL/LEL	Lower Flammability Limit / Lower Explosive Limit
LOC	Loss of Containment
P&ID	Piping and Instrument Diagram
PLL	Potential Loss of Life
QRA	Quantitative Risk Assessment
SOP	Standard Operating Procedure

EXECUTIVE SUMMARY

Adani group intends to expand its current port facility at Adani Mundra Port Pvt Ltd. ADANI is developing LPG, Propane, Butane handling and storage facility at their Port in Mundra. Propylene and propane will be stored and handled in the terminal in a scenario where LPG business subsides. The Adani group has appointed iFluids engineering to carry out Quantitative Risk Assessment and recommend cost effective measures to address the hazardous scenarios.

OVERALL FACILITY DESCRIPTION

ADANI is developing LPG, Propane, Butane handling and storage facility at their Port in Mundra. Propylene and propane will be stored and handled in the terminal in a scenario where LPG business subsides.

ADANI has envisaged the following services for set up in Import/Export terminal at Mundra,

- Import of Propane / Butane in cryogenic state in jetties through ship tankers and transferring through unloading arms and pipelines.
- Transfer of product through the unloading line and storing in dedicated refrigerated / cryogenic tanks.
- Transfer of products from tanks through pumps to heating train and then to online blending system for mix of Domestic, Auto & Industrial LPG
- Mercaptan dosing of the LPG, Propane and Butane
- Transfer to loading gantry for loading in to road tankers for dispatch of following products through Tanker loading facility.
    - LPG (AUTOMOTIVE)/ (INDUSTRIAL)
    - LPG (DOMESTIC)
    - LPG PROPANE
    - BUTANE
    - PROPYLENE (In future when LPG demand subsides BUTANE import would stop and PROPYLENE shall be imported and stored in Storage tank).

- Simultaneous operation of Berth 1 with Berth 2, 3 & 4 respectively

This document only covers the Pipeline transfer of the products from the Jetties to the Storage Tanks

STUDY RESULT

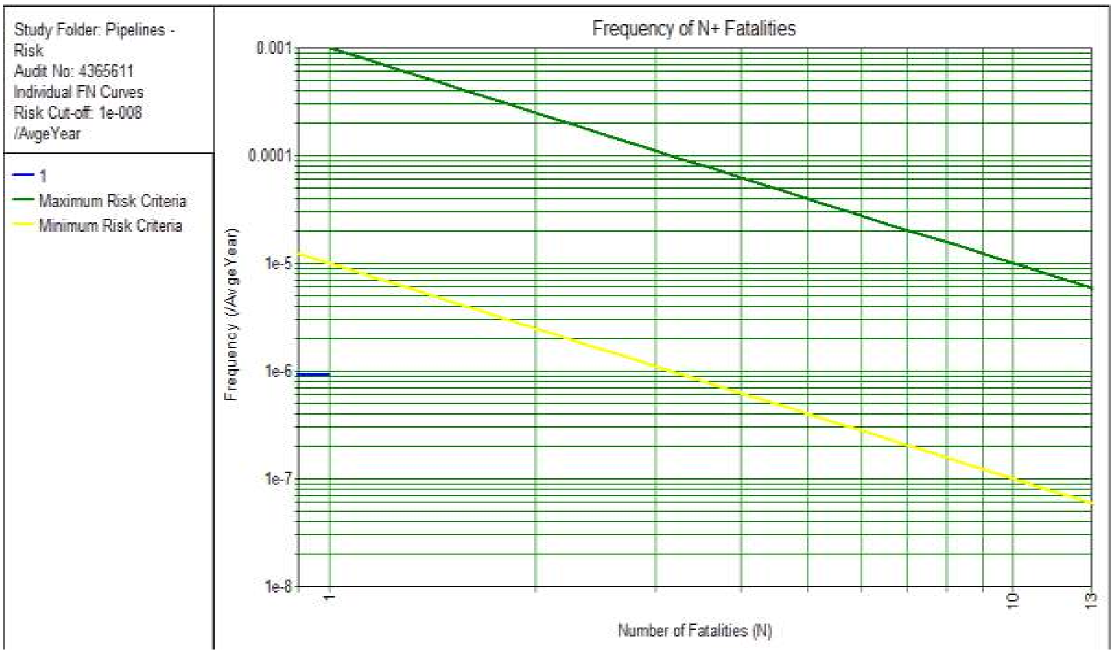
RISK ANALYSIS

The risk estimated due to the activities conducted at the Mundra port is shown in the risk contour map provided **Figure 1**.

The F-N curve demonstrates the societal risk is within As Low as Reasonably Practicable (ALARP) level shown in the **Figure 2**.

FIGURE 1: RISK CONTOURS

FIGURE 2: FN CURVE



INDIVIDUAL & SOCIETAL RISK PER ANNUM

Individual Risk per Annum	3.98E-07
Societal Risk per Annum	4.74E-07

RECOMMENDATIONS

The Following measures shall be implemented for safe operation

- Periodical inspection of pipelines
- Leak detection systems based on pressure, temperature and flow
- CCTV monitoring of the pipeline corridor/jetty, in control room
- Surge Analysis shall be performed to ensure adequate time lag between closure of ROVs at jetty end and at the tank end. The time lag shall be engineered so that surge pressure does not increase beyond the design limit. While engineering the closure time of each ROV, a consideration shall be given so that the pressure due to surge does not exceed the design pressure.

- A suitable continuous back-up power supply shall be provided for the control system and operation of ROVs both at jetty end and tank end.
- Electrical equipment including for lighting system shall conform to hazardous area classification and be selected in accordance with IS: 5571. These shall be tested by agencies such as CMRI, ERTL, CPRI or independent test laboratory of country of origin for such equipment. Indigenous Flameproof equipment shall comply with relevant BIS standard as per requirements of statutory authorities
- Pressure testing/ Low pressure leak check (with N2) of the piping / flanged joints completed for entire pipeline and associated station piping before commissioning of the pipelines after any maintenance activity In case of displacement of Nitrogen with LPG, it should be done to flare

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1. INTRODUCTION

Adani group intends to expand its current port facility at Adani Mundra Port Pvt Ltd. ADANI is developing LPG, Propane, Butane handling and storage facility at their Port in Mundra. Propylene and propane will be stored and handled in the terminal in a scenario where LPG business subsides. The report prepared addresses risk assessment of unloading and transportation facilities to provide a better understanding of the risk posed to the plant and surrounding population.

This document describes the results after the completion of Quantitative Risk Assessment study for the Adani Mundra port-New LPG facility.

1.1 Project Objective

The objective of the QRA is to assess the risk levels associated with the facilities under scope; evaluate those risks based on the HSE UK Risk Acceptance Criteria, and if risks are outside the tolerable region, then risk reduction measures shall be proposed to bring the risks into tolerable or As Low As Reasonably Practicable (ALARP) Levels and lower levels.

1.2 Scope of Work

IFluids Engineering has been awarded the Project to carry out the QRA study to assess risks at the following in the Mundra port;

- Berth 2 (White oil-Motor Spirit representing worst case scenario) Pipeline transfer Facilities
- Berth 1 (Propane/Butane) Pipeline Transfer facilities
- Berth 3 & 4 - Berth 3 handling LPG (typical as Berth 1 in terms of inventory and process conditions) and Berth 4 (White oil-Motor Spirit representing worst case scenario)
- To study the impact of LPG pipeline on existing pipelines.
- To study the impact of Simultaneous berth operations of berth 1 with berth 2 , 3 & 4 respectively.
- To study the impact of facilities around LPG plot

a) T9, T10 handling fertilizers to the south of LPG plot.

b) Steel yard to the east side of LPG Plot &

c) Existing pipeline & conveyor to the west of LPG plot.

2. FACILITIES OVERVIEW

2.1 Propane/Butane Unloading and Storage Tank

Storage tank (2000-FB-01 and 2000-FB-02) is vertical flat bottom, double wall, full containment refrigerated storage tank, which is designed to store Propane/Butane/Propylene from jetty. The function of these tanks is to store Propane/Butane/Propylene. Both these tanks are identical in all respect and Propane/Butane/Propylene can be stored in any of these tanks. The capacity of each tank is 25000 MT.

Propane/Butane/Propylene is pumped by shipping pump through marine unloading arm to storage tanks through two marine unloading arm at the rate of 500 MT/hr each.

The tank operating pressure is 500 mm WC & temperature of approximately -45°C in case of propane, - 5°C in case of Butane and -47°C in case of Propylene will be maintained in Propane/Butane Storage Tank (2000-FB-01 and 2000-FB-02).

2.2 Precooling Operation

The pre-cooling operation is one of the requirements prior to the ship unloading operation. During precooling operation, cold Propane/ Butane from the Storage Tank I & II is pumped into one of the unloading line going to the Jetty Area, from where it flows towards the Propane/Butane Storage Area and returns into the tank through the other unloading line. Flash compressor will cater the flash gas generated during this operation.

For precooling during propylene/propane unloading scenario two additional lines shall be installed (in future) from storage tank till jetty to avoid any contamination of propylene and Propane inventory.

2.3 Other unloading operations and Transfer to Tank farm area

Following Hazardous Chemicals are unloaded at berth 1, 2, 3 & 4 and transferred to the tank farm via pipelines

1. Propane

2. Butane
3. Propylene
4. Crude oil (future)
5. Furnace oil
6. Excluded petroleum products such as Furnace and vegetable oil

FIGURE 3: GOOGLE EARTH IMAGE OF THE FACILITY

3. RISK TOLERABILITY CRITERIA

The assessment and control of risk are essential requirements for a proactive HSE management system. In order to make a valued judgment and to decide on what risks are acceptable, an easily understood set of criteria should be set and followed rigorously. Risk criteria are required to promote consistency in evaluating the results of relevant studies and to formulate a proactive approach to incident prevention. The Risk Acceptance Criteria used in this assessment is from the UK HSE guidelines.

3.1 Individual Risk Criteria

Individual Risk Criteria is a measure of the risk to a person within an occupied area or building. This includes the nature of the injury to the individual, the likelihood of the injury occurring, and the time over which the injury might occur. It is the probability of death occurring because of accidents at a plant facility, installation or a transport route expressed as a function of the distance from such an activity. It is the frequency at which an individual or an individual within a group who may be expected to sustain a given level of harm (typically death) from the realization of specific hazards.

Occupancy is the proportion of exposure time of the individual to the hazard.

The exposure of an individual is related to:

- The likelihood of occurrence of an event involving a release and Ignition of hydrocarbon;
- The vulnerability of the person to the event; and
- The proportion of time the person will be exposed to the event (which is termed 'occupancy' in the QRA terminology).

There is a need to determine the limits for IR, based on numeric values (which would be regarded as intolerable. Figure 4 shows the principle of this framework.

Figure 4: Risk Acceptance graph

3.2 Societal Risk Criteria

Assessment of societal risks is even more important than assessment of individual risk because they involve the likelihood of multiple fatalities. Societal risk is the risk to any person or group of persons who are not connected to project facilities and are outside the facility fence line.

F-N Curve

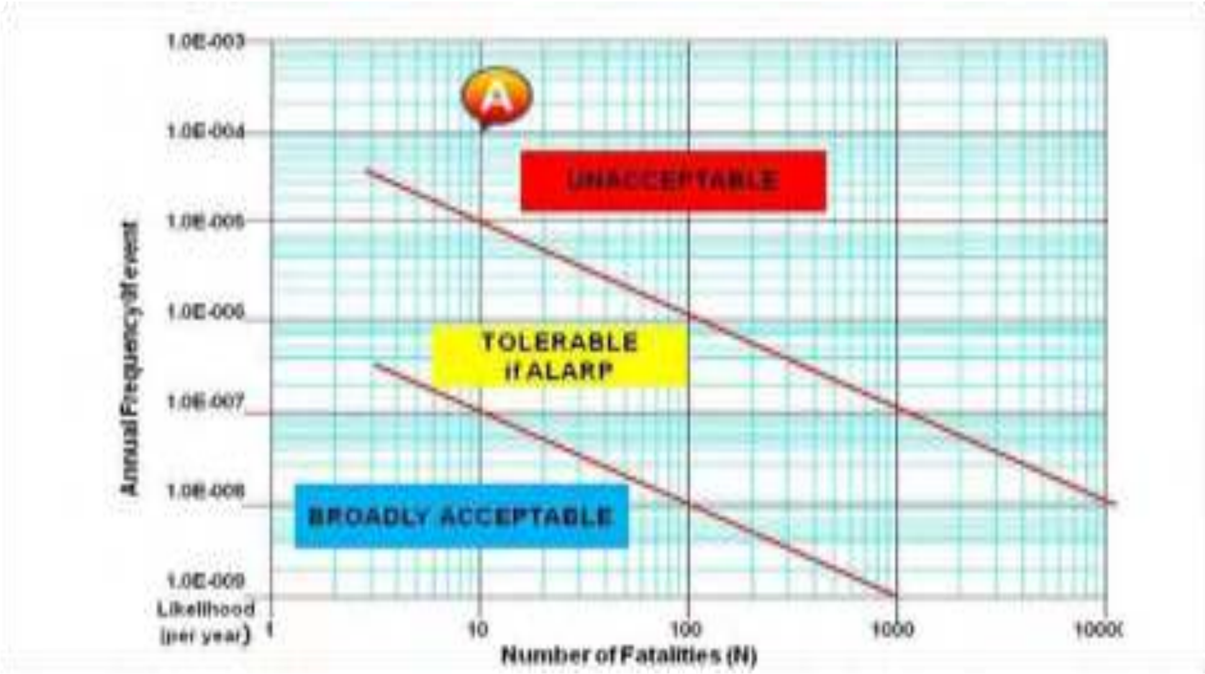
It is helpful to consider group risk in the demonstration that risks are ALARP. This allows consideration to be given to events, which, although low in frequency, may cause multiple injuries or fatalities. Group risk can be presented in the form of a plot of cumulative frequency versus number of fatalities (F-N curve).

F = Frequency (experienced or predicted)

N =No. of multiple fatalities.

„N‟includes indirect deaths caused because of the main event occurring and can therefore be difficult to predict e.g. many people may die years after exposure to a toxic chemical. F-N Curve is generated for customers and benchmarked against risk acceptance criteria. The risk acceptance criteria used to compare the predicted risks for this proposed project can be understood from Figure 5.

Figure 5: Risk acceptance criteria- FN Curve



4. METROLOGICAL CONDITIONS

This chapter describes the meteorological data, used for the risk assessment study of Adani Mundra Port.

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

4.1 Wind Direction

N	NE	E	SE	S	SW	W	NW
0.0148	0.1211	0.1374	0.0404	0.0179	0.559	0.087	0.0225

4.2 Ambient Conditions

Maximum Ambient temperature: 35°C

Minimum Ambient temperature: 7°C

Relative humidity: 70%

Atmospheric Pressure: 1.013 Bar

Incident solar radiation: 0.215 kW/m2

Surface roughness parameter: 0.3 m

4.3 Atmospheric Stability

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

Pasquill has defined six stability classes ranging from „A" (extremely unstable) to „F" (very stable). Wind speeds, intensity of solar radiation (daytime insulation) at night time sky cover have beam identified as prime factors defining these stability categories. Below table indicates the various Pasquill stability classes.

TABLE 1: PASQUILL"S STABILITY CLASS

Wind Speed (m/s)	Day: Solar Radiation			Night: cloud Cover		
	Strong	Moderate	Slight	Thinly < 40%	Moderate	Overcast > 80%
<2	A	A-B	B	-	-	D
2-3	A-B	B	C	E	F	D
3-5	B	B-C	C	D	E	D
5-6	C	C-D	D	D	D	D
>6	C	D	D	D	D	D

A – Very Unstable

B – Unstable

C – Slightly Unstable

D – Neutral

E – Stable

F – Very Stable

When the atmosphere is unstable and wind speeds are moderate or high or gusty, rapid dispersion of pollutants will occur. Under these conditions, pollutant concentrations in air will be moderate or low and the material will be dispersed rapidly. When the atmosphere is stable and wind speed is low, dispersion of material will be limited and pollutant concentration in air will be high. In general, worst dispersion conditions (i.e. contributing to greater hazard distances) occur during low wind speed and very stable weather conditions, such as that at 1F weather condition (i.e. 1 m/s wind speed and Pasquill stability F).

Stability category for the present study is identified based on the cloud amount and wind speed.

Based on the weather analysis, predominant weather stability of “F” and “D” was selected with wind speed 1.5m/s, 2m/s and 5m/s for consequence analysis, respectively. 2F is the most prevalent weather condition for this location.

TABLE 2: WEATHER CONDITIONS

Wind Speed in m/s	Pasquill Stability
1.5	F
2	F
5	D

5 QUANTITATIVE RISK ASSESSMENT METHODOLOGY

5.1 General Overview

Quantitative Risk Assessment (QRA) is used for risk management and safety improvement in many industries. It provides a quantitative assessment of potential risks identified and provides a basis for evaluating process safety with respect to a predetermined risk acceptance criterion. The usefulness of the QRA results is highly dependent on the availability and accuracy of the input data, with more complete input data providing a higher confidence on the validity and robustness of the results obtained.

In most practical applications, there will be uncertainties in both the key parameters used and the QRA model itself. The effect of these uncertainties should be evaluated to confirm there is no impact on the conclusion. The QRA model will include:

- Examination of flammable/toxic material related to Major Accident Hazards;
- Quantification of the likelihood of flammable/toxic Major Accident Hazardous events;
- Quantification of the consequences of flammable/toxic Major Accident Hazardous events;
- Combination of consequences and likelihood of Major Accident Hazard events to assess risk profiles for individuals, and assets;
- Identification of the predicted levels of risk with regard to Individual Risk (IR) levels and Societal Risk (SR);
- Identification and assessment of risk reduction solutions (to the extent required to reduce predicted risks to acceptable levels); and
- Demonstration that the risks have been reduced to As Low As Reasonably Practicable (ALARP), when risks cannot be reduces to acceptable levels).

The following schematic (**Figure 6**) displays the methodology used to perform the Quantitative Risk Assessment Study for the Adani Mundra Port – New LPG Facilities.

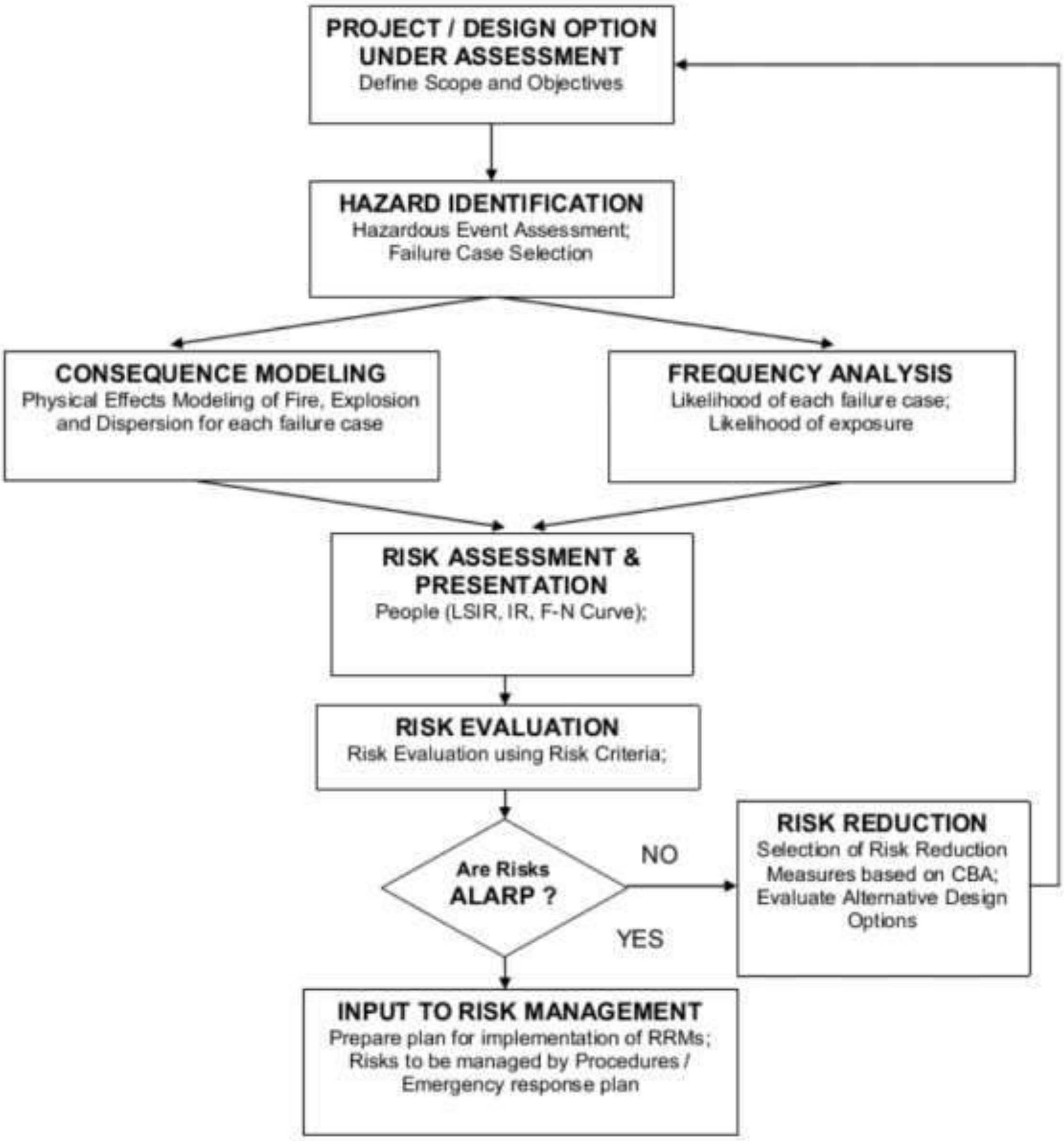


FIGURE 6: QUANTITATIVE RISK ASSESSMENT METHODOLOGY

5.2 Scenario Description and Operating Conditions

To carry out the QRA study the following basic data were used:

- Process parameters such as operating pressure, temperature & flow rate of equipment and process pipelines as well as the composition of the process streams etc;
- Manning details at strategic locations at site and meteorological details of Adani Mundra port area;

- Failure frequencies of leak sources, Ignition probabilities, operating probabilities etc.; and
- Isolation and detection time, Impact criteria for consequences such as fire, explosion and toxic concentration.

5.3 QRA Approach

The QRA was carried out using the standard, internationally accepted approach consisting of the steps shown below:

Data used for the QRA were project and site specific; however, where this was not possible, the use of generic data was documented in the assumptions register prior to being applied within the study. As such, the QRA results was also specific to the planned operations, building design and personnel and general population occupancy levels expected at the time of data collection. Given the above, the consequence and risk results are only applicable to the site under study in this QRA and cannot be applied to any other location.

The following information was considered in the QRA:

- Facility design, function, location, capacity and layout;
- Environmental weather data e.g. wind rose, cloud coverage, stability class;
- Process engineering details e.g. composition, heat and mass balance, equipment items, process parameters - pressure and temperature regimes, inventories, flow schemes;
- Facility operation e.g. operational and emergency procedures; and
- Work force deployment, estimated occupancy and exposure.

5.4 Hazard Identification

A technique commonly used to generate an incident list is to consider potential leaks and major releases from fractures of all process pipelines and vessels. This compilation includes all pipe work and vessels in direct communication, as these may share a significant inventory that cannot be isolated in an emergency. The following data were collected to envisage scenarios:

- Composition of materials stored in vessels / flowing through pipeline;
- Inventory of materials stored in vessels;
- Flow rate of materials passing through pipelines;
- Vessels / Pipeline conditions (phase, temperature, pressure); and Connecting piping and piping dimensions.

Accidental release of flammable liquids / gases has the potential for severe consequences. Delayed ignition of flammable gases can result in blast overpressures covering large areas. This may lead to extensive loss of life and property. In contrast, fires have localized consequences. Fires can be extinguished or contained in most cases; there are few mitigating actions one can take once a flammable gas or a vapour cloud gets released.

5.4.1 Factors for Hazard Identification

In any installation, main hazards arise due to loss of containment during handling of flammable liquids / gases. To formulate a structured approach to the identification of hazards, a list of contributory factors is provided below:

Blast over Pressures

Blast Overpressures depend upon the reactivity class of material and the amount of gas between two explosive limits. For example, Motor spirit/Gasoline once released and not ignited immediately is expected to give rise to a gas cloud. These gases in general have medium reactivity and in case of confinement of the gas cloud, on delayed ignition may result in an explosion and overpressures.

Operating Parameters

Potential gas release for the same material depends significantly on the operating conditions. The gases are likely to operate at atmospheric temperature (and hence high pressures). This operating range is enough to release a large amount of gas in case of a leak / rupture, therefore the pipeline leaks and ruptures need to be considered in the risk analysis calculations.

Inventory

Inventory Analysis is commonly used in understanding the relative hazards and short listing of release scenarios. Inventory plays an important role when considering a potential hazard. The larger the inventory of a vessel or a system, the larger the quantity of potential release. A practice commonly used to generate an incident list is to consider potential leaks and major releases from fractures of pipelines and vessels/tanks containing sizable inventories.

Range of Incidents

Both the complexity of study and the number of incident outcome cases are affected by the range of initiating events and incidents covered. This not only reflects the inclusion of accidents and / or non-accident-initiated events, but also the size of those events. For instance, studies may evaluate one or more of the following:

- Catastrophic failure of container;
- Large hole (large continuous release);
- Smaller holes (continuous release); and
- Leaks at fittings or valves (small continuous release).

  In general, quantitative studies do not include very small continuous releases or short duration small releases if past experience or preliminary consequence modelling shows that such releases do not contribute to the overall risk levels.

5.5 Isolatable Sections

The following table describes the isolatable section considered for the study:

TABLE 3: ISOLATABLE SECTIONS

Isolatable section identification	Description	Scenario	Diameter m	Pressure barg.	Temperature C	Isolation time s	Total Inventory, kg
Berth 1							
IS-1	Transfer of Propane from Jetty to Storage Tank 2000-FB-01	7	0.406	8	-42.67	120	143322
IS-2		25	0.406	8	-42.67	120	144343
IS-3		150	0.406	8	-42.67	120	159902
IS-4	Transfer of Butane from Jetty to Storage Tank 2000-FB-02	7	0.406	8	-2.90	120	147605
IS-5		25	0.406	8	-2.90	120	148655
IS-6		150	0.406	8	-2.90	120	164183
IS-7	Transfer of Propylene from Jetty to Storage Tank 2000-FB-02	7	0.406	8	-44.86	120	150204
IS-8		25	0.406	8	-44.86	120	151247
IS-9		150	0.406	8	-44.86	120	166782
IS-10	Propylene precooling line	7	0.305	8	-45	120	90158
IS-11		25	0.305	8	-45	120	91201

Isolatable section identification	Description	Scenario	Diameter m	Pressure barg.	Temperature C	Isolation time s	Total Inventory, kg
IS-12		150	0.305	8	-45	120	94736
Berth 2							
IS-13	Methanol P/L	10	0.305	10	35	120	11809
IS-14		150	0.305	10	35	120	24885
IS-15	MS P/L	10	0.406	10	35	120	18894
IS-16		150	0.406	10	35	120	35336
IS-17	HSD P/L	10	0.610	10	35	120	48967
IS-18		150	0.610	10	35	120	82050
IS-19	SKO P/L	10	0.305	10	35	120	12058
IS-20		150	0.305	10	35	120	21814
IS-21	Furnace Oil	10	0.305	10	55	120	13848
IS-22		150	0.305	10	55	120	21916
IS-23	Crude	10	0.9144	10	35	120	121023
IS-24		150	0.9144	10	35	120	177890

6 CONSEQUENCE ANALYSIS

6.1 Overview

Consequence is the measure of the expected outcomes for a given accidental release. For this project, consequence is defined as the hazard distance or hazard zone to various fatality endpoints. During the execution of site-specific consequence analysis, it is essential to accurately model the release, dilution, and dispersion of gases and aerosols if a precise assessment of potential exposure is to be attained. Consequence modelling, also known as physical effects modelling, is a technique in which computer based mathematical modelling is used to predict physical behaviour under accident conditions in order to make a quantitative estimation of risk. Internationally accepted and validated software PHAST v6.7 and PHAST RISK v.6.7, (both developed by DNV GL) have been used for this project.

PHAST v6.7 contains a set of complex models that calculate release conditions, initial dilution of the vapour (dependent upon the release characteristics), and the subsequent dispersion of the vapour introduced into the atmosphere. It permits the user to evaluate the downwind dispersion of the chemical cloud based on the toxicological/physical characteristics of the released chemical, atmospheric conditions, and specific circumstances of the release.

PHAST v6.7 will be used to estimate threat zones associated with several types of hazardous chemical releases, including toxic gas clouds, fires, and explosions.

It is most important that the QRA model effectively reflect reality, thus those familiar with the facilities and their operation are required for proper evaluation. This is particularly true in relation to the preparation of input data and assumptions and the review of results from the evaluation. The QRA model must identify the major hazard contributors to the work force and third parties, quantify risks, and identify and assess any risk reduction methods that may be proposed. In addition to modelling the current situation within the field, the model shall be extendible to add additional facilities as development occurs and provide an active method of planning any proposed development.

6.2 Consequence Modelling

Discharge Rate

The initial rate of release through a leak depends mainly on the pressure inside the equipment, size of the hole and phases of the release (liquid, gas or two phase). The release rate decreases with time as the equipment depressurizes. The reduction mainly on the inventory and the actions taken to isolate the leak and blow-down the equipment

Dispersion

A vapour cloud may be formed when a vaporizing liquid is released for an extended duration. If the gas cloud does not immediately ignite, it disperses based on the prevalent wind direction, speed and stability category (i.e. degree of turbulence).

The cloud dispersion simulation is carried out to provide the distance (from the leak) at which the concentration of flammable material falls below the Lower Flammability Limit (LFL).

Consequence Events

The following describes the probabilities associated with the sequence of events which must take place for the incident scenarios to produce hazardous effects. Considering the present case, the outcomes expected are:

- Flash Fire (FF);
- Jet fires;
- Pool fire;
- Vapour Cloud Explosion.

Flash Fire

The vapour/gas release from a pool would disperse under the influence of the prevailing wind; with material concentration in air reducing with distance. At a particular location downwind, the concentration will drop below its lower flammable level (LFL) value. If ignited within the flammable envelope, the mass of the material available between the LFL and ½ LFL will be likely to burn as a flash fire; rapidly spreading through the cloud from the point of ignition back to the source of release.

Although flash fires are generally low intensity transitory events, the burning velocity is quite high and escape following ignition is not possible. Flash fires often remain close to the ground, where most ignition sources are present. It is assumed that personnel caught inside a flash fire will not survive while those outside suffer no significant harm. If other combustible material is present within the flash fire it is also likely to ignite and a secondary fire could result.

Jet Fire

Jet fire causes damage due to the resulting heat radiation. The working level heat radiation impact will vary widely depending on the angle of the flame to the horizontal plane, which in turn mainly depends on the location of the leak. The flame direction was considered horizontal for consequence analysis of leaks and ruptures from process equipment. Jet fire heat radiation impacts were estimated for the identified credible and worst case scenarios.

Upon accidental leakage, the pressurized fluid will disperse as a jet, initially moving forward in the spatial direction of the leak until the kinetic energy is lost and gravity slumping or lifting of the cloud occurs, dependent upon whether the fluid is heavier or lighter than air.

The primary hazard associated with jet fires is thermal radiation and potential for flame impingement on adjacent pipelines/equipment, resulting in escalation. High pressure releases have the potential to cover large areas due to its relatively large flame length. However, the effects of escalation are minimized if the flame length reduces to less than the separation distance between other equipment and the jet fire source.

Pool Fire

A liquid pool is formed during a prolonged leakage if the rate of leakage exceeds the rate of vaporization. On ignition, this would result in a pool fire whose size/radius would depend on the mass flow rate, ambient temperature, heat of vaporization of material released, vapour pressure, duration of discharge and effects of containment or dykes. The pool fire could cause damage to equipment or injury/fatality to personnel due to thermal radiation effects.

A pool fire is not envisaged for liquid systems that are highly pressurized. Any leak or rupture would result in a pressurized release leading to a liquid jet fire or flash fire.

Vapour Cloud Explosion

Vapour cloud explosion is the result of flammable materials in the atmosphere, a subsequent dispersion phase, and after some delay an ignition of the vapour cloud. Turbulence is the governing factor in blast generation which could intensify combustion to the level that will result in an explosion. Turbulence is often created by obstacles in the path of vapour cloud or when the cloud finds a confined area, as under the bullets. Insignificant level of confinement will result in a flash fire. The VCE will result in overpressures.

6.3 Damage Criteria

Damage criteria gives the relation between the extent of the physical effects (exposure) and the effect of consequences. For assessing the effects on humans, consequences are expressed in terms of injuries and the effects on equipment / property in terms of monetary loss. The consequences for release of toxic substances or fire can be categorized as:

- Damage caused by heat radiation on material and people;
- Damage caused by explosion on structure and people; and

In Consequence Analysis studies, three main types of exposure to hazardous effects are categorized as:

- Heat radiation due to fires.
- Jet fires and flash fires;
- Explosions;

The knowledge about these relations depends strongly on the nature of the exposure. The following discusses the criteria selected for damage estimation:

Heat Radiation:

The effect of fire on a human being is in the form of burns. There are three categories of burns: first degree, second degree and third degree burns being the most severe. The consequences caused by exposure to heat radiation are a function of:

- The radiation energy onto the human body [kW/m^2];
- The exposure duration [sec]; and
- The protection of the skin tissue (clothed or bare body).

The physical effects of hazard events are given in the table below:

Table 4: Effects due to Incident Radiation Intensity

Incident Radiation (kW/m^2)	Type of Damage
4.7	Sufficient to cause pain within 20 sec. Blistering of skin(first degree burns are likely)
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing"s etc.
37.5	Sufficient to cause damage to the equipment

The actual results would be less severe due to the various assumptions made in the models arising out of the flame geometry, emissivity, angle of incidence, view factor and others. The radiation output of the flame would be dependent upon the fire size, extent of mixing with air and the flame temperature. Some fraction of the radiation is absorbed by carbon dioxide and water vapour in the intervening atmosphere. Finally, the incident flux at an observer location would depend upon the radiation view factor, which is a function of the distance from the flame surface, the observer"s orientation and the flame geometry.

Blast Overpressure from Vapour cloud Explosion (VCE)

The assessment aims are to determine the impact of overpressure in the event that a flammable gas cloud is ignited. A Vapour cloud Explosion (VCE) results when a flammable vapour is released and mixes with the air to form a flammable vapour cloud. If ignited, the flame speed may accelerate to high velocities and produce significant blast overexposure.

The assessment goals are to determine the impact of overpressure in the event that a flammable gas cloud is ignited. The damage effects due to 0.01 bar, 0.1 bar & 0.3 bar are reported in terms of distance from the overpressure source.

In case of vapour cloud explosion, two physical effects may occur:

- A flash fire over the whole length of the explosive gas cloud;
- A blast wave, with typical peak overpressures circular around ignition source.

  For the blast wave, the lethality criterion is based on:

- A peak overpressure of 0.1bar will cause serious damage to 10% of the housing/structures;
- Falling fragments will kill one of each eight persons in the destroyed buildings.

The following damage criteria may be distinguished with respect to the peak overpressures resulting from a blast wave:

TABLE 5: DAMAGES DUE TO BLAST OVERPRESSURE

Peak Overpressure	Damage Type	Description
0.30 bar	Heavy Damage	Major damage to plant equipment structure
0.10 bar	Moderate Damage	Repairable damage to plant equipment & structure
0.01 bar	Significant Damage	Shattering of glass

The summary of the consequence modelling is shown below in

TABLE 6: IMPACT DISTANCE IN METER

Isolatable Section	Description	Release category	Flash Fire Effects: 100% LFL Ellipse			Radiation Effects: Jet Fire Ellipse				Radiation Effects: Pool Fire				Overpressure			
			Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Overpressure level bar	Distance in meters		
			5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F
IS - 1	Transfer of Propane from Jetty to Storage Tank 2000-FB-01	7	6.41862	12.2659	10.1915	4	23.1853	26.7283	25.9291	4	NR	NR	NR	0.01	NR	74.9525	70.1064
			6.41862	12.2659	10.1915	12.5	17.5949	21.3412	20.4624	12.5	NR	NR	NR	0.1	NR	29.5322	28.6915
			6.41862	12.2659	10.1915	37.5	13.9777	17.7971	16.878	37.5	NR	NR	NR	0.3	NR	24.7597	24.34
IS - 2		25	35.6415	59.6057	54.5213	4	73.8934	84.2143	81.9038	4	NR	NR	NR	0.01	228.541	518.96	438.727
			35.6415	59.6057	54.5213	12.5	56.2605	67.2694	64.6926	12.5	NR	NR	NR	0.1	80.97	147.877	125.695
			35.6415	59.6057	54.5213	37.5	45.5539	56.6361	53.9634	37.5	NR	NR	NR	0.3	65.4644	108.887	92.8036
IS - 3		150	179.492	272.883	239.639	4	364.347	410.315	400.219	4	329.126	371.147	370.567	0.01	1302.15	2534.23	2207.2
			179.492	272.883	239.639	12.5	274.039	323.382	311.984	12.5	226.117	234.372	238.39	0.1	432.507	745.411	655.622
			179.492	272.883	239.639	37.5	219.755	270.113	258.104	37.5	146.3	134.926	139.299	0.3	341.132	557.456	492.594
IS - 4	Transfer of Butane from Jetty to Storage Tank 2000-FB-02	7	6.46825	12.8952	10.4079	4	23.6816	27.0127	26.2689	4	NR	NR	NR	0.01	NR	77.6978	71.7312
			6.46825	12.8952	10.4079	12.5	17.7488	21.3121	20.4816	12.5	NR	NR	NR	0.1	NR	30.0084	28.9734
			6.46825	12.8952	10.4079	37.5	13.9617	17.6272	16.7539	37.5	NR	NR	NR	0.3	NR	24.9975	24.4807
IS - 5		25	35.9099	61.1679	55.2733	4	75.6169	85.3103	83.1708	4	NR	NR	NR	0.01	232.205	530.996	445.155
			35.9099	61.1679	55.2733	12.5	56.808	67.2758	64.8483	12.5	NR	NR	NR	0.1	81.6056	149.965	126.81
			35.9099	61.1679	55.2733	37.5	45.5372	56.1973	53.6472	37.5	NR	NR	NR	0.3	65.7818	109.929	93.3604
IS - 6		150	178.137	283.149	243.278	4	374.027	417.208	407.894	4	376.004	423.016	421.929	0.01	1344.39	2577.29	2292.63
			178.137	283.149	243.278	12.5	277.694	324.579	313.853	12.5	256.289	266.515	270.538	0.1	439.835	735.63	662.175
			178.137	283.149	243.278	37.5	220.237	268.515	257.08	37.5	167.521	153.603	158.552	0.3	344.791	547.565	490.86
IS - 7	Transfer of Propylene	7	6.47378	12.7954	10.4078	4	23.322	26.962	26.1355	4	NR	NR	NR	0.01	NR	77.4421	71.5503

Isolatable Section	Description	Release category	Flash Fire Effects: 100% LFL Ellipse			Radiation Effects: Jet Fire Ellipse				Radiation Effects: Pool Fire				Overpressure			
			Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Overpressure level bar	Distance in meters		
			5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F
	from Jetty to Storage Tank 2000-FB-02		6.47378	12.7954	10.4078	12.5	17.7566	21.5923	20.6914	12.5	NR	NR	NR	0.1	NR	29.964	28.942
			6.47378	12.7954	10.4078	37.5	14.1527	18.0722	17.1118	37.5	NR	NR	NR	0.3	NR	24.9754	24.4651
IS -8		25	36.0195	61.4873	55.5823	4	74.246	84.8547	82.4757	4	NR	33.8476	29.8157	0.01	231.313	517.363	445.217
			36.0195	61.4873	55.5823	12.5	56.714	67.9793	65.3411	12.5	NR	27.0093	24.8155	0.1	81.4509	147.6	135.086
			36.0195	61.4873	55.5823	37.5	46.0263	57.3125	54.5893	37.5	NR	20.7604	19.6272	0.3	65.7046	108.749	102.5
IS - 9		150	177.169	273.005	242.261	4	365.626	412.901	402.501	4	404.296	446.482	443.088	0.01	1332.93	2598.88	2281.88
			177.169	273.005	242.261	12.5	275.88	326.399	314.715	12.5	271.459	287.83	288.582	0.1	446.112	772.777	685.107
			177.169	273.005	242.261	37.5	221.805	273.177	260.912	37.5	190.319	183.969	187.903	0.3	352.932	581.134	517.331
IS - 10	Propylene precooling line	7	7.41065	17.6767	15.5991	4	23.5639	27.2164	26.3892	4	11.926	15.4551	14.9825	0.01	50.9971	125.56	108.471
			7.41065	17.6767	15.5991	12.5	18.1806	22.0249	21.1171	12.5	10.3905	12.0427	11.9505	0.1	17.1114	38.3107	35.3463
			7.41065	17.6767	15.5991	37.5	14.8198	18.6104	17.6889	37.5	8.59991	9.03457	8.83125	0.3	13.551	29.1432	27.663
IS - 11		25	37.2279	50.7936	46.5364	4	74.3176	84.9283	82.548	4	56.441	70.0417	68.7812	0.01	261.617	529.885	449.768
			37.2279	50.7936	46.5364	12.5	56.8288	68.0994	65.4597	12.5	41.0686	47.3376	47.2271	0.1	86.7074	141.507	119.345
			37.2279	50.7936	46.5364	37.5	46.2006	57.4791	54.7526	37.5	29.0907	30.0176	30.6312	0.3	68.3293	100.699	84.6261
IS - 12		150	156.477	238.735	210.132	4	365.639	394.67	385.972	4	412.21	428.202	427.84	0.01	1250.69	2285.99	2098.45
			156.477	238.735	210.132	12.5	275.903	312.104	301.894	12.5	273.449	272.883	275.502	0.1	415.316	627.962	609.652
			156.477	238.735	210.132	37.5	221.838	261.274	250.357	37.5	188.759	171.12	176.19	0.3	327.542	455.408	464.633
IS - 13	Methanol P/L	10	6.83624	11.399	11.0517	4	35.979	44.0716	42.1378	4	NR	44.3716	43.1432	0.01	37.965	65.8894	64.6327
			6.83624	11.399	11.0517	12.5	29.5076	37.1441	35.2776	12.5	NR	30.9147	30.7607	0.1	14.8509	27.96	27.7421
			6.83624	11.399	11.0517	37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	12.4222	23.9747	23.8659
IS - 14		150	50.0444	70.6208	69.2059	4	209.858	235.718	226.635	4	142.032	136.037	136.988	0.01	226.029	294.232	298.903

Isolatable Section	Description	Release category	Flash Fire Effects: 100% LFL Ellipse			Radiation Effects: Jet Fire Ellipse				Radiation Effects: Pool Fire				Overpressure			
			Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Overpressure level bar	Distance in meters		
			5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F
			50.0444	70.6208	69.2059	12.5	171.207	199.537	190.182	12.5	108.836	97.0531	99.1266	0.1	97.0651	125.426	133.727
			50.0444	70.6208	69.2059	37.5	139.528	NR	NR	37.5	75.5624	72.4929	72.3265	0.3	83.5145	109.603	116.841
IS - 15	MS P/L	10	15.2315	26.4028	23.5931	4	33.671	37.5937	36.724	4	NR	NR	NR	0.01	98.5467	225.457	172.851
			15.2315	26.4028	23.5931	12.5	24.9996	29.3562	28.3433	12.5	NR	NR	NR	0.1	33.6248	63.9044	46.5137
			15.2315	26.4028	23.5931	37.5	19.8615	24.3735	23.2947	37.5	NR	NR	NR	0.3	26.8034	46.9296	33.2392
IS - 16		150	113.8	169.587	148.074	4	303.961	326.379	321.139	4	168.27	136.482	142.569	0.01	818.819	1189.97	1184.48
			113.8	169.587	148.074	12.5	224.278	249.763	243.019	12.5	82.0953	79.7338	79.518	0.1	266.014	317.542	308.385
			113.8	169.587	148.074	37.5	177.003	204.073	196.518	37.5	NR	NR	NR	0.3	207.93	248.759	241.121
IS - 17	HSD P/L	10	12.8557	11.3689	11.2462	4	11.9794	9.23875	9.2571	4	85.1624	70.0438	73.0102	0.01	32.693	30.4035	31.4317
			12.8557	11.3689	11.2462	12.5	8.73359	7.02619	6.95779	12.5	41.0876	37.835	37.668	0.1	13.9364	13.5392	13.7176
			12.8557	11.3689	11.2462	37.5	6.71139	5.43322	5.3477	37.5	NR	NR	NR	0.3	11.9656	11.7673	11.8563
IS - 18		150	33.0364	29.5573	29.4445	4	29.4646	28.7595	28.2825	4	218.455	185.219	191.383	0.01	51.2393	29.4186	29.6151
			33.0364	29.5573	29.4445	12.5	21.557	22.1526	21.5302	12.5	118.02	113.912	113.79	0.1	33.6842	21.6338	21.6678
			33.0364	29.5573	29.4445	37.5	16.9013	18.1956	17.4941	37.5	NR	NR	NR	0.3	31.8397	20.8158	20.8328
IS - 19	SKO P/L	10	12.9275	11.4289	11.2942	4	33.6751	26.8337	26.8878	4	77.6411	66.7752	69.687	0.01	57.5866	53.7609	55.9137
			12.9275	11.4289	11.2942	12.5	24.7386	20.7828	20.5746	12.5	36.4009	35.1158	34.8127	0.1	18.2545	17.5908	17.9643
			12.9275	11.4289	11.2942	37.5	19.4742	17.1296	16.783	37.5	NR	NR	NR	0.3	14.1217	13.7904	13.9768
IS - 20		150	32.7517	29.2454	29.1351	4	90.2507	88.3046	86.9503	4	147.559	121.643	126.421	0.01	78.1448	72.8802	73.4377
			32.7517	29.2454	29.1351	12.5	65.7575	67.6656	65.8591	12.5	78.5757	73.4972	73.3811	0.1	38.3513	37.4381	37.5348
			32.7517	29.2454	29.1351	37.5	51.4125	55.4211	53.3769	37.5	NR	NR	NR	0.3	34.1701	33.7141	33.7624
IS - 21	FURNACE OIL	10	13.4331	11.3746	13.4331	4	NR	NR	NR	4	79.8512	67.7607	70.0269	0.01	NR	NR	NR

Isolatable Section	Description	Release category	Flash Fire Effects: 100% LFL Ellipse			Radiation Effects: Jet Fire Ellipse				Radiation Effects: Pool Fire				Overpressure			
			Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Overpressure level bar	Distance in meters		
			5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F
			13.4331	11.3746	13.4331	12.5	NR	NR	NR	12.5	42.2865	38.5883	38.4596	0.1	NR	NR	NR
			13.4331	11.3746	13.4331	37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	NR	NR	NR
IS - 22		150	NR	NR	NR	4	NR	NR	NR	4	109.734	94.4439	97.0658	0.01	NR	NR	NR
			NR	NR	NR	12.5	NR	NR	NR	12.5	66.4692	61.6346	61.5704	0.1	NR	NR	NR
			NR	NR	NR	37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	NR	NR	NR
IS - 23	CRUDE	10	16.6034	28.6941	25.8864	4	29.749	34.6209	34.0991	4	NR	NR	NR	0.01	104.653	237.787	206.342
			16.6034	28.6941	25.8864	12.5	21.3767	25.8094	25.124	12.5	NR	NR	NR	0.1	34.6841	66.043	60.5885
			16.6034	28.6941	25.8864	37.5	16.4918	20.6567	19.8868	37.5	NR	NR	NR	0.3	27.3323	47.9976	45.2739
IS - 24		150	202.34	332.297	283.898	4	268.919	325.533	314.373	4	163.372	164.136	170.158	0.01	1583.86	2994.33	2733.84
			202.34	332.297	283.898	12.5	198.353	247.302	236.963	12.5	81.2582	96.7701	95.8433	0.1	489.64	791.031	754.644
			202.34	332.297	283.898	37.5	156.56	200.903	191.054	37.5	NR	NR	NR	0.3	374.667	590.249	547.046

*NH- No Hazard, NR- Not Reached

7 FREQUENCY ANALYSIS

7.1 Overview

Frequency of occurrence of the representative hazardous events needs to be evaluated by referencing appropriate generic industry data. Both generic industry and company / vendor based information has been used, and particular care has been taken to ensure its validity. Generic failure data was applied where site specific or company / vendor data is not available.

Initiating event failure frequencies for each case developed have been estimated using various sources (listed in order of preference) including:

- TNO Guidelines for Quantitative Risk Assessment (Purple Book);
- OGP Risk Assessment Data Directory, Process Release Frequencies, 2010; and
- Health & Safety Executive (HSE) failure rates & event data for land use planning.

Given the potential for release from each of these scenarios, an event tree of possible outcomes has been developed using this individual component failure data. The table given below shows the frequency of failure of the selected isolatable sections calculated by parts count.

7.2 Event tree analysis

A release can result in several possible outcomes or scenarios (fire, explosions, un-ignited release etc.). A specific outcome for a release scenario may be dependent on other unrelated events following the initial release. Event tree analysis is used to identify potential outcomes of a release and to quantify the risk associated with each of these outcomes. The event tree for this QRA study is shown in **Figure 7**:

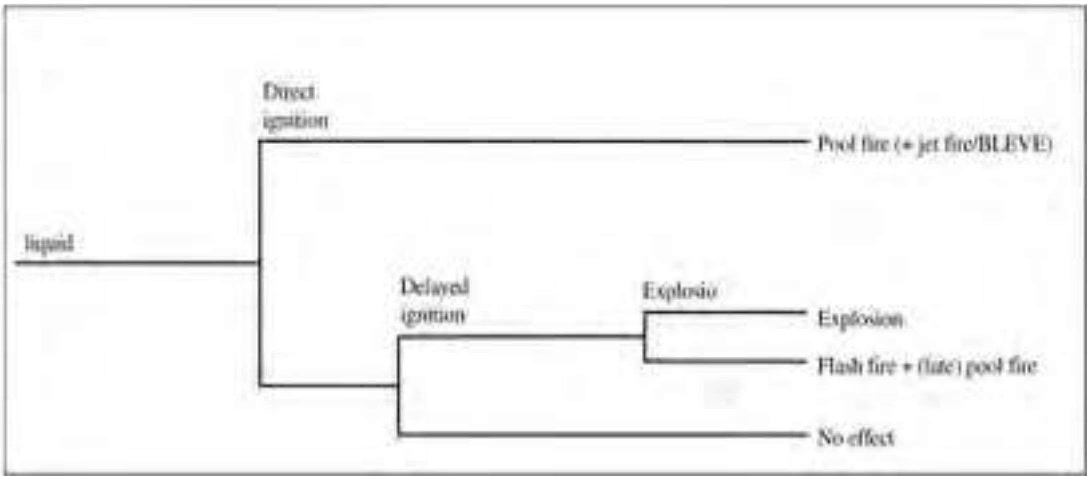


Figure 7: Event Tree

For calculating the frequency used for modeling, the following modification factors were taken into consideration:

- Design/Quality Maintenance
- Time is use

Table 7: Failure Frequency of an Event

Isolatable Sections	Description	Scenario	Total Frequency
IS-1	Transfer of Propane from Jetty to Storage Tank 2000-FB-01	7	1.94E-04
IS-2		25	1.06E-06
IS-3		150	1.25E-07
IS-4	Transfer of Butane from Jetty to Storage Tank 2000-FB-02	7	1.49E-04
IS-5		25	8.78E-07
IS-6		150	6.83E-08
IS-7	Transfer of Propylene from Jetty to Storage	7	1.49E-04

Isolatable Sections	Description	Scenario	Total Frequency
IS-8	Tank 2000-FB-02	25	8.78E-07
IS-9		150	6.83E-08
IS-10	Propylene precooling line	7	1.69E-04
IS-11		25	5.00E-06
IS-12		150	5.00E-06
IS-13	Methanol P/L	10	2.28E-06
IS-14		150	1.44E-08
IS-15	MS P/L	10	2.50E-06
IS-16		150	1.58E-08
IS-17	HSD P/L	10	7.03E-06
IS-18		150	4.56E-08
IS-19	SKO P/L	10	4.94E-06
IS-20		150	3.12E-08
IS-21	Furnace Oil	10	1.20E-05
IS-22		150	7.56E-08
IS-23	Crude	10	4.05E-07
IS-24		150	1.26E-08

8 RISK ASSESSMENT & PRESENTATION

8.1 Overview

Risk is often defined as a function of the likelihood that a specified undesired event will occur, and the severity of the consequences of that event. Risk is derived from the product of likelihood and potential consequence. Risk in general is a measure of potential economic loss or human injury in terms of the probability of the loss or injury occurring and magnitude of the loss or injury if it occurs.

$$Risk = f\,(\text{Severity}, \text{Frequency})$$

Quantification of effects of the hazardous event were done using the Event Tree approach in which all the possible outcomes of the hazardous event were considered and the likelihood of each type of end event determined. This step in the process involves the use of consequence modelling to predict both physical phenomena such as dispersion of gas, size and duration of fires, overpressures due to explosions, and the performance of equipment and systems such as availability of a fire & gas detection system, availability of emergency shutdown system, and availability of fire protection system. The end result of this phase of the assessment is a series of “end events”, together with their estimated frequency of occurrence.

8.2 Risk Results

The risk modelling has been performed using DNV PHAST RISK 6.7 software. Thereby, the details of the input data used for the risk modelling such as vulnerability criteria, ignition probability and occupancy data. The results of a QRA are expressed using Individual Risk Contours and Societal Risk Graphs.

The Individual Risk represents the frequency of an individual dying due to loss of containment events (LOCs). The individual is assumed to be unprotected and to be present during the total exposure time. The Individual Risk is presented as contour lines on a topographic map.

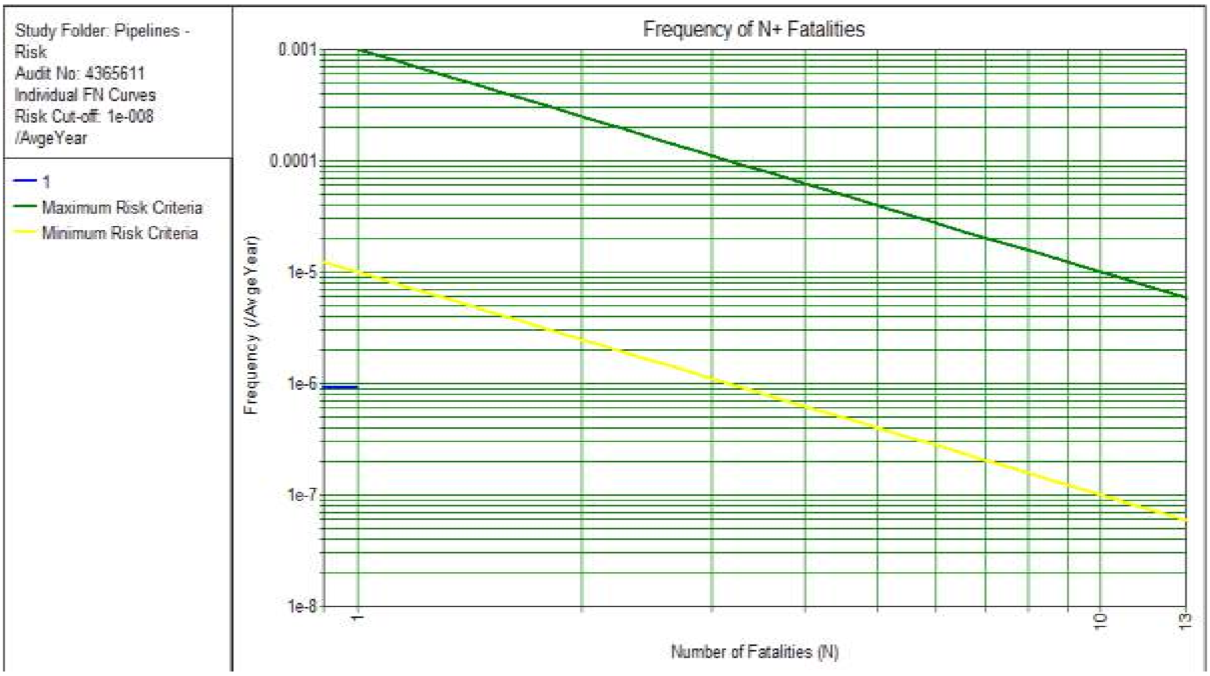
The Societal Risk represents the frequency of having an accident with N or more people being killed simultaneously. The people involved are assumed to have some means of protection. The Societal Risk is presented as an F-N curve, where N is the number of deaths and F the cumulative frequency of accidents with N or more deaths.

The Individual Risk estimated due to the activities being conducted at the Adani Mundra port is represented by a risk contour in the Figure 8 below. The risk reaching beyond the Pipeline transfer facility is less than 1E-06/Avg. year.

Figure 8: Risk Contour

The Societal Risk pertaining to group of individuals is represented in **Figure 9**.

Figure 9: FN Curve



9 RECOMMENDATIONS

The Following measures shall be implemented for safe operation

- Periodical inspection of pipelines
- Leak detection systems based on pressure, temperature and flow
- CCTV monitoring of the pipeline corridor/jetty, in control room
- Surge Analysis shall be performed to ensure adequate time lag between closure of ROVs at jetty end and at the tank end. The time lag shall be engineered so that surge pressure does not increase beyond the design limit. While engineering the closure time of each ROV, a consideration shall be given so that the pressure due to surge does not exceed the design pressure.
- A suitable continuous back-up power supply shall be provided for the control system and operation of ROVs both at jetty end and tank end.
- Electrical equipment including for lighting system shall conform to hazardous area classification and be selected in accordance with IS:5571. These shall be tested by agencies such as CMRI, ERTL, CPRI or independent test laboratory of country of origin for such equipment. Indigenous Flameproof equipment shall comply with relevant BIS standard as per requirements of statutory authorities
- Pressure testing/ Low pressure leak check (with N2) of the piping / flanged joints completed for entire pipeline and associated station piping before commissioning of the pipelines after any maintenance activity In case of displacement of Nitrogen with LPG, it should be done to flare

APPENDIX 1 CONSEQUENCE CONTOURS

PROPANE PIPELINE FROM BERTH 1 - 25mm LEAK

FLASH FIRE

JET FIRE

EXPLOSION

BUTANE PIPELINE FROM BERTH 1- 25mm LEAK

FLASH FIRE

JET FIRE

EXPLOSION

PROPYLENE PIPELINE FROM BERTH 1-25 mm LEAK

FLASH FIRE

JET FIRE

POOL FIRE

EXPLOSION

PROPYLENE PRECOOLING PIPELINE FROM BERTH 1-25 mm LEAK

FLASH FIRE

JET FIRE

POOL FIRE

EXPLOSION

METHANOL PIPELINE FROM BERTH 2-25 mm LEAK

FLASH FIRE

JET FIRE

EXPLOSION

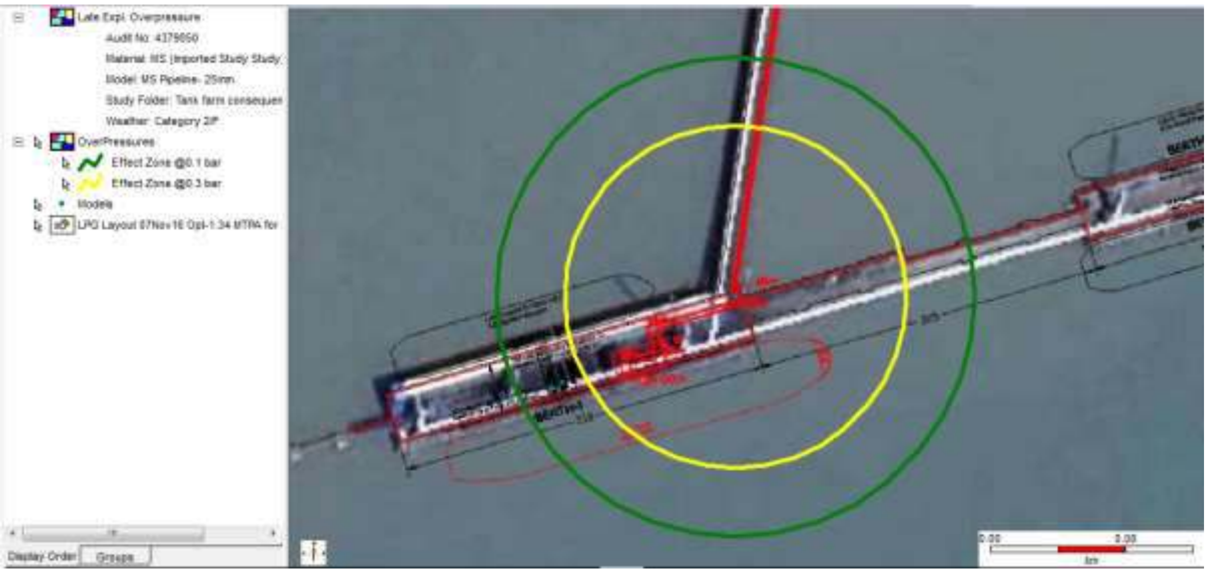
MS PIPELINE FROM BERTH 2-25 mm LEAK

FLASH FIRE

JET FIRE

POOL FIRE

EXPLOSION

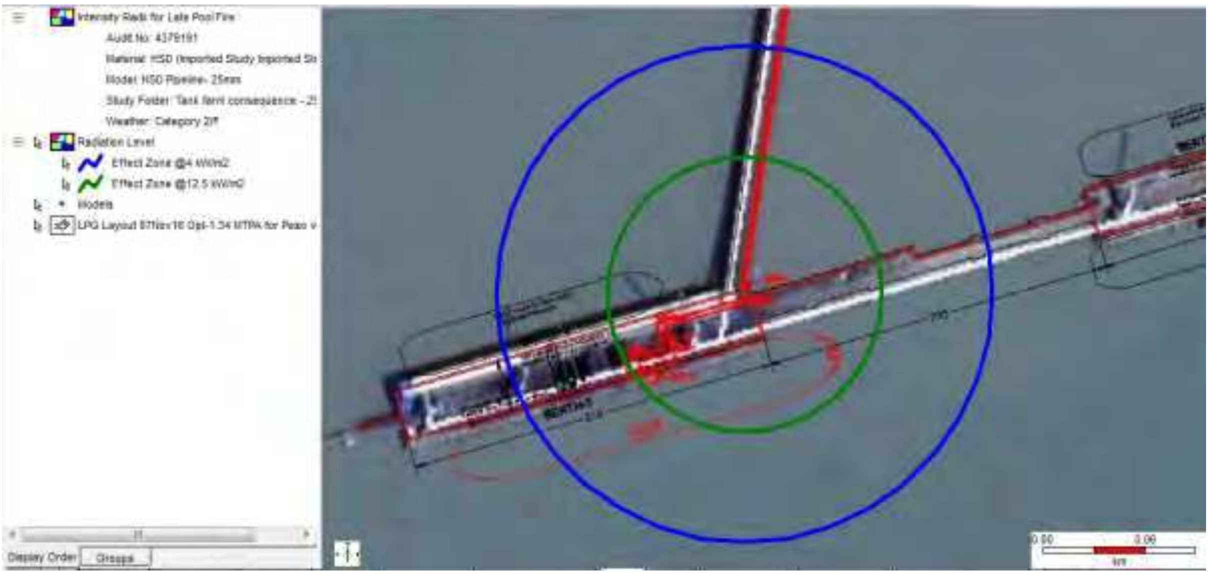


HSD PIPELINE FROM BERTH 2-25 mm LEAK

FLASH FIRE

JET FIRE

POOL FIRE



EXPLOSION

SKO PIPELINE FROM BERTH 2-25 mm LEAK

FLASH FIRE

JET FIRE

POOL FIRE

EXPLOSION

FURNACE OIL PIPELINE FROM BERTH 2-25 mm LEAK

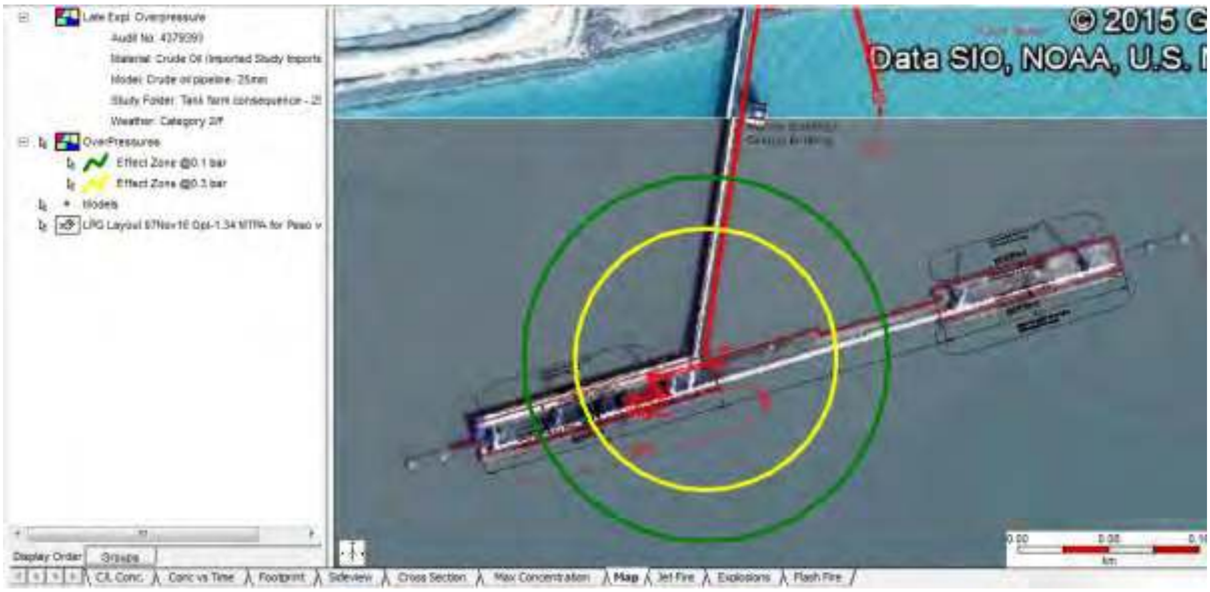
POOL FIRE

CRUDE PIPELINE FROM BERTH 2-25 mm LEAK

FLASH FIRE

JET FIRE

EXPLOSION



Late Expl Overpressure
Audit No: 4379393
Material: Crude Oil (Imported Study Imports
Model: Crude oil pipeline- 25mm
Study Folder: Tank farm consequence - 2
Weather: Category 2/F
OverPressures
Effect Zone @0.1 bar
Effect Zone @0.3 bar
Models
LPG Layout 07Nov16 Opt-1.34 MTPA for Peso v
© 2015 G
Data SIO, NOAA, U.S.
Display Order
Groups
C/L Conc
Conc vs Time
Footprint
Sideview
Cross Section
Max Concentration
Map
Jet Fire
Explosions
Flash Fire

QUANTITATIVE RISK ASSESSMENT REPORT FOR TANK FARM AREA

MUNDRA PORT – NEW LPG FACILITIES

EC

PMC

http://ifluids.com

Document Title	:	Quantitative Risk Assessment Report for Tank farm area
Project Title	:	Mundra Port - New LPG Facilities
Client Company Name	:	Adani
Engineering consultant	:	Technip India Limited
PMC	:	HOWE Engineering Projects (India) Pvt. Ltd.
Consultant	:	iFluids Engineering

DISCLAIMER

The report rendered by consultants is in the nature of guidelines based on good engineering practices and generally accepted safety procedures. The recommendations shown in the report shall be considered as a Technical professional opinion and not binding on the parties involved viz. Technip and iFluids Engineering. The technical recommendations and the conclusions thus expressed may have to be re-considered in light of any modifications or alterations that would invalidate the data shown in the documents which are referred to therein. These recommendations and conclusions would become null and void should the consultants not be kept informed of such modifications or alterations with specific reference to the present report.

A	28-Nov-16	Final Report	VP	JS	
Rev	**Date**	**Description**	**Prepared by**	**Reviewed by**	**Approved by**

LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
EA	Environmental Assessment
ERP	Emergency Response Plan
ESD	Emergency Shutdown
HAZID	Hazard Identification
HAZOP	Hazard & Operability Study
HC	Hydrocarbon
HSE	Health Safety & Environment
IRPA	Individual Risk Per Annum
LFL/LEL	Lower Flammability Limit / Lower Explosive Limit
LOC	Loss of Containment
P&ID	Piping and Instrument Diagram
PLL	Potential Loss of Life
QRA	Quantitative Risk Assessment
SOP	Standard Operating Procedure

EXECUTIVE SUMMARY

Adani group intends to expand its current port facility at Adani Mundra Port Pvt Ltd. ADANI is developing LPG, Propane, Butane handling and storage facility at their Port in Mundra. Propylene and propane will be stored and handled in the terminal in a scenario when LPG business subsides. The Adani group has appointed iFluids engineering to carry out Quantitative Risk Assessment and recommend cost effective measures to address the hazardous scenarios.

OVERALL FACILITY DESCRIPTION

ADANI is developing LPG, Propane, Butane handling and storage facility at their Port in Mundra. Propylene and propane will be stored and handled in the terminal in a scenario when LPG business subsides.

ADANI has envisaged the following services for set up in Import/Export terminal at Mundra,

- Import of Propane / Butane in cryogenic state in jetties through ship tankers and transferring through unloading arms and pipelines.
- Transfer of product through the unloading line and storing in dedicated refrigerated / cryogenic tanks.
- Transfer of products from tanks through pumps to heating train and then to online blending system for mix of Domestic, Auto & Industrial LPG
- Mercaptan dosing of the LPG, Propane and Butane
- Transfer to loading gantry for loading into road tankers for dispatch of following products through Tanker loading facility.
    - LPG (AUTOMOTIVE)/ (INDUSTRIAL)
    - LPG (DOMESTIC)
    - LPG PROPANE
    - BUTANE
    - PROPYLENE (In future when LPG demand subsides BUTANE import would stop and PROPYLENE shall be imported and stored in Storage tank).
- Simultaneous operation of Berth 1 with Berth 2, 3 & 4 respectively

STUDY RESULT

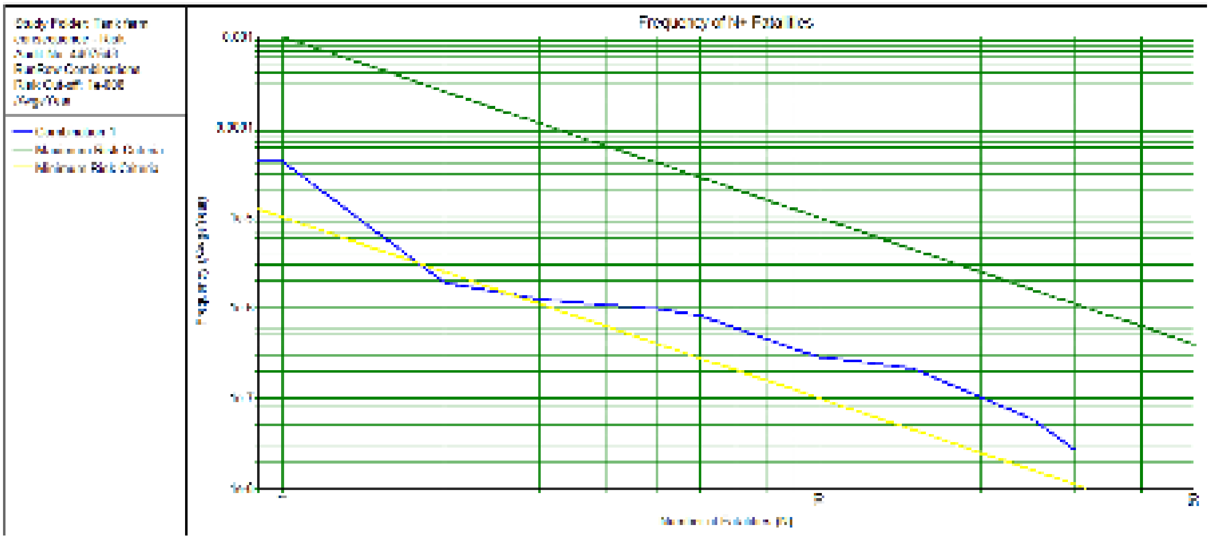
RISK ANALYSIS

The risk estimated due to the activities conducted at the Mundra port is shown in the risk contour map provided **Figure 1**.

The F-N curve demonstrates the societal risk is within As Low as Reasonably Practicable (ALARP) level shown in the **Figure 2**.

FIGURE 1: RISK CONTOURS

FIGURE 2: FN CURVE



INDIVIDUAL & SOCIETAL RISK PER ANNUM

Individual Risk per Annum	4.328E-05
Societal Risk per Annum	5.125E-05

Location Specific Individual Risk

Area	LSIR indoor	LSIR outdoor
Jetty	3.56E-07	4.06E-07
Tank farm	1.40E-07	1.80E-07
BOG & FOG	5.57E-07	6.37E-07
Control room	1.57E-07	3.36E-07
Blending and heating	7.46E-05	1.00E-04
Truck loading area	7.21E-07	1.26E-06

RECOMMENDATIONS

The Following measures shall be implemented for safe operation

1. F&G mapping study to be carried to identify the location of the detectors and voting logic to be used to ensure tripping of the unit, in case of any hydrocarbon leak
2. Hydraulic analysis and simulation study to be carried out, to operate heating trains at the minimum pressure possible to reduce the effects of LFL and jet fire scenarios
3. Consider converting level indications on Propane BOG / Flash Condensate Receiver (2000-FA-05) and Butane BOG / Flash Condensate Receiver (2000-FA-06) as 1oo2 voting logic for tripping on low level and average selection control philosophy for controlling the level to improve the reliability
4. Consider shifting the PSV on the inlet of the CW supply header of Propane BOG / Flash Condenser (2000-EA-03) and Butane BOG / Flash Condenser (2000-EA-04) to return header with reduced set point and LFL sensors at the outlet of the PSV
5. Consider providing discharge PT on 2000-GA-05/06 discharge common header with low pressure alarm
6. Revisit fail safe conditions of ROV-063/64 (considered as fail open) by HAZOP study

7. Consider additional PSV on Propane BOG / Flash Condensate Receiver (2000-FA-05) and Butane BOG / Flash Condensate Receiver (2000-FA-06) to increase the reliability and standby condition in case of maintenance of other PSV (same nozzle with separate isolation valves)
8. Consider providing remote operated sprinklers systems based on LFL sensors covering Propane BOG / Flash Condensate Receiver (2000-FA-05) and Butane BOG / Flash Condensate Receiver (2000-FA-06) and propane and butane handling pumps.
9. Consider trip logic for the steam boilers based LFL sensors on the tank farm
10. Consider shifting the PSV-063/PSV-034 provided downstream ROV-063 and ROV-064 relocated to Propane BOG / Flash Condensate Pumps (2000-GA-05) and Butane BOG / Flash Condensate Pumps (2000-GA-06) common discharge headers.
11. Consider voting logic between PT-016/017/018 for tripping on high and low pressure interlocks of the propane and butane tanks and MID point selection control philosophy for controlling the tank pressure to improve the reliability
12. Provide flow meters in N2 line to PSV headers to ensure continuous flow of N2
13. Ensure SOP developed and followed on all critical activities, interlocks checking before unloading operations
14. SOP and work instructions on display in local and English near the critical activity locations
15. Consider HAZOP and SIL study before commissioning the facility and concerns addressed
16. Ensure CCTV coverage of critical locations and remote monitoring is done continuously
17. Ensure all portable electrical equipment used in the location are Ex rated and covered under PTW systems, and certified
18. Selection of electrical and other instruments based on hazardous area classification (IS 5572: 2008)
19. All flanges shall be connected for bonding for electrical continuity and earthing of the equipment's to be ensured as per IS-3043
20. Lightning protection shall be provided as per the requirements of IS: 2309.
21. Periodical maintenance schedule should be implemented and meticulously followed
22. F&G systems management to be inspected periodically and availability ensured
23. Periodical inspection of pipeline and drain systems

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1. INTRODUCTION

Adani group intends to expand its current port facility at Adani Mundra Port Pvt Ltd. ADANI is developing LPG, Propane, Butane handling and storage facility at their Port in Mundra. Propylene and propane will be stored and handled in the terminal in a scenario where LPG business subsides. The report prepared addresses risk assessment of unloading, storage and transportation facilities to provide a better understanding of the risk posed to the plant and surrounding population.

This document describes the results after the completion of Quantitative Risk Assessment study for the Adani Mundra port-New LPG facility.

1.1 Project Objective

The objective of the QRA is to assess the risk levels associated with the facilities under scope; evaluate those risks based on the HSE UK Risk Acceptance Criteria, and if risks are outside the tolerable region, then risk reduction measures shall be proposed to bring the risks into tolerable or As Low As Reasonably Practicable (ALARP) Levels and lower levels.

1.2 Scope of Work

IFluids Engineering has been awarded the Project to carry out the QRA study to assess risks at the following in the Mundra port;

- Berth 2 (White oil-Motor Spirit representing worst case scenario) Pipeline transfer Facilities
- Berth 1 (Propane/Butane) Pipeline Transfer facilities
- Berth 3 & 4 - Berth 3 handling LPG (typical as Berth 1 in terms of inventory and process conditions) and Berth 4 (White oil-Motor Spirit representing worst case scenario)
- To study the impact of LPG pipeline on existing pipelines.
- To study the impact of Simultaneous berth operations of berth 1 with berth 2, 3 & 4 respectively.
- To study the impact of facilities around LPG plot
    a) T9, T10 handling fertilizers to the south of LPG plot.

b) Steel yard to the east side of LPG Plot

c) Existing pipeline & conveyor to the west of LPG plot.

2. FACILITIES OVERVIEW

2.1 Propane/Butane Unloading and Storage Tank

Storage tank (2000-FB-01 and 2000-FB-02) is vertical flat bottom, double wall, full containment refrigerated storage tank, which is designed to store Propane/Butane/Propylene from jetty. The function of these tanks is to store Propane/Butane/Propylene. Both these tanks are identical in all respect and Propane/Butane/Propylene can be stored in any of these tanks. The capacity of each tank is 25000 MT.

Propane/Butane/Propylene is pumped by shipping pump through marine unloading arm to storage tanks through two marine unloading arm at the rate of 500 MT/hr each.

The tank operating pressure is 500 mm WC & temperature of approximately -45°C in case of propane, -5°C in case of Butane and -47°C in case of Propylene will be maintained in Propane/Butane Storage Tank (2000-FB-01 and 2000-FB-02).

2.2 Precooling Operation

The pre-cooling operation is one of the requirements prior to the ship unloading operation. During precooling operation, cold Propane/ Butane from the Storage Tank I & II is pumped into one of the unloading line going to the Jetty Area, from where it flows towards the Propane/Butane Storage Area and returns into the tank through the other unloading line. Flash compressor will cater the flash gas generated during this operation.

For precooling during propylene/propane unloading scenario two additional lines shall be installed (in future) from storage tank till jetty to avoid any contamination of propylene and Propane inventory.

2.3 Other unloading operations and Transfer to Tank farm area

Following Hazardous Chemicals are unloaded at berth 1, 2, 3 & 4 and transferred to the tank farm via pipelines

1. Propane
2. Butane

3. Propylene
4. Crude oil (future)
5. Furnace oil
6. Excluded petroleum products such as Furnace and vegetable oil

FIGURE 3: GOOGLE EARTH IMAGE OF THE FACILITY

3 RISK TOLERABILITY CRITERIA

The assessment and control of risk are essential requirements for a proactive HSE management system. In order to make a valued judgment and to decide on what risks are acceptable, an easily understood set of criteria should be set and followed rigorously. Risk criteria are required to promote consistency in evaluating the results of relevant studies and to formulate a proactive approach to incident prevention. The Risk Acceptance Criteria used in this assessment is from the UK HSE guidelines.

3.1 Individual Risk Criteria

Individual Risk (IR) Criteria is a measure of the risk to a person within an occupied area or building. This includes the nature of the injury to the individual, the likelihood of the injury occurring, and the time over which the injury might occur. It is the probability of death occurring because of accidents at a plant facility, installation or a transport route expressed as a function of the distance from such an activity. It is the frequency at which an individual or an individual within a group who may be expected to sustain a given level of harm (typically death) from the realization of specific hazards.

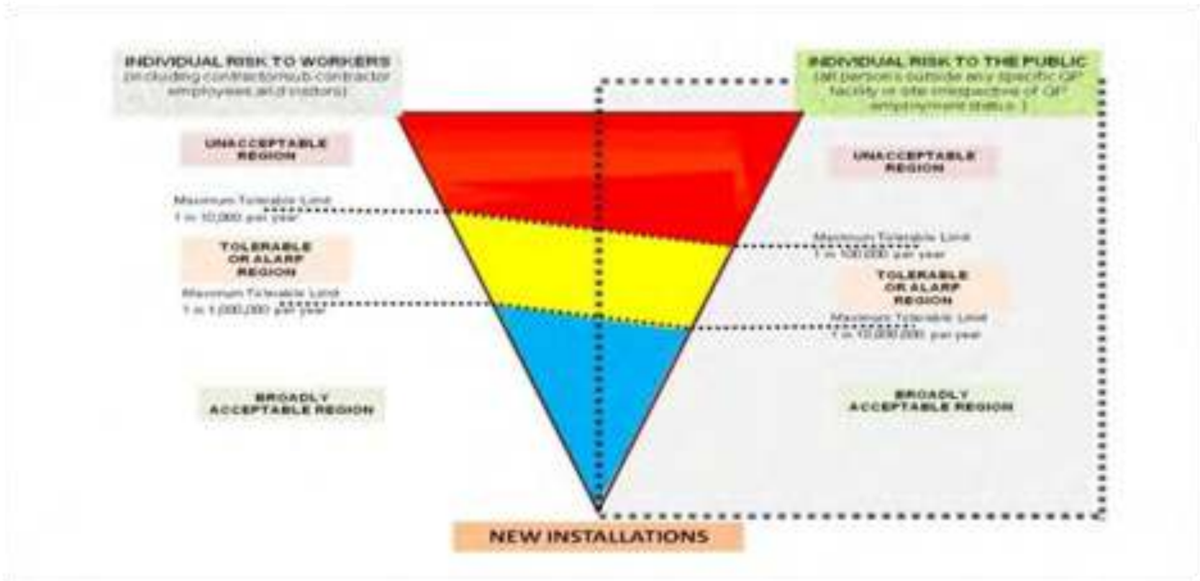
Occupancy is the proportion of exposure time of the individual to the hazard.

The exposure of an individual is related to:

- The likelihood of occurrence of an event involving a release and Ignition of hydrocarbon;
- The vulnerability of the person to the event; and
- The proportion of time the person will be exposed to the event (which is termed 'occupancy' in the QRA terminology).

There is a need to determine the limits for IR, based on numeric values (which would be regarded as intolerable. Figure 4 shows the principle of this framework.

Figure 4: Risk Acceptance graph



3.2 Societal Risk Criteria

Assessment of societal risks is even more important than assessment of individual risk because they involve the likelihood of multiple fatalities. Societal risk is the risk to any person or group of persons who are not connected to project facilities and are outside the facility fence line.

F-N Curve

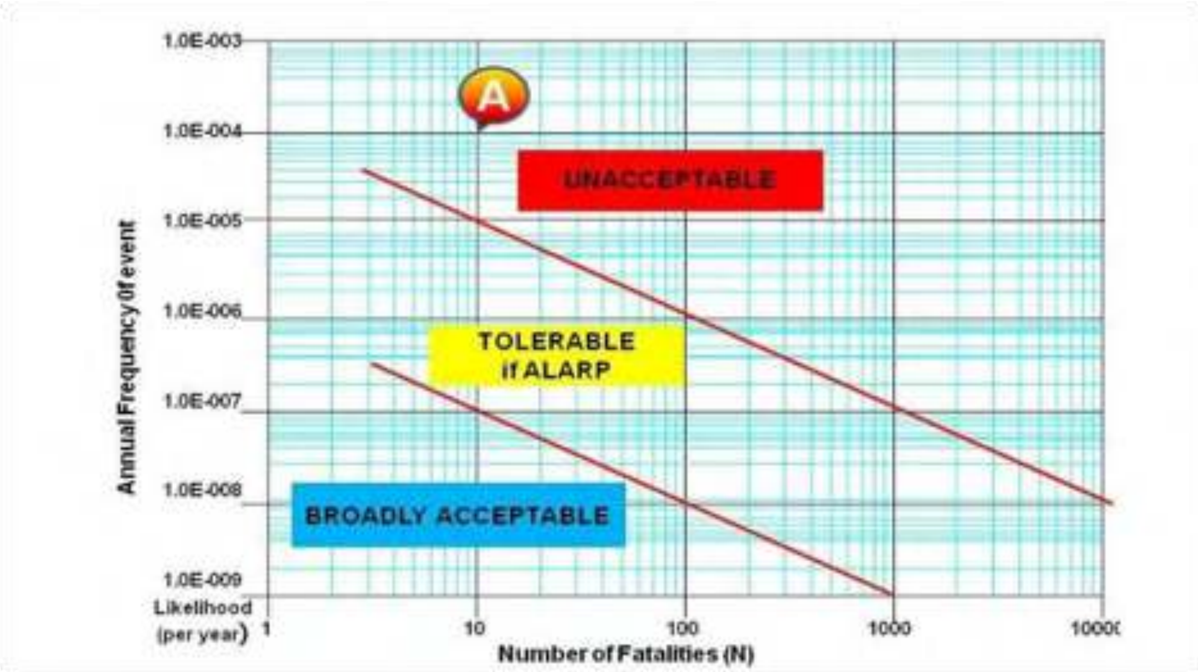
It is helpful to consider group risk in the demonstration that risks are ALARP. This allows consideration to be given to events, which, although low in frequency, may cause multiple injuries or fatalities. Group risk can be presented in the form of a plot of cumulative frequency versus number of fatalities (F-N curve).

F = Frequency (experienced or predicted)

N =No. of multiple fatalities.

'N' includes indirect deaths caused because of the main event occurring and can therefore be difficult to predict e.g. many people may die years after exposure to a toxic chemical. F-N Curve is generated for customers and benchmarked against risk acceptance criteria. The risk acceptance criteria used to compare the predicted risks for this proposed project can be understood from Figure 5.

Figure 5: Risk acceptance criteria- FN Curve



4 METROLOGICAL CONDITIONS

This chapter describes the meteorological data, used for the risk assessment study of Adani Mundra Port.

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

4.1 Wind Direction

N	NE	E	SE	S	SW	W	NW
0.0148	0.1211	0.1374	0.0404	0.0179	0.559	0.087	0.0225

4.2 Ambient Conditions

Maximum Ambient temperature: 35°C

Minimum Ambient temperature: 7°C

Relative humidity: 70%

Atmospheric Pressure: 1.013 bar

Incident solar radiation: 0.215 kW/m2

Surface roughness parameter: 0.3 m

4.3 Atmospheric Stability

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

Pasquill has defined six stability classes ranging from ‘A’ (extremely unstable) to ‘F’ (very stable). Wind speeds, intensity of solar radiation (daytime insulation) at night time sky cover have beam identified as prime factors defining these stability categories. Below table indicates the various Pasquill stability classes.

TABLE 1: PASQUILL’S STABILITY CLASS

Wind Speed (m/s)	Day: Solar Radiation			Night: cloud Cover		
	Strong	Moderate	Slight	Thinly < 40%	Moderate	Overcast > 80%
<2	A	A-B	B	-	-	D
2-3	A-B	B	C	E	F	D
3-5	B	B-C	C	D	E	D
5-6	C	C-D	D	D	D	D
>6	C	D	D	D	D	D

A – Very Unstable

B – Unstable

C – Slightly Unstable

D – Neutral

E – Stable

F – Very Stable

When the atmosphere is unstable and wind speeds are moderate or high or gusty, rapid dispersion of pollutants will occur. Under these conditions, pollutant concentrations in air will be moderate or low and the material will be dispersed rapidly. When the atmosphere is stable and wind speed is low, dispersion of material will be limited and pollutant concentration in air will be high. In general, worst dispersion conditions (i.e. contributing to greater hazard distances) occur during low wind speed and very stable weather conditions, such as that at 1F weather condition (i.e. 1 m/s wind speed and Pasquill stability F).

Stability category for the present study is identified based on the cloud amount and wind speed.

Based on the weather analysis, predominant weather stability of “F” and “D” was selected with wind speed 1.5m/s, 2m/s and 5m/s for consequence analysis, respectively. 2F is the most prevalent weather condition for this location.

TABLE 2: WEATHER CONDITIONS

Wind Speed in m/s	Pasquill Stability
1.5	F
2	F
5	D

5 QUANTITATIVE RISK ASSESSMENT METHODOLOGY

5.1 General Overview

Quantitative Risk Assessment (QRA) is used for risk management and safety improvement in many industries. It provides a quantitative assessment of potential risks identified and provides a basis for evaluating process safety with respect to a predetermined risk acceptance criterion. The usefulness of the QRA results is highly dependent on the availability and accuracy of the input data, with more complete input data providing a higher confidence on the validity and robustness of the results obtained.

In most practical applications, there will be uncertainties in both the key parameters used and the QRA model itself. The effect of these uncertainties should be evaluated to confirm there is no impact on the conclusion. The QRA model will include:

- Examination of flammable/toxic material related to Major Accident Hazards;
- Quantification of the likelihood of flammable/toxic Major Accident Hazardous events;
- Quantification of the consequences of flammable/toxic Major Accident Hazardous events;
- Combination of consequences and likelihood of Major Accident Hazard events to assess risk profiles for individuals, and assets;
- Identification of the predicted levels of risk with regard to Individual Risk (IR) levels and Societal Risk (SR);
- Identification and assessment of risk reduction solutions (to the extent required to reduce predicted risks to acceptable levels); and
- Demonstration that the risks have been reduced to As Low As Reasonably Practicable (ALARP), when risks cannot be reduces to acceptable levels).

The following schematic (**Figure 6**) displays the methodology used to perform the Quantitative Risk Assessment Study for the Adani Mundra Port – New LPG Facilities.

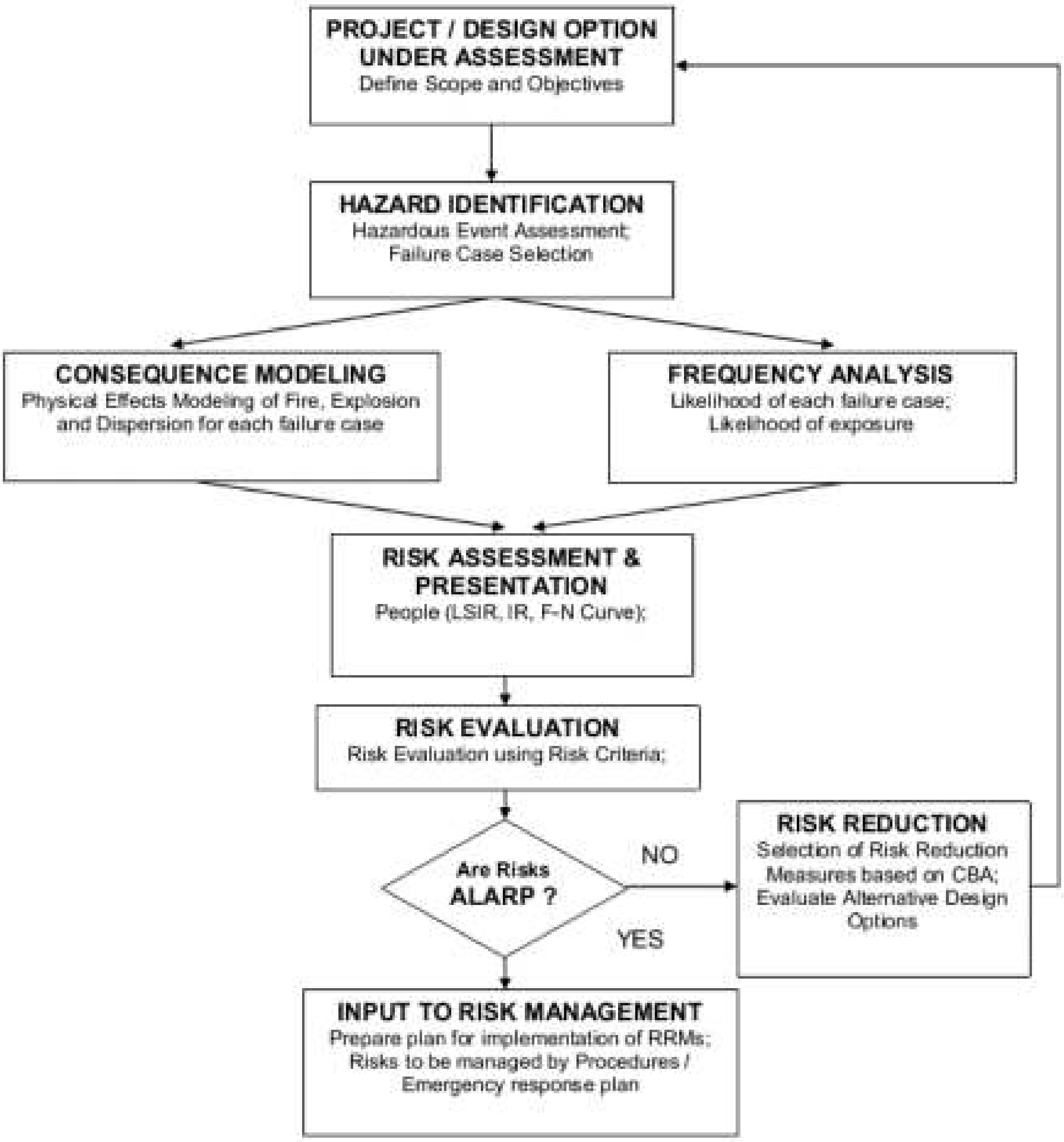


FIGURE 6: QUANTITATIVE RISK ASSESSMENT METHODOLOGY

5.2 Scenario Description and Operating Conditions

To carry out the QRA study the following basic data were used:

- Process parameters such as operating pressure, temperature & flow rate of equipment and process pipelines as well as the composition of the process streams etc.;
- Manning details at strategic locations at site and meteorological details of Adani Mundra port area;

- Failure frequencies of leak sources, Ignition probabilities, operating probabilities etc.; and
- Isolation and detection time, Impact criteria for consequences such as fire, explosion and toxic concentration.

5.3 QRA Approach

The QRA was carried out using the standard, internationally accepted approach consisting of the steps shown below:

Data used for the QRA were project and site specific; however, where this was not possible, the use of generic data was documented in the assumptions register prior to being applied within the study. As such, the QRA results was also specific to the planned operations, building design and personnel and general population occupancy levels expected at the time of data collection. Given the above, the consequence and risk results are only applicable to the site under study in this QRA and cannot be applied to any other location.

The following information was considered in the QRA:

- Facility design, function, location, capacity and layout;
- Environmental weather data e.g. wind rose, cloud coverage, stability class;
- Process engineering details e.g. composition, heat and mass balance, equipment items, process parameters - pressure and temperature regimes, inventories, flow schemes;
- Facility operation e.g. operational and emergency procedures; and
- Work force deployment, estimated occupancy and exposure.

5.4 Hazard Identification

A technique commonly used to generate an incident list is to consider potential leaks and major releases from fractures of all process pipelines and vessels. This compilation includes all pipe work and vessels in direct communication, as these may share a significant inventory that cannot be isolated in an emergency. The following data were collected to envisage scenarios:

- Composition of materials stored in vessels / flowing through pipeline;

- Inventory of materials stored in vessels;
- Flow rate of materials passing through pipelines;
- Vessels / Pipeline conditions (phase, temperature, pressure); and Connecting piping and piping dimensions.

Accidental release of flammable liquids / gases has the potential for severe consequences. Delayed ignition of flammable gases can result in blast overpressures covering large areas. This may lead to extensive loss of life and property. In contrast, fires have localized consequences. Fires can be extinguished or contained in most cases; there are few mitigating actions one can take once a flammable gas or a vapour cloud gets released.

5.4.1 Factors for Hazard Identification

In any installation, main hazards arise due to loss of containment during handling of flammable liquids / gases. To formulate a structured approach to the identification of hazards, a list of contributory factors is provided below:

Blast over Pressures

Blast Overpressures depend upon the reactivity class of material and the amount of gas between two explosive limits. For example, Motor spirit/Gasoline once released and not ignited immediately is expected to give rise to a gas cloud. These gases in general have medium reactivity and in case of confinement of the gas cloud, on delayed ignition may result in an explosion and overpressures.

Operating Parameters

Potential gas release for the same material depends significantly on the operating conditions. The gases are likely to operate at atmospheric temperature (and hence high pressures). This operating range is enough to release a large amount of gas in case of a leak / rupture, therefore the pipeline leaks and ruptures need to be considered in the risk analysis calculations.

Inventory

Inventory Analysis is commonly used in understanding the relative hazards and short listing of release scenarios. Inventory plays an important role when considering a potential hazard. The larger the inventory of a vessel or a system, the larger the quantity of potential release. A practice commonly used to generate an incident list is to consider potential leaks and major releases from fractures of pipelines and vessels/tanks containing sizable inventories.

Range of Incidents

Both the complexity of study and the number of incident outcome cases are affected by the range of initiating events and incidents covered. This not only reflects the inclusion of accidents and / or non-accident-initiated events, but also the size of those events. For instance, studies may evaluate one or more of the following:

- Catastrophic failure of container;
- Large hole (large continuous release);

- Smaller holes (continuous release); and
- Leaks at fittings or valves (small continuous release).

In general, quantitative studies do not include very small continuous releases or short duration small releases if past experience or preliminary consequence modelling shows that such releases do not contribute to the overall risk levels.

5.5 Isolatable Sections

The following table describes the isolatable section considered for the study:

TABLE 3: ISOLATABLE SECTIONS

Isolatable section identification	Description	Scenario	Diameter m	Pressure barg.	Temperature C	Isolation time s	Total Inventory, kg
Berth 1							
IS-1	Transfer of Propane from Jetty to Storage Tank 2000-FB-01	7	0.406	8	-42.67	120	143322
IS-2		25	0.406	8	-42.67	120	144343
IS-3		150	0.406	8	-42.67	120	159902
IS-4	Transfer of Butane from Jetty to Storage Tank 2000-FB-02	7	0.406	8	-2.90	120	147605
IS-5		25	0.406	8	-2.90	120	148655
IS-6		150	0.406	8	-2.90	120	164183
IS-7	Transfer of Propylene from Jetty to Storage Tank 2000-FB-02	7	0.406	8	-44.86	120	150204
IS-8		25	0.406	8	-44.86	120	151247
IS-9		150	0.406	8	-44.86	120	166782
IS-10	Propylene precooling line	7	0.305	8	-45	120	90158

Isolatable section identification	Description	Scenario	Diameter m	Pressure barg.	Temperature C	Isolation time s	Total Inventory, kg
IS-11		25	0.305	8	-45	120	91201
IS-12		150	0.305	8	-45	120	94736
Berth 2							
IS-13	Methanol P/L	10	0.305	10	35	120	11809
IS-14		150	0.305	10	35	120	24885
IS-15	MS P/L	10	0.406	10	35	120	18894
IS-16		150	0.406	10	35	120	35336
IS-17	HSD P/L	10	0.610	10	35	120	48967
IS-18		150	0.610	10	35	120	82050
IS-19	SKO P/L	10	0.305	10	35	120	12058
IS-20		150	0.305	10	35	120	21814
IS-21	Furnace Oil	10	0.305	10	55	120	13848
IS-22		150	0.305	10	55	120	21916
IS-23	Crude	10	0.9144	10	35	120	121023
IS-24		150	0.9144	10	35	120	177890

Isolatable section identification	Description	Scenario	Diameter m	Pressure barg.	Temperature C	Isolation time s	Total Inventory, kg
Tank farm							
IS-25	Inlet of Boil Off Compressor 2000-GB-01A/B(Propane rich BOG)To Inlet of Bullet 2000-FA-07	7	0.203	20.00	100.46	120	101.8
IS-26		25	0.203	20.00	100.46	120	358.7
IS-27		150	0.203	20.00	100.46	120	10122.5
IS-28	Inlet of Boil Off Compressor 2000-GB-02A/B(Butane rich BOG) To Inlet of Bullet 2000-FA-08	7	0.203	4.52	61.30	120	51.6
IS-29		25	0.203	4.52	61.30	120	129.4
IS-30		150	0.203	4.52	61.30	120	3084.0
IS-31	Inlet of Boil Off Compressor 2000-GB-02A/B(Propylene rich BOG) To Inlet of Bullet 2000-FA-08	7	0.203	17.83	111.17	120	117.5
IS-32		25	0.203	17.83	111.17	120	389.2
IS-33		150	0.203	17.83	111.17	120	10544.9
IS-34	Propane from 2000 -GA-01A/B/C to Propane heater I, 2000-EA-05 &Propane heater II, 2000-EA-07	7	0.203	25.60	-44.27	120	20700.1
IS-35		25	0.203	25.60	-44.27	120	22534.5
IS-36		150	0.203	25.60	-44.27	120	92200.3
IS-37	Butane from 2000-GA-02A/B/C to Butane heater I, 2000-EA-08 & Butane heater II, 2000-EA-10 to Static blender	7	0.203	25.60	-4.17	120	21320.8
IS-38		25	0.203	25.60	-4.07	120	23200.4

Isolatable section identification	Description	Scenario	Diameter m	Pressure barg.	Temperature C	Isolation time s	Total Inventory, kg
IS-39		150	0.203	25.60	-4.07	120	94579.3
IS-40	Propylene from 2000-GA-02A/B/C to heater I, 2000-EA-08 & Propylene heater II, 2000-EA-10 to Static blender	7	0.203	24.10	-46.45	120	21685.2
IS-41		25	0.203	24.10	-46.45	120	23581.6
IS-42		150	0.203	24.10	-46.45	120	92338.2
IS-43	Inlet of Flash & Off Gas Compressor 2000-GB-03A/B(Propane rich FOG)To Inlet of Bullet 2000-FA-07	7	0.508	20.00	100.46	120	3218.8
IS-44		25	0.508	20.00	100.46	120	3475.7
IS-45		150	0.508	20.00	100.46	120	13229.1
IS-46	Inlet of Flash & Off Gas Compressor 2000-GB-04A/B(Butane rich FOG) To Inlet of Bullet 2000-FA-08	7	0.508	4.50	56.22	120	1178.6
IS-47		25	0.508	4.50	56.22	120	1256.4
IS-48		150	0.508	4.50	56.22	120	4211.0
IS-49	Inlet of Flash & Off Gas Compressor 2000-GB-04A/B(Propylene rich BOG) To Inlet of Bullet 2000-FA-08	7	0.508	17.70	106.39	120	2570.6
IS-50		25	0.508	17.70	106.39	120	2788.7
IS-51		150	0.508	17.70	106.39	120	11073.6
IS-52	Bullet 2000-FA-07 through Bullet Pump 2000-GA -07A/B To Static Blender(Propane Rich	7	0.203	23.30	46.00	120	339068.3
IS-53		25	0.203	23.30	46.00	120	340670.1

Isolatable section identification	Description	Scenario	Diameter m	Pressure barg.	Temperature C	Isolation time s	Total Inventory, kg
IS-54	stream)	150	0.203	23.30	46.00	120	395837.3
IS-55	Bullet 2000-FA-08 through Bullet Pump 2000-GA -08A/B To Static Blender(Butane Rich stream)	7	0.203	24.00	46.42	120	410938.9
IS-56		25	0.203	24.00	46.42	120	412677.4
IS-57		150	0.203	24.00	46.42	120	478702.0
IS-58	Bullet 2000-FA-08 through Bullet Pump 2000-GA -08A/B To Static Blender(Propylene Rich stream)	7	0.203	21.00	45.07	120	363254.2
IS-59		25	0.203	21.00	45.07	120	364797.1
IS-60		150	0.203	21.00	45.07	120	423390.1
IS-61	Mercaptan Dosing System 2000-CS-01 To Static Blender	7	0.025	12.30	36.29	120	1711.6
IS-62		25	0.025	12.30	36.29	120	3258.1
IS-63	Static Blender outlet to Tanker Loading Bay	7	0.356	12.30	15.39	120	27129.1
IS-64		25	0.356	12.30	15.39	120	28340.6
IS-65		150	0.356	12.30	15.39	120	74352.2

6 CONSEQUENCE ANALYSIS

6.1 Overview

Consequence is the measure of the expected outcomes for a given accidental release. For this project, consequence is defined as the hazard distance or hazard zone to various fatality endpoints. During the execution of site-specific consequence analysis, it is essential to accurately model the release, dilution, and dispersion of gases and aerosols if a precise assessment of potential exposure is to be attained. Consequence modelling, also known as physical effects modelling, is a technique in which computer based mathematical modelling is used to predict physical behaviour under accident conditions in order to make a quantitative estimation of risk. Internationally accepted and validated software PHAST v6.7 and PHAST RISK v.6.7, (both developed by DNV GL) have been used for this project.

PHAST v6.7 contains a set of complex models that calculate release conditions, initial dilution of the vapour (dependent upon the release characteristics), and the subsequent dispersion of the vapour introduced into the atmosphere. It permits the user to evaluate the downwind dispersion of the chemical cloud based on the toxicological/physical characteristics of the released chemical, atmospheric conditions, and specific circumstances of the release.

PHAST v6.7 will be used to estimate threat zones associated with several types of hazardous chemical releases, including toxic gas clouds, fires, and explosions.

It is most important that the QRA model effectively reflect reality, thus those familiar with the facilities and their operation are required for proper evaluation. This is particularly true in relation to the preparation of input data and assumptions and the review of results from the evaluation. The QRA model must identify the major hazard contributors to the work force and third parties, quantify risks, and identify and assess any risk reduction methods that may be proposed. In addition to modelling the current situation within the field, the model shall be extendible to add additional facilities as development occurs and provide an active method of planning any proposed development.

6.2 Consequence Modelling

Discharge Rate

The initial rate of release through a leak depends mainly on the pressure inside the equipment, size of the hole and phases of the release (liquid, gas or two phase). The release rate decreases with time as the equipment depressurizes. The reduction mainly on the inventory and the actions taken to isolate the leak and blow-down the equipment

Dispersion

A vapour cloud may be formed when a vaporizing liquid is released for an extended duration. If the gas cloud does not immediately ignite, it disperses based on the prevalent wind direction, speed and stability category (i.e. degree of turbulence).

The cloud dispersion simulation is carried out to provide the distance (from the leak) at which the concentration of flammable material falls below the Lower Flammability Limit (LFL).

Consequence Events

The following describes the probabilities associated with the sequence of events which must take place for the incident scenarios to produce hazardous effects. Considering the present case, the outcomes expected are:

- Flash Fire (FF);
- Jet fires;
- Pool fire;
- Vapour Cloud Explosion.

Flash Fire

The vapour/gas release from a pool would disperse under the influence of the prevailing wind; with material concentration in air reducing with distance. At a particular location downwind, the concentration will drop below its lower flammable level (LFL) value. If ignited within the flammable envelope, the mass of the material available between the LFL and ½ LFL will be likely to burn as a flash fire; rapidly spreading through the cloud from the point of ignition back to the source of release.

Although flash fires are generally low intensity transitory events, the burning velocity is quite high and escape following ignition is not possible. Flash fires often remain close to the ground, where most ignition sources are present. It is assumed that personnel caught inside a flash fire will not survive while those outside suffer no significant harm. If other combustible material is present within the flash fire it is also likely to ignite and a secondary fire could result.

Jet Fire

Jet fire causes damage due to the resulting heat radiation. The working level heat radiation impact will vary widely depending on the angle of the flame to the horizontal plane, which in turn mainly depends on the location of the leak. The flame direction was considered horizontal for consequence analysis of leaks and ruptures from process equipment. Jet fire heat radiation impacts were estimated for the identified credible and worst case scenarios.

Upon accidental leakage, the pressurized fluid will disperse as a jet, initially moving forward in the spatial direction of the leak until the kinetic energy is lost and gravity slumping or lifting of the cloud occurs, dependent upon whether the fluid is heavier or lighter than air.

The primary hazard associated with jet fires is thermal radiation and potential for flame impingement on adjacent pipelines/equipment, resulting in escalation. High pressure releases have the potential to cover large areas due to its relatively large flame length. However, the effects of escalation are minimized if the flame length reduces to less than the separation distance between other equipment and the jet fire source.

Pool Fire

A liquid pool is formed during a prolonged leakage if the rate of leakage exceeds the rate of vaporization. On ignition, this would result in a pool fire whose size/radius would depend on the mass flow rate, ambient temperature, heat of vaporization of material released, vapour pressure, duration of discharge and effects of containment or dykes. The pool fire could cause damage to equipment or injury/fatality to personnel due to thermal radiation effects.

A pool fire is not envisaged for liquid systems that are highly pressurized. Any leak or rupture would result in a pressurized release leading to a liquid jet fire or flash fire.

Vapour Cloud Explosion

Vapour cloud explosion is the result of flammable materials in the atmosphere, a subsequent dispersion phase, and after some delay an ignition of the vapour cloud. Turbulence is the governing factor in blast generation which could intensify combustion to the level that will result in an explosion. Turbulence is often created by obstacles in the path of vapour cloud or when the cloud finds a confined area, as under the bullets. Insignificant level of confinement will result in a flash fire. The VCE will result in overpressures.

6.3 Damage Criteria

Damage criteria gives the relation between the extent of the physical effects (exposure) and the effect of consequences. For assessing the effects on humans, consequences are expressed in terms of injuries and the effects on equipment / property in terms of monetary loss. The consequences for release of toxic substances or fire can be categorized as:

- Damage caused by heat radiation on material and people;
- Damage caused by explosion on structure and people; and

In Consequence Analysis studies, three main types of exposure to hazardous effects are categorized as:

- Heat radiation due to fires.
- Jet fires and flash fires;
- Explosions;

The knowledge about these relations depends strongly on the nature of the exposure. The following discusses the criteria selected for damage estimation:

Heat Radiation:

The effect of fire on a human being is in the form of burns. There are three categories of burns: first degree, second degree and third degree burns being the most severe. The consequences caused by exposure to heat radiation are a function of:

- The radiation energy onto the human body [kW/m^2];

- The exposure duration [sec]; and
- The protection of the skin tissue (clothed or bare body).

The physical effects of hazard events are given in the table below:

Table 4: Effects due to Incident Radiation Intensity

Incident Radiation (kW/m^2)	Type of Damage
4.7	Sufficient to cause pain within 20 sec. Blistering of skin(first degree burns are likely)
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing's etc.
37.5	Sufficient to cause damage to the equipment

The actual results would be less severe due to the various assumptions made in the models arising out of the flame geometry, emissivity, angle of incidence, view factor and others. The radiation output of the flame would be dependent upon the fire size, extent of mixing with air and the flame temperature. Some fraction of the radiation is absorbed by carbon dioxide and water vapour in the intervening atmosphere. Finally, the incident flux at an observer location would depend upon the radiation view factor, which is a function of the distance from the flame surface, the observer's orientation and the flame geometry.

Blast Overpressure from Vapour cloud Explosion (VCE)

The assessment aims are to determine the impact of overpressure in the event that a flammable gas cloud is ignited. A Vapour cloud Explosion (VCE) results when a flammable vapour is released and mixes with the air to form a flammable vapour cloud. If ignited, the flame speed may accelerate to high velocities and produce significant blast overexposure.

The assessment goals are to determine the impact of overpressure in the event that a flammable gas cloud is ignited. The damage effects due to 0.01 bar, 0.1 bar & 0.3 bar are reported in terms of distance from the overpressure source.

In case of vapour cloud explosion, two physical effects may occur:

- A flash fire over the whole length of the explosive gas cloud;
- A blast wave, with typical peak overpressures circular around ignition source.

For the blast wave, the lethality criterion is based on:

- A peak overpressure of 0.1bar will cause serious damage to 10% of the housing/structures;
- Falling fragments will kill one of each eight persons in the destroyed buildings.

The following damage criteria may be distinguished with respect to the peak overpressures resulting from a blast wave

TABLE 5: DAMAGES DUE TO BLAST OVERPRESSURE

Peak Overpressure	Damage Type	Description
0.30 bar	Heavy Damage	Major damage to plant equipment structure
0.10 bar	Moderate Damage	Repairable damage to plant equipment & structure
0.01 bar	Significant Damage	Shattering of glass

The summary of the consequence modelling is shown below in

TABLE 6: IMPACT DISTANCE IN METER

Isolatable Section/Description	Release category	Flash Fire Effects: 0.5% LFL Ellipse Distance in meters			Flash Fire Effects: 100% LFL Ellipse Distance in meters			Radiation Effects: Jet Fire Ellipse				Radiation Effects: Pool Fire				Overpressure			
								Radiation Levels (kW/m2)	Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Over-pressure level bar	Distance in meters		
		5D	1.5F	2F	5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F
Transfer of Propane from Jetty to Storage Tank 2000-FB-01	7	8.19104	24.4843	21.0653	6.41862	12.2659	10.1915	4	23.1853	26.7283	25.9291	4	NR	NR	NR	0.01	NR	74.9525	70.1064
		8.19104	24.4843	21.0653	6.41862	12.2659	10.1915	12.5	17.5949	21.3412	20.4624	12.5	NR	NR	NR	0.1	NR	29.5322	28.6915
		8.19104	24.4843	21.0653	6.41862	12.2659	10.1915	37.5	13.9777	17.7971	16.878	37.5	NR	NR	NR	0.3	NR	24.7597	24.34
	25	52.1634	73.6826	68.0846	35.6415	59.6057	54.5213	4	73.8934	84.2143	81.9038	4	NR	NR	NR	0.01	228.541	518.96	438.727
		52.1634	73.6826	68.0846	35.6415	59.6057	54.5213	12.5	56.2605	67.2694	64.6926	12.5	NR	NR	NR	0.1	80.97	147.877	125.695
		52.1634	73.6826	68.0846	35.6415	59.6057	54.5213	37.5	45.5539	56.6361	53.9634	37.5	NR	NR	NR	0.3	65.4644	108.887	92.8036
	150	258.749	375.621	337.936	179.492	272.883	239.639	4	364.347	410.315	400.219	4	329.126	371.147	370.567	0.01	1302.15	2534.23	2207.2
		258.749	375.621	337.936	179.492	272.883	239.639	12.5	274.039	323.382	311.984	12.5	226.117	234.372	238.39	0.1	432.507	745.411	655.622
		258.749	375.621	337.936	179.492	272.883	239.639	37.5	219.755	270.113	258.104	37.5	146.3	134.926	139.299	0.3	341.132	557.456	492.594
Transfer of Butane from Jetty to Storage Tank 2000-FB-02	7	8.35503	24.7542	21.424	6.46825	12.8952	10.4079	4	23.6816	27.0127	26.2689	4	NR	NR	NR	0.01	NR	77.6978	71.7312
		8.35503	24.7542	21.424	6.46825	12.8952	10.4079	12.5	17.7488	21.3121	20.4816	12.5	NR	NR	NR	0.1	NR	30.0084	28.9734
		8.35503	24.7542	21.424	6.46825	12.8952	10.4079	37.5	13.9617	17.6272	16.7539	37.5	NR	NR	NR	0.3	NR	24.9975	24.4807
	25	52.4963	74.8549	68.8995	35.9099	61.1679	55.2733	4	75.6169	85.3103	83.1708	4	NR	NR	NR	0.01	232.205	530.996	445.155
		52.4963	74.8549	68.8995	35.9099	61.1679	55.2733	12.5	56.808	67.2758	64.8483	12.5	NR	NR	NR	0.1	81.6056	149.965	126.81
		52.4963	74.8549	68.8995	35.9099	61.1679	55.2733	37.5	45.5372	56.1973	53.6472	37.5	NR	NR	NR	0.3	65.7818	109.929	93.3604
	150	252.695	369.884	327.053	178.137	283.149	243.278	4	374.027	417.208	407.894	4	376.004	423.016	421.929	0.01	1344.39	2577.29	2292.63
		252.695	369.884	327.053	178.137	283.149	243.278	12.5	277.694	324.579	313.853	12.5	256.289	266.515	270.538	0.1	439.835	735.63	662.175
		252.695	369.884	327.053	178.137	283.149	243.278	37.5	220.237	268.515	257.08	37.5	167.521	153.603	158.552	0.3	344.791	547.565	490.86
Transfer of Propylene from Jetty to Storage Tank 2000-FB-02	7	8.48215	25.1073	21.6186	6.47378	12.7954	10.4078	4	23.322	26.962	26.1355	4	NR	NR	NR	0.01	NR	77.4421	71.5503
		8.48215	25.1073	21.6186	6.47378	12.7954	10.4078	12.5	17.7566	21.5923	20.6914	12.5	NR	NR	NR	0.1	NR	29.964	28.942
		8.48215	25.1073	21.6186	6.47378	12.7954	10.4078	37.5	14.1527	18.0722	17.1118	37.5	NR	NR	NR	0.3	NR	24.9754	24.4651
	25	53.298	76.7204	70.6404	36.0195	61.4873	55.5823	4	74.246	84.8547	82.4757	4	NR	33.8476	29.8157	0.01	231.313	517.363	445.217
		53.298	76.7204	70.6404	36.0195	61.4873	55.5823	12.5	56.714	67.9793	65.3411	12.5	NR	27.0093	24.8155	0.1	81.4509	147.6	135.086
		53.298	76.7204	70.6404	36.0195	61.4873	55.5823	37.5	46.0263	57.3125	54.5893	37.5	NR	20.7604	19.6272	0.3	65.7046	108.749	102.5
	150	261.821	392.817	354.39	177.169	273.005	242.261	4	365.626	412.901	402.501	4	404.296	446.482	443.088	0.01	1332.93	2598.88	2281.88
		261.821	392.817	354.39	177.169	273.005	242.261	12.5	275.88	326.399	314.715	12.5	271.459	287.83	288.582	0.1	446.112	772.777	685.107

Isolatable Section/Description	Release category	Flash Fire Effects: 0.5% LFL Ellipse			Flash Fire Effects: 100% LFL Ellipse			Radiation Effects: Jet Fire Ellipse				Radiation Effects: Pool Fire				Overpressure			
		Distance in meters			Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Over-pressure level bar	Distance in meters		
		5D	1.5F	2F	5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F
		261.821	392.817	354.39	177.169	273.005	242.261	37.5	221.805	273.177	260.912	37.5	190.319	183.969	187.903	0.3	352.932	581.134	517.331
Propylene precooling line	7	13.0493	22.6792	20.4644	7.41065	17.6767	15.5991	4	23.5639	27.2164	26.3892	4	11.926	15.4551	14.9825	0.01	50.9971	125.56	108.471
		13.0493	22.6792	20.4644	7.41065	17.6767	15.5991	12.5	18.1806	22.0249	21.1171	12.5	10.3905	12.0427	11.9505	0.1	17.1114	38.3107	35.3463
		13.0493	22.6792	20.4644	7.41065	17.6767	15.5991	37.5	14.8198	18.6104	17.6889	37.5	8.59991	9.03457	8.83125	0.3	13.551	29.1432	27.663
	25	52.6439	64.8035	59.6876	37.2279	50.7936	46.5364	4	74.3176	84.9283	82.548	4	56.441	70.0417	68.7812	0.01	261.617	529.885	449.768
		52.6439	64.8035	59.6876	37.2279	50.7936	46.5364	12.5	56.8288	68.0994	65.4597	12.5	41.0686	47.3376	47.2271	0.1	86.7074	141.507	119.345
		52.6439	64.8035	59.6876	37.2279	50.7936	46.5364	37.5	46.2006	57.4791	54.7526	37.5	29.0907	30.0176	30.6312	0.3	68.3293	100.699	84.6261
	150	241.63	361.827	341.00	156.477	238.735	210.132	4	365.639	394.67	385.972	4	412.21	428.202	427.84	0.01	1250.69	2285.99	2098.45
		241.63	361.827	341.00	156.477	238.735	210.132	12.5	275.903	312.104	301.894	12.5	273.449	272.883	275.502	0.1	415.316	627.962	609.652
		241.63	361.827	341.00	156.477	238.735	210.132	37.5	221.838	261.274	250.357	37.5	188.759	171.12	176.19	0.3	327.542	455.408	464.633
Methanol P/L	10	13.2879	23.4516	21.0787	6.83624	11.399	11.0517	4	35.979	44.0716	42.1378	4	NR	44.3716	43.1432	0.01	37.965	65.8894	64.6327
		13.2879	23.4516	21.0787	6.83624	11.399	11.0517	12.5	29.5076	37.1441	35.2776	12.5	NR	30.9147	30.7607	0.1	14.8509	27.96	27.7421
		13.2879	23.4516	21.0787	6.83624	11.399	11.0517	37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	12.4222	23.9747	23.8659
	150	76.6849	121.93	106.998	50.0444	70.6208	69.2059	4	209.858	235.718	226.635	4	142.032	136.037	136.988	0.01	226.029	294.232	298.903
		76.6849	121.93	106.998	50.0444	70.6208	69.2059	12.5	171.207	199.537	190.182	12.5	108.836	97.0531	99.1266	0.1	97.0651	125.426	133.727
		76.6849	121.93	106.998	50.0444	70.6208	69.2059	37.5	139.528	NR	NR	37.5	75.5624	72.4929	72.3265	0.3	83.5145	109.603	116.841
MS P/L	10	23.2156	32.6662	29.6652	15.2315	26.4028	23.5931	4	33.671	37.5937	36.724	4	NR	NR	NR	0.01	98.5467	225.457	172.851
		23.2156	32.6662	29.6652	15.2315	26.4028	23.5931	12.5	24.9996	29.3562	28.3433	12.5	NR	NR	NR	0.1	33.6248	63.9044	46.5137
		23.2156	32.6662	29.6652	15.2315	26.4028	23.5931	37.5	19.8615	24.3735	23.2947	37.5	NR	NR	NR	0.3	26.8034	46.9296	33.2392
	150	155.249	207.395	185.209	113.8	169.587	148.074	4	303.961	326.379	321.139	4	168.27	136.482	142.569	0.01	818.819	1189.97	1184.48
		155.249	207.395	185.209	113.8	169.587	148.074	12.5	224.278	249.763	243.019	12.5	82.0953	79.7338	79.518	0.1	266.014	317.542	308.385
		155.249	207.395	185.209	113.8	169.587	148.074	37.5	177.003	204.073	196.518	37.5	NR	NR	NR	0.3	207.93	248.759	241.121
HSD P/L	10	13.5951	11.582	11.4441	12.8557	11.3689	11.2462	4	11.9794	9.23875	9.2571	4	85.1624	70.0438	73.0102	0.01	32.693	30.4035	31.4317
		13.5951	11.582	11.4441	12.8557	11.3689	11.2462	12.5	8.73359	7.02619	6.95779	12.5	41.0876	37.835	37.668	0.1	13.9364	13.5392	13.7176
		13.5951	11.582	11.4441	12.8557	11.3689	11.2462	37.5	6.71139	5.43322	5.3477	37.5	NR	NR	NR	0.3	11.9656	11.7673	11.8563
	150	33.0936	29.5643	29.4502	33.0364	29.5573	29.4445	4	29.4646	28.7595	28.2825	4	218.455	185.219	191.383	0.01	51.2393	29.4186	29.6151
		33.0936	29.5643	29.4502	33.0364	29.5573	29.4445	12.5	21.557	22.1526	21.5302	12.5	118.02	113.912	113.79	0.1	33.6842	21.6338	21.6678
		33.0936	29.5643	29.4502	33.0364	29.5573	29.4445	37.5	16.9013	18.1956	17.4941	37.5	NR	NR	NR	0.3	31.8397	20.8158	20.8328
SKO P/L	10	13.95	17.2974	15.6677	12.9275	11.4289	11.2942	4	33.6751	26.8337	26.8878	4	77.6411	66.7752	69.687	0.01	57.5866	53.7609	55.9137
		13.95	17.2974	15.6677	12.9275	11.4289	11.2942	12.5	24.7386	20.7828	20.5746	12.5	36.4009	35.1158	34.8127	0.1	18.2545	17.5908	17.9643

Isolatable Section/Description	Release category	Flash Fire Effects: 0.5% LFL Ellipse			Flash Fire Effects: 100% LFL Ellipse			Radiation Effects: Jet Fire Ellipse				Radiation Effects: Pool Fire				Overpressure			
		Distance in meters			Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Over-pressure level bar	Distance in meters		
		5D	1.5F	2F	5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F
		13.95	17.2974	15.6677	12.9275	11.4289	11.2942	37.5	19.4742	17.1296	16.783	37.5	NR	NR	NR	0.3	14.1217	13.7904	13.9768
	150	39.798	37.3946	37.767	32.7517	29.2454	29.1351	4	90.2507	88.3046	86.9503	4	147.559	121.643	126.421	0.01	78.1448	72.8802	73.4377
		39.798	37.3946	37.767	32.7517	29.2454	29.1351	12.5	65.7575	67.6656	65.8591	12.5	78.5757	73.4972	73.3811	0.1	38.3513	37.4381	37.5348
		39.798	37.3946	37.767	32.7517	29.2454	29.1351	37.5	51.4125	55.4211	53.3769	37.5	NR	NR	NR	0.3	34.1701	33.7141	33.7624
FURNACE OIL	10	14.7963	NR	11.7005	13.4331	NR	11.3746	4	NR	NR	NR	4	79.8512	67.7607	70.0269	0.01	NR	NR	NR
		14.7963	NR	11.7005	13.4331	NR	11.3746	12.5	NR	NR	NR	12.5	42.2865	38.5883	38.4596	0.1	NR	NR	NR
		14.7963	NR	11.7005	13.4331	NR	11.3746	37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	NR	NR	NR
	150	NR	NR	NR	NR	NR	NR	4	NR	NR	NR	4	109.734	94.4439	97.0658	0.01	NR	NR	NR
		NR	NR	NR	NR	NR	NR	12.5	NR	NR	NR	12.5	66.4692	61.6346	61.5704	0.1	NR	NR	NR
		NR	NR	NR	NR	NR	NR	37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	NR	NR	NR
CRUDE	10	24.9248	35.8405	32.5164	16.6034	28.6941	25.8864	4	29.749	34.6209	34.0991	4	NR	NR	NR	0.01	104.653	237.787	206.342
		24.9248	35.8405	32.5164	16.6034	28.6941	25.8864	12.5	21.3767	25.8094	25.124	12.5	NR	NR	NR	0.1	34.6841	66.043	60.5885
		24.9248	35.8405	32.5164	16.6034	28.6941	25.8864	37.5	16.4918	20.6567	19.8868	37.5	NR	NR	NR	0.3	27.3323	47.9976	45.2739
	150	269.536	403.72	348.47	202.34	332.297	283.898	4	268.919	325.533	314.373	4	163.372	164.136	170.158	0.01	1583.86	2994.33	2733.84
		269.536	403.72	348.47	202.34	332.297	283.898	12.5	198.353	247.302	236.963	12.5	81.2582	96.7701	95.8433	0.1	489.64	791.031	754.644
		269.536	403.72	348.47	202.34	332.297	283.898	37.5	156.56	200.903	191.054	37.5	NR	NR	NR	0.3	374.667	590.249	547.046
Inlet of Boil Off Compressor 2000-GB-01A/B(Propane rich BOG)To Inlet of Bullet 2000-FA-07	7	3.95939	5.69915	5.3805	2.59421	3.23132	3.13596	4	5.76976	6.14772	6.10136	4	NR	NR	NR	0.01	NR	NR	NR
		3.95939	5.69915	5.3805	2.59421	3.23132	3.13596	12.5	NR	NR	NR	12.5	NR	NR	NR	0.1	NR	NR	NR
		3.95939	5.69915	5.3805	2.59421	3.23132	3.13596	37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	NR	NR	NR
	25	25.2116	44.6141	41.4835	8.62918	11.9576	11.4839	4	25.77	25.6478	25.6709	4	NR	NR	NR	0.01	56.3862	83.3316	82.6209
		25.2116	44.6141	41.4835	8.62918	11.9576	11.4839	12.5	21.3237	20.4915	20.6151	12.5	NR	NR	NR	0.1	26.3116	47.5164	47.3931
		25.2116	44.6141	41.4835	8.62918	11.9576	11.4839	37.5	17.5892	16.2824	16.471	37.5	NR	NR	NR	0.3	23.1516	43.7532	43.6916
	150	200.447	319.821	319.826	134.394	244.158	237.316	4	144.978	145.496	145.553	4	NR	NR	NR	0.01	723.876	1134.21	1076.15
		200.447	319.821	319.826	134.394	244.158	237.316	12.5	111.284	106.445	107.231	12.5	NR	NR	NR	0.1	290.872	395.112	401.57
		200.447	319.821	319.826	134.394	244.158	237.316	37.5	86.3595	80.8619	81.6215	37.5	NR	NR	NR	0.3	245.376	342.868	330.691
Inlet of Boil Off Compressor 2000-GB-02A/B(Butan	7	2.45641	3.57427	3.36176	1.63578	2.06461	1.99585	4	NR	NR	NR	4	NR	NR	NR	0.01	NR	NR	NR
		2.45641	3.57427	3.36176	1.63578	2.06461	1.99585	12.5	NR	NR	NR	12.5	NR	NR	NR	0.1	NR	NR	NR
		2.45641	3.57427	3.36176	1.63578	2.06461	1.99585	37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	NR	NR	NR
	25	8.44544	16.9822	15.956	5.1015	6.99531	6.66499	4	14.7788	14.4225	14.4778	4	NR	NR	NR	0.01	NR	36.5785	35.9817
		8.44544	16.9822	15.956	5.1015	6.99531	6.66499	12.5	11.8075	11.0018	11.118	12.5	NR	NR	NR	0.1	NR	14.6104	14.5068

Isolatable Section/Description	Release category	Flash Fire Effects: 0.5% LFL Ellipse			Flash Fire Effects: 100% LFL Ellipse			Radiation Effects: Jet Fire Ellipse				Radiation Effects: Pool Fire				Overpressure			
		Distance in meters			Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Over-pressure level bar	Distance in meters		
		5D	1.5F	2F	5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F
e rich BOG) To Inlet of Bullet 2000-FA-08		8.44544	16.9822	15.956	5.1015	6.99531	6.66499	37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	NR	12.3021	12.2504
	150	106.375	192.361	154.192	71.0223	122.021	108.628	4	85.4202	85.5175	85.6015	4	NR	NR	NR	0.01	373.054	636.474	585.652
		106.375	192.361	154.192	71.0223	122.021	108.628	12.5	67.1765	62.8469	63.5541	12.5	NR	NR	NR	0.1	147.364	242.65	225.569
		106.375	192.361	154.192	71.0223	122.021	108.628	37.5	53.0092	47.5393	48.3427	37.5	NR	NR	NR	0.3	123.651	201.27	187.734
Inlet of Boil Off Compressor 2000-GB-02A/B(Propylene rich BOG) To Inlet of Bullet 2000-FA-08	7	3.74988	5.37039	5.07568	2.44292	3.03678	2.94537	4	5.11187	5.28508	5.27753	4	NR	NR	NR	0.01	NR	NR	NR
		3.74988	5.37039	5.07568	2.44292	3.03678	2.94537	12.5	NR	NR	NR	12.5	NR	NR	NR	0.1	NR	NR	NR
		3.74988	5.37039	5.07568	2.44292	3.03678	2.94537	37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	NR	NR	NR
	25	22.3451	39.7375	37.8588	7.89982	10.7341	10.3657	4	23.1513	23.1449	23.1507	4	NR	NR	NR	0.01	53.3822	69.0904	68.6161
		22.3451	39.7375	37.8588	7.89982	10.7341	10.3657	12.5	19.2151	18.622	18.7105	12.5	NR	NR	NR	0.1	25.7905	36.7807	36.6984
		22.3451	39.7375	37.8588	7.89982	10.7341	10.3657	37.5	15.7669	14.7774	14.9189	37.5	NR	NR	NR	0.3	22.8914	33.3858	33.3448
	150	195.067	329.94	297.749	129.692	244.385	199.975	4	134.061	134.213	134.277	4	NR	NR	NR	0.01	674.044	1067.71	1022.77
		195.067	329.94	297.749	129.692	244.385	199.975	12.5	103.747	99.3784	100.078	12.5	NR	NR	NR	0.1	273.963	408.373	417.108
		195.067	329.94	297.749	129.692	244.385	199.975	37.5	81.1141	76.0181	76.7142	37.5	NR	NR	NR	0.3	231.926	340.567	353.469
Propane from 2000 -GA-01A/B/C to Propane heater I, 2000-EA-05 &Propane heater II, 2000-EA-07 to static blender	7	19.761	31.425	28.524	11.2991	23.8286	21.2006	4	28.6403	32.5995	31.6409	4	NR	NR	NR	0.01	60.2337	152.037	120.419
		19.761	31.425	28.524	11.2991	23.8286	21.2006	12.5	21.9826	26.3452	25.2892	12.5	NR	NR	NR	0.1	18.7136	51.1687	37.4188
		19.761	31.425	28.524	11.2991	23.8286	21.2006	37.5	17.9353	22.4273	21.3381	37.5	NR	NR	NR	0.3	14.351	40.5703	28.6978
	25	69.8805	84.949	92.733	50.7261	75.225	67.8084	4	90.7644	102.242	99.4697	4	NR	NR	NR	0.01	331.136	713.254	606.746
		69.8805	84.949	92.733	50.7261	75.225	67.8084	12.5	69.0289	81.8424	78.7467	12.5	NR	NR	NR	0.1	107.032	198.111	171.37
		69.8805	84.949	92.733	50.7261	75.225	67.8084	37.5	56.0267	69.3661	66.1407	37.5	NR	NR	NR	0.3	83.4846	143.983	125.624
	150	332.293	511.80	452.15	228.004	373.582	319.509	4	448.824	499.767	487.531	4	384.649	388.834	392.24	0.01	1636.84	2534.65	2391.51
		332.293	511.80	452.15	228.004	373.582	319.509	12.5	337.395	394.824	380.99	12.5	264.012	246.374	252.914	0.1	548.421	705.959	710.059
		332.293	511.80	452.15	228.004	373.582	319.509	37.5	270.747	331.247	316.64	37.5	170.826	142.871	148.642	0.3	434.058	562.789	544.81
Butane from 2000-GA-02A/B/C to Butane heater I, 2000-EA-08 & Butane heater II,	7	20.040	31.591	28.678	11.5227	24.1719	21.5152	4	29.2466	32.9126	32.0248	4	NR	NR	NR	0.01	74.1382	156.082	123.826
		20.040	31.591	28.678	11.5227	24.1719	21.5152	12.5	22.1385	26.2542	25.2582	12.5	NR	NR	NR	0.1	29.3909	51.8705	38.0098
		20.040	31.591	28.678	11.5227	24.1719	21.5152	37.5	17.8779	22.1732	21.1338	37.5	NR	NR	NR	0.3	24.6892	40.9207	28.9929
	25	70.154	94.000	85.768	51.0051	77.1093	68.493	4	92.9257	103.529	100.971	4	NR	NR	NR	0.01	346.894	732.265	618.804
		70.154	94.000	85.768	51.0051	77.1093	68.493	12.5	69.7011	81.7708	78.8568	12.5	NR	NR	NR	0.1	118.031	201.408	173.462
		70.154	94.000	85.768	51.0051	77.1093	68.493	37.5	55.95	68.6765	65.5977	37.5	NR	NR	NR	0.3	93.9833	145.63	126.669
	150	315.764	467.07	422.24	221.611	363.052	316.332	4	441.45	507.849	496.596	4	422.199	427.104	430.462	0.01	1543.58	2571.79	2385.38

Isolatable Section/Description	Release category	Flash Fire Effects: 0.5% LFL Ellipse – Distance in meters 5D	1.5F	2F	Flash Fire Effects: 100% LFL Ellipse – Distance in meters 5D	1.5F	2F	Radiation Effects: Jet Fire Ellipse – Radiation Levels (kW/m2)	Distance in meters 5D	1.5F	2F	Radiation Effects: Pool Fire – Radiation Levels (kW/m2)	Distance in meters 5D	1.5F	2F	Overpressure – Over-pressure level bar	Distance in meters 5D	1.5F	2F
2000-EA-10 to Static blender		315.764	467.07	422.24	221.611	363.052	316.332	12.5	330.12	395.927	382.938	12.5	288.016	270.183	276.926	0.1	514.011	695.511	678.844
		315.764	467.07	422.24	221.611	363.052	316.332	37.5	263.714	328.735	314.856	37.5	188.405	156.971	163.396	0.3	406.863	542.383	524.217
Propylene from 2000-GA-02A/B/C to heater I, 2000-EA-08 & Propylene heater II, 2000-EA-10 to Static blender	7	19.844	31.462	28.529	11.3612	23.9377	21.3021	4	28.5746	32.6279	31.6498	4	NR	NR	NR	0.01	61.7557	155.459	123.806
		19.844	31.462	28.529	11.3612	23.9377	21.3021	12.5	22.0029	26.4434	25.3708	12.5	NR	NR	NR	0.1	18.9776	51.7623	38.0064
		19.844	31.462	28.529	11.3612	23.9377	21.3021	37.5	17.9849	22.5362	21.4337	37.5	NR	NR	NR	0.3	14.4829	40.8667	28.9912
	25	70.291	92.734	84.917	50.6028	74.3666	67.4316	4	90.4281	102.184	99.3588	4	NR	NR	NR	0.01	343.836	711.515	608.42
		70.291	92.734	84.917	50.6028	74.3666	67.4316	12.5	68.9988	82.0344	78.8932	12.5	NR	NR	NR	0.1	117.5	197.809	171.661
		70.291	92.734	84.917	50.6028	74.3666	67.4316	37.5	56.1259	69.6339	66.3678	37.5	NR	NR	NR	0.3	93.7184	143.833	125.769
	150	333.78	519.81	472.86	223.71	363.798	314.673	4	446.51	498.668	486.229	4	437.366	449.931	450.833	0.01	1632.17	2525.39	2390.76
		333.78	519.81	472.86	223.71	363.798	314.673	12.5	336.675	395.089	381.066	12.5	294.286	290.819	294.3	0.1	547.612	710.325	712.117
		333.78	519.81	472.86	223.71	363.798	314.673	37.5	270.824	332.113	317.333	37.5	207.007	186.668	192.342	0.3	433.655	556.628	540.831
Inlet of Flash & Off Gas Compressor 2000-GB-03A/B(Propane rich FOG)To Inlet of Bullet 2000-FA-07	7	3.95954	5.69831	5.38078	2.59431	3.23143	3.13617	4	5.77006	6.14799	6.10163	4	NR	NR	NR	0.01	NR	NR	NR
		3.95954	5.69831	5.38078	2.59431	3.23143	3.13617	12.5	NR	NR	NR	12.5	NR	NR	NR	0.1	NR	NR	NR
		3.95954	5.69831	5.38078	2.59431	3.23143	3.13617	37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	NR	NR	NR
	25	25.2116	44.6141	41.4835	8.62918	11.9576	11.4839	4	25.77	25.6478	25.6709	4	NR	NR	NR	0.01	56.3862	83.3316	82.6209
		25.2116	44.6141	41.4835	8.62918	11.9576	11.4839	12.5	21.3237	20.4915	20.6151	12.5	NR	NR	NR	0.1	26.3116	47.5164	47.3931
		25.2116	44.6141	41.4835	8.62918	11.9576	11.4839	37.5	17.5892	16.2824	16.471	37.5	NR	NR	NR	0.3	23.1516	43.7532	43.6916
	150	200.584	349.068	315.935	134.43	260.457	210.956	4	144.908	145.421	145.478	4	NR	NR	NR	0.01	723.645	1167.51	1124.99
		200.584	349.068	315.935	134.43	260.457	210.956	12.5	111.24	106.408	107.193	12.5	NR	NR	NR	0.1	290.832	425.683	451.37
		200.584	349.068	315.935	134.43	260.457	210.956	37.5	86.3319	80.8407	81.599	37.5	NR	NR	NR	0.3	245.356	367.265	380.591
Inlet of Flash & Off Gas Compressor 2000-GB-04A/B(Butane rich FOG) To Inlet of Bullet	7	2.47275	3.60481	3.38894	1.65008	2.08582	2.01659	4	NR	NR	NR	4	NR	NR	NR	0.01	NR	NR	NR
		2.47275	3.60481	3.38894	1.65008	2.08582	2.01659	12.5	NR	NR	NR	12.5	NR	NR	NR	0.1	NR	NR	NR
		2.47275	3.60481	3.38894	1.65008	2.08582	2.01659	37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	NR	NR	NR
	25	8.53475	17.3862	16.3397	5.14268	7.07018	6.72097	4	14.9219	14.5433	14.6019	4	NR	NR	NR	0.01	NR	36.868	36.1891
		8.53475	17.3862	16.3397	5.14268	7.07018	6.72097	12.5	11.9244	11.0832	11.2034	12.5	NR	NR	NR	0.1	NR	14.6606	14.5428
		8.53475	17.3862	16.3397	5.14268	7.07018	6.72097	37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	NR	12.3272	12.2684
	150	105.912	172.455	153.129	70.9915	122.296	108.688	4	85.6548	85.8061	85.8891	4	NR	NR	NR	0.01	374.617	654.652	591.271
		105.912	172.455	153.129	70.9915	122.296	108.688	12.5	67.3363	62.9594	63.6787	12.5	NR	NR	NR	0.1	147.636	254.069	226.544

Isolatable Section/Description	Release category	Flash Fire Effects: 0.5% LFL Ellipse			Flash Fire Effects: 100% LFL Ellipse			Radiation Effects: Jet Fire Ellipse				Radiation Effects: Pool Fire				Overpressure			
		Distance in meters			Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Radiation Levels (kW/m2)	Distance in meters			Over-pressure level bar	Distance in meters		
		5D	1.5F	2F	5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F		5D	1.5F	2F
2000-FA-08		105.912	172.455	153.129	70.9915	122.296	108.688	37.5	53.1171	47.5709	48.3869	37.5	NR	NR	NR	0.3	123.786	211.978	188.221
Inlet of Flash & Off Gas Compressor 2000-GB-04A/B(Propylene rich BOG) To Inlet of Bullet 2000-FA-08	7	3.75984	5.39311	5.09535	2.45411	3.05385	2.96217	4	5.13068	5.29607	5.28927	4	NR	NR	NR	0.01	NR	NR	NR
		3.75984	5.39311	5.09535	2.45411	3.05385	2.96217	12.5	NR	NR	NR	12.5	NR	NR	NR	0.1	NR	NR	NR
		3.75984	5.39311	5.09535	2.45411	3.05385	2.96217	37.5	NR	NR	NR	37.5	NR	NR	NR	0.3	NR	NR	NR
	25	22.5011	40.1051	37.9405	7.94576	10.8439	10.4094	4	23.2472	23.2237	23.232	4	NR	NR	NR	0.01	53.5631	79.4429	68.7383
		22.5011	40.1051	37.9405	7.94576	10.8439	10.4094	12.5	19.2892	18.6681	18.7608	12.5	NR	NR	NR	0.1	25.8219	46.8418	36.7196
		22.5011	40.1051	37.9405	7.94576	10.8439	10.4094	37.5	15.8213	14.7922	14.9399	37.5	NR	NR	NR	0.3	22.9071	43.4164	33.3553
	150	193.846	333.968	296.976	128.965	246.587	199.259	4	134.211	134.38	134.446	4	NR	NR	NR	0.01	674.291	1078.48	1029.12
		193.846	333.968	296.976	128.965	246.587	199.259	12.5	103.808	99.3808	100.096	12.5	NR	NR	NR	0.1	274.006	410.24	418.209
		193.846	333.968	296.976	128.965	246.587	199.259	37.5	81.1133	75.9729	76.6781	37.5	NR	NR	NR	0.3	231.947	343.568	354.019
Bullet 2000-FA-07 through Bullet Pump 2000-GA -07A/B To Static Blender(Propane Rich stream)	7	15.393	31.4454	27.8761	6.62655	9.94566	9.32763	4	21.9862	25.2871	24.4518	4	NR	NR	NR	0.01	39.9469	66.9189	55.8825
		15.393	31.4454	27.8761	6.62655	9.94566	9.32763	12.5	16.9759	20.5051	19.6324	12.5	NR	NR	NR	0.1	15.1946	36.404	26.2242
		15.393	31.4454	27.8761	6.62655	9.94566	9.32763	37.5	13.9611	17.5581	16.6875	37.5	NR	NR	NR	0.3	12.5939	33.1977	23.108
	25	73.9247	117.339	104.627	50.358	88.9154	77.6929	4	70.8513	80.8057	78.2743	4	NR	NR	NR	0.01	270.677	500.108	439.698
		73.9247	117.339	104.627	50.358	88.9154	77.6929	12.5	54.4237	65.1486	62.4967	12.5	NR	NR	NR	0.1	104.81	177.669	158.925
		73.9247	117.339	104.627	50.358	88.9154	77.6929	37.5	44.7288	55.7172	53.0473	37.5	NR	NR	NR	0.3	87.3817	143.789	129.423
	150	377.4	692.051	606.159	277.529	549.239	472.385	4	346.189	403.16	391.408	4	NR	NR	NR	0.01	1755.09	3733	3221.82
		377.4	692.051	606.159	277.529	549.239	472.385	12.5	264.98	321.556	309.162	12.5	NR	NR	NR	0.1	610.261	1217.84	1054.79
		377.4	692.051	606.159	277.529	549.239	472.385	37.5	216.785	272.573	259.986	37.5	NR	NR	NR	0.3	489.971	953.571	827.091
Bullet 2000-FA-08 through Bullet Pump 2000-GA -08A/B To Static Blender(Butane Rich stream)	7	18.0602	32.9234	29.4777	8.72707	18.2068	15.9082	4	25.873	29.166	28.3313	4	NR	NR	NR	0.01	49.2502	94.6799	80.357
		18.0602	32.9234	29.4777	8.72707	18.2068	15.9082	12.5	19.6235	23.304	22.3954	12.5	NR	NR	NR	0.1	16.8084	41.2195	30.4696
		18.0602	32.9234	29.4777	8.72707	18.2068	15.9082	37.5	15.8982	19.7442	18.8067	37.5	NR	NR	NR	0.3	13.3997	35.6023	25.2279
	25	72.3968	105.704	95.1811	51.8335	84.5054	75.4253	4	82.834	92.5141	90.0481	4	NR	NR	NR	0.01	314.625	635.469	549.553
		72.3968	105.704	95.1811	51.8335	84.5054	75.4253	12.5	62.3516	73.3069	70.5951	12.5	NR	NR	NR	0.1	112.433	192.883	169.715
		72.3968	105.704	95.1811	51.8335	84.5054	75.4253	37.5	50.299	61.8356	59.0224	37.5	NR	NR	NR	0.3	91.1883	146.38	129.804
	150	360.661	622.827	540.527	261.807	499.795	420.565	4	384.434	458.029	446.927	4	178.057	267.805	268.903	0.01	1828.95	4095.64	3440.8
		360.661	622.827	540.527	261.807	499.795	420.565	12.5	290.582	358.573	346.232	12.5	132.748	177.183	181.202	0.1	614.807	1222.89	1043.18
		360.661	622.827	540.527	261.807	499.795	420.565	37.5	234.759	299.176	286.246	37.5	97.9639	110.99	115.047	0.3	487.234	921.044	791.255
Bullet 2000-FA-08	7	15.5519	31.7013	28.0916	6.65713	10.0513	9.44351	4	21.362	24.6549	23.8245	4	NR	NR	NR	0.01	39.7807	66.7162	55.7614
		15.5519	31.7013	28.0916	6.65713	10.0513	9.44351	12.5	16.5553	20.0587	19.1968	12.5	NR	NR	NR	0.1	15.1658	36.3689	26.2032

Isolatable Section/Description	Release category	Flash Fire Effects: 0.5% LFL Ellipse – Distance in meters 5D	1.5F	2F	Flash Fire Effects: 100% LFL Ellipse – Distance in meters 5D	1.5F	2F	Radiation Effects: Jet Fire Ellipse – Radiation Levels (kW/m2)	Distance in meters 5D	1.5F	2F	Radiation Effects: Pool Fire – Radiation Levels (kW/m2)	Distance in meters 5D	1.5F	2F	Overpressure – Over-pressure level bar	Distance in meters 5D	1.5F	2F
through Bullet Pump 2000-GA -08A/B To Static Blender(Propylene Rich stream)		15.5519	31.7013	28.0916	6.65713	10.0513	9.44351	37.5	13.6536	17.215	16.35	37.5	NR	NR	NR	0.3	12.5795	33.1802	23.0975
	25	74.7468	118.35	105.513	50.9086	89.4158	78.2911	4	68.8686	78.8204	76.2963	4	NR	NR	NR	0.01	269.355	493.622	434.984
		74.7468	118.35	105.513	50.9086	89.4158	78.2911	12.5	53.1168	63.7821	61.1481	12.5	NR	NR	NR	0.1	104.58	176.544	158.107
		74.7468	118.35	105.513	50.9086	89.4158	78.2911	37.5	43.8033	54.6917	52.0498	37.5	NR	NR	NR	0.3	87.2672	143.228	129.015
	150	382.916	696.441	611.555	279.588	553.017	474.306	4	342.116	393.336	381.595	4	NR	NR	NR	0.01	1766.46	3690.47	3193.18
		382.916	696.441	611.555	279.588	553.017	474.306	12.5	262.03	314.896	302.567	12.5	NR	NR	NR	0.1	620.498	1210.47	1058.08
		382.916	696.441	611.555	279.588	553.017	474.306	37.5	214.513	267.709	255.224	37.5	NR	NR	NR	0.3	500.089	949.888	833.743
Mercaptan Dosing System 2000-CS-01 To Static Blender	7	8.76848	20.4176	17.7923	5.10721	7.68888	7.17258	4	23.5058	27.679	26.6694	4	21.3157	23.6326	23.3148	0.01	NR	50.025	39.1027
		8.76848	20.4176	17.7923	5.10721	7.68888	7.17258	12.5	18.7109	23.1002	22.0398	12.5	16.8955	17.0496	17.1706	0.1	NR	25.2082	15.0482
		8.76848	20.4176	17.7923	5.10721	7.68888	7.17258	37.5	15.5379	19.7614	18.7482	37.5	12.1308	12.8416	12.5558	0.3	NR	22.6006	12.5207
	25	41.7166	63.6041	57.0692	28.0319	49.5263	43.2257	4	74.0322	86.2239	83.2895	4	57.5445	58.5861	58.7422	0.01	159.92	287.457	244.99
		41.7166	63.6041	57.0692	28.0319	49.5263	43.2257	12.5	58.5121	71.4845	68.3505	12.5	43.5203	40.6053	41.6678	0.1	60.8016	99.4551	83.8234
		41.7166	63.6041	57.0692	28.0319	49.5263	43.2257	37.5	48.6416	61.5374	58.393	37.5	26.3682	25.5562	25.7562	0.3	50.387	79.7013	66.8892
Static Blender outlet to Tanker Loading Bay	7	13.6154	28.3587	25.1053	6.27307	10.5873	9.90391	4	20.7819	23.8571	23.0804	4	NR	NR	NR	0.01	39.8233	58.8711	57.8912
		13.6154	28.3587	25.1053	6.27307	10.5873	9.90391	12.5	16.0653	19.3962	18.5737	12.5	NR	NR	NR	0.1	15.1732	26.7426	26.5727
		13.6154	28.3587	25.1053	6.27307	10.5873	9.90391	37.5	13.1989	16.6142	15.7855	37.5	NR	NR	NR	0.3	12.5832	23.3668	23.282
	25	64.3399	96.2879	86.7139	44.8784	75.7985	66.7298	4	66.7074	75.8667	73.5449	4	NR	NR	NR	0.01	251.737	493.866	422.679
		64.3399	96.2879	86.7139	44.8784	75.7985	66.7298	12.5	51.2749	61.2991	58.8218	12.5	NR	NR	NR	0.1	93.2591	160.055	139.442
		64.3399	96.2879	86.7139	44.8784	75.7985	66.7298	37.5	42.111	52.4465	49.9368	37.5	NR	NR	NR	0.3	76.6074	124.981	109.681
	150	325.171	622.282	594.779	235.55	514.597	492.699	4	334.771	376.434	365.819	4	NR	NR	NR	0.01	1559.32	2656.32	2609.2
		325.171	622.282	594.779	235.55	514.597	492.699	12.5	254.438	300.485	289.077	12.5	NR	NR	NR	0.1	534.975	931.757	894.491
		325.171	622.282	594.779	235.55	514.597	492.699	37.5	206.721	254.722	243.02	37.5	NR	NR	NR	0.3	427.345	769.024	733.982

*NH- No Hazard, NR- Not Reached

7 FREQUENCY ANALYSIS

7.1 Overview

Frequency of occurrence of the representative hazardous events needs to be evaluated by referencing appropriate generic industry data. Both generic industry and company / vendor based information has been used, and particular care has been taken to ensure its validity. Generic failure data was applied where site specific or company / vendor data is not available.

Initiating event failure frequencies for each case developed have been estimated using various sources (listed in order of preference) including:

- TNO Guidelines for Quantitative Risk Assessment (Purple Book);
- OGP Risk Assessment Data Directory, Process Release Frequencies, 2010; and
- Health & Safety Executive (HSE) failure rates & event data for land use planning.

Given the potential for release from each of these scenarios, an event tree of possible outcomes has been developed using this individual component failure data. The table given below shows the frequency of failure of the selected isolatable sections calculated by parts count.

7.2 Event tree analysis

A release can result in several possible outcomes or scenarios (fire, explosions, un-ignited release etc.). A specific outcome for a release scenario may be dependent on other unrelated events following the initial release. Event tree analysis is used to identify potential outcomes of a release and to quantify the risk associated with each of these outcomes. The event tree for this QRA study is shown in **Figure 7**:

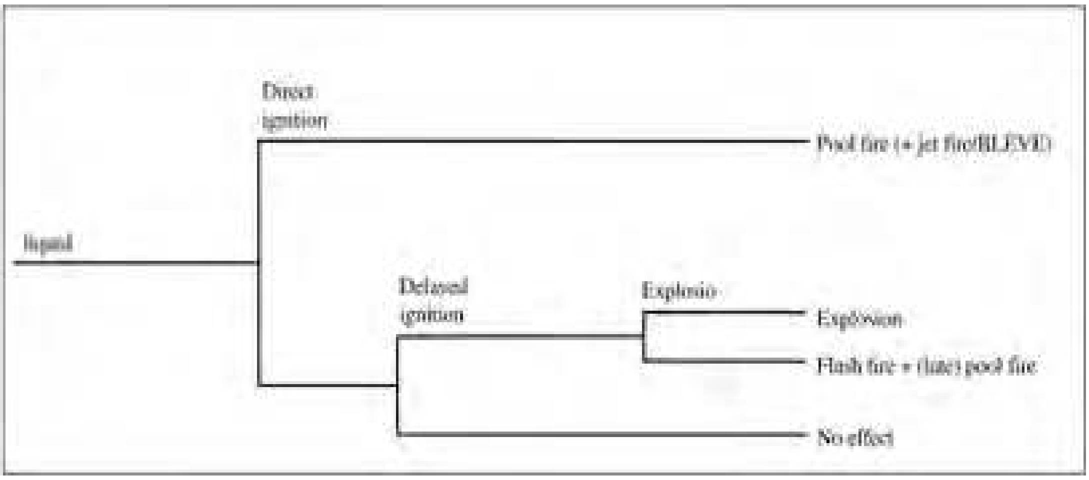


Figure 7: Event Tree

For calculating the frequency used for modeling, the following modification factors were taken into consideration:

- Design/Quality Maintenance
- Time is use

Table 7: Failure Frequency of an Event

Isolatable Sections	Description	Scenario	Total Frequency
IS-1	Transfer of Propane from Jetty to Storage Tank 2000-FB-01	7	1.94E-04
IS-2		25	1.06E-06
IS-3		150	1.25E-07
IS-4	Transfer of Butane from Jetty to Storage Tank 2000-FB-02	7	1.49E-04
IS-5		25	8.78E-07
IS-6		150	6.83E-08
IS-7	Transfer of Propylene from Jetty to Storage Tank 2000-FB-02	7	1.49E-04
IS-8		25	8.78E-07
IS-9		150	6.83E-08
IS-10	Propylene precooling line	7	1.69E-04
IS-11		25	5.00E-06
IS-12		150	5.00E-06
IS-13	Methanol P/L	10	2.28E-06
IS-14		150	1.44E-08
IS-15	MS P/L	10	2.50E-06
IS-16		150	1.58E-08
IS-17	HSD P/L	10	7.03E-06
IS-18		150	4.56E-08

Isolatable Sections	Description	Scenario	Total Frequency
IS-19	SKO P/L	10	4.94E-06
IS-20		150	3.12E-08
IS-21	Furnace Oil	10	1.20E-05
IS-22		150	7.56E-08
IS-23	Crude	10	4.05E-07
IS-24		150	1.26E-08
IS-25	Inlet of Boil Off Compressor 2000-GB-01A/B(Propane rich BOG)To Inlet of Bullet 2000-FA-07	7	1.92E-04
IS-26		25	1.32E-06
IS-27		150	2.88E-07
IS-28	Inlet of Boil Off Compressor 2000-GB-02A/B(Butane rich BOG) To Inlet of Bullet 2000-FA-08	7	1.98E-04
IS-29		25	1.35E-06
IS-30		150	2.90E-07
IS-31	Inlet of Boil Off Compressor 2000-GB-02A/B(Propylene rich BOG) To Inlet of Bullet 2000-FA-08	7	1.98E-04
IS-32		25	1.35E-06
IS-33		150	2.90E-07
IS-34	Propane from 2000 -GA-01A/B/C to Propane heater I, 2000-EA-05 &Propane heater II, 2000-EA-07	7	2.99E-04
IS-35		25	1.35E-06
IS-36		150	2.90E-07
IS-37	Butane from 2000-GA-02A/B/C to	7	2.97E-04

Isolatable Sections	Description	Scenario	Total Frequency
IS-38	Butane heater I, 2000-EA-08 & Butane heater II, 2000-EA-10 to Static blender	25	1.57E-06
IS-39		150	1.97E-07
IS-40	Propylene from 2000-GA-02A/B/C to heater I, 2000-EA-08 & Propylene heater II, 2000-EA-10 to Static blender	7	2.97E-04
IS-41		25	1.57E-06
IS-42		150	1.97E-07
IS-43	Inlet of Flash & Off Gas Compressor 2000-GB-03A/B(Propane rich FOG)To Inlet of Bullet 2000-FA-07	7	8.98E-05
IS-44		25	4.36E-07
IS-45		150	4.02E-08
IS-46	Inlet of Flash & Off Gas Compressor 2000-GB-04A/B(Butane rich FOG) To Inlet of Bullet 2000-FA-08	7	1.19E-04
IS-47		25	7.76E-07
IS-48		150	1.53E-07
IS-49	Inlet of Flash & Off Gas Compressor 2000-GB-04A/B(Propylene rich BOG) To Inlet of Bullet 2000-FA-08	7	1.19E-04
IS-50		25	7.76E-07
IS-51		150	1.53E-07
IS-52	Bullet 2000-FA-07 through Bullet Pump 2000-GA -07A/B To Static Blender(Propane Rich stream)	7	9.77E-05
IS-53		25	4.60E-07
IS-54		150	5.36E-08
IS-55	Bullet 2000-FA-08 through Bullet Pump 2000-GA -08A/B To Static Blender(Butane Rich stream)	7	9.77E-05
IS-56		25	4.60E-07

Isolatable Sections	Description	Scenario	Total Frequency
IS-57		150	5.36E-08
IS-58	Bullet 2000-FA-08 through Bullet Pump 2000-GA -08A/B To Static Blender(Propylene Rich stream)	7	9.77E-05
IS-59		25	4.60E-07
IS-60		150	5.36E-08
IS-61	Mercaptan Dosing System 2000-CS-01 To Static Blender	7	1.75E-05
IS-62		25	1.08E-07
IS-63	Static Blender outlet to Tanker Loading Bay	7	1.26E-04
IS-64		25	7.95E-07
IS-65		150	8.37E-08

8 RISK ASSESSMENT & PRESENTATION

8.1 Overview

Risk is often defined as a function of the likelihood that a specified undesired event will occur, and the severity of the consequences of that event. Risk is derived from the product of likelihood and potential consequence. Risk in general is a measure of potential economic loss or human injury in terms of the probability of the loss or injury occurring and magnitude of the loss or injury if it occurs.

$$Risk = f\,(\text{Severity, Frequency})$$

Quantification of effects of the hazardous event were done using the Event Tree approach in which all the possible outcomes of the hazardous event were considered and the likelihood of each type of end event determined. This step in the process involves the use of consequence modelling to predict both physical phenomena such as dispersion of gas, size and duration of fires, overpressures due to explosions, and the performance of equipment and systems such as availability of a fire & gas detection system, availability of emergency shutdown system, and availability of fire protection system. The end result of this phase of the assessment is a series of "end events", together with their estimated frequency of occurrence.

8.2 Risk Results

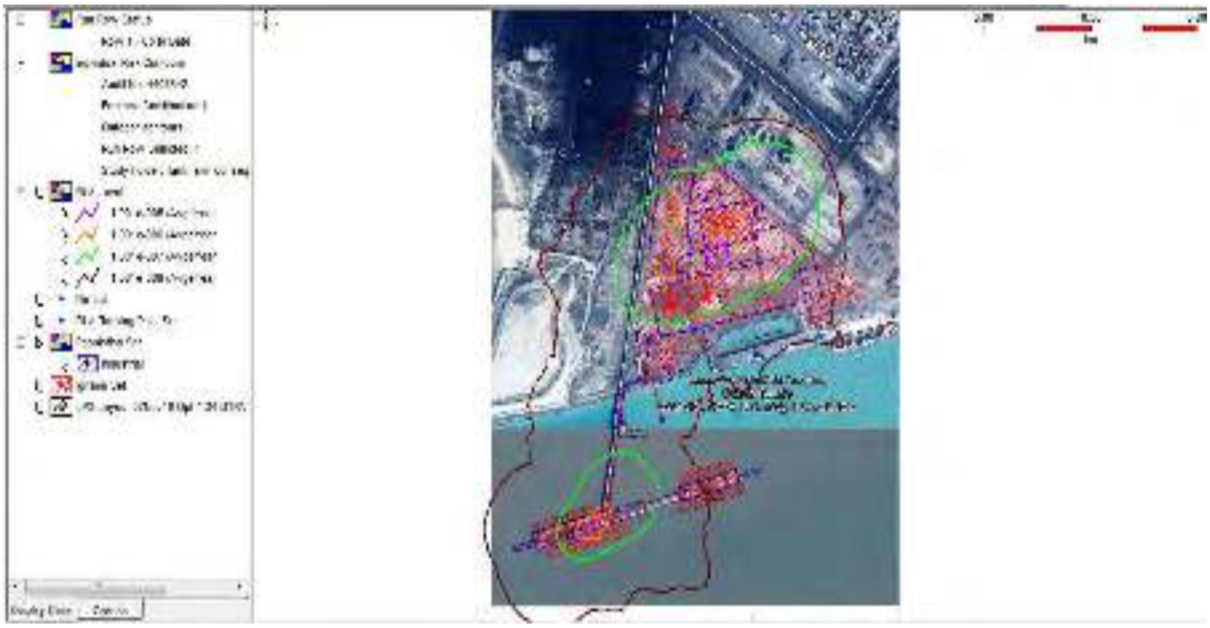
The risk modelling has been performed using DNV PHAST RISK 6.7 software. Thereby, the details of the input data used for the risk modelling such as vulnerability criteria, ignition probability and occupancy data are given in the QRA Assumption Register (Appendix 2). The results of a QRA are expressed using Individual Risk Contours and Societal Risk Graphs.

The Individual Risk represents the frequency of an individual dying due to loss of containment events (LOCs). The individual is assumed to be unprotected and to be present during the total exposure time. The Individual Risk is presented as contour lines on a topographic map.

The Societal Risk represents the frequency of having an accident with N or more people being killed simultaneously. The people involved are assumed to have some means of protection. The Societal Risk is presented as an F-N curve, where N is the number of deaths and F the cumulative frequency of accidents with N or more deaths.

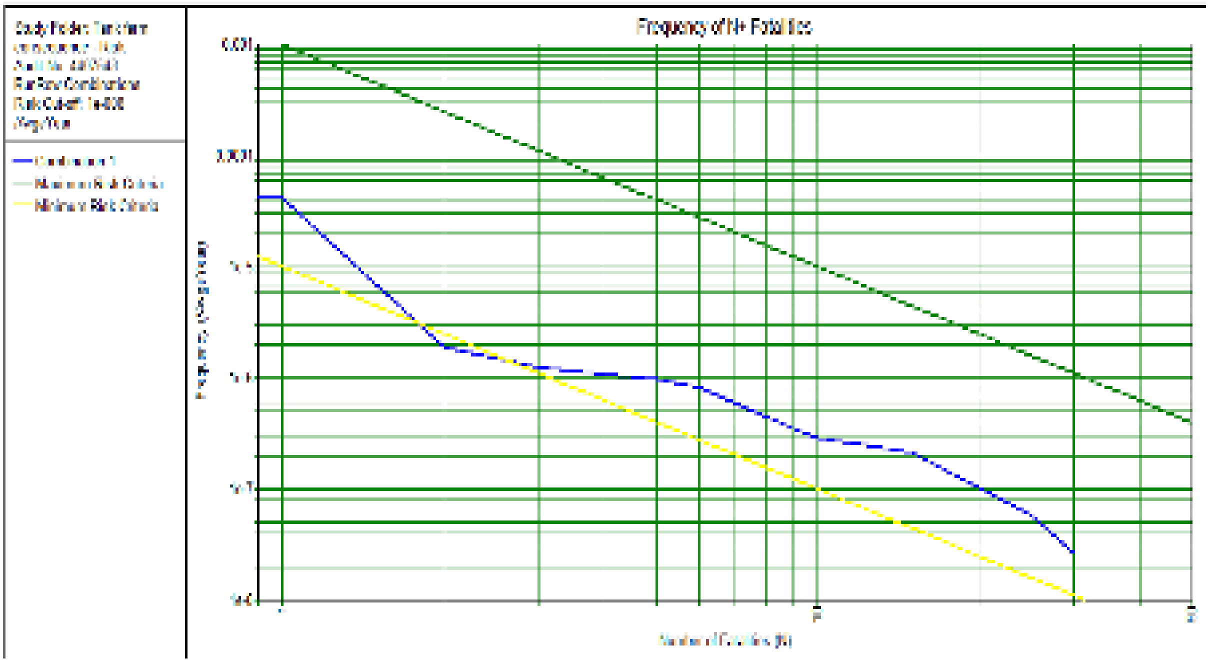
The Individual Risk estimated due to the activities being conducted at the Adani Mundra port is represented by a risk contour in the Figure 8 below.

Figure 8: Risk Contour



The Societal Risk pertaining to group of individuals is represented in **Figure 9**.

Figure 9: FN Curve



9 RECOMMENDATIONS

The Following measures shall be implemented for safe operation

1. F&G mapping study to be carried to identify the location of the detectors and voting logic to be used to ensure tripping of the unit, in case of any hydrocarbon leak
2. Hydraulic analysis and simulation study to be carried out, to operate heating trains at the minimum pressure possible to reduce the effects of LFL and jet fire scenarios
3. Consider converting level indications on Propane BOG / Flash Condensate Receiver (2000-FA-05) and Butane BOG / Flash Condensate Receiver (2000-FA-06) as 1oo2 voting logic for tripping on low level and average selection control philosophy for controlling the level to improve the reliability
4. Consider shifting the PSV on the inlet of the CW supply header of Propane BOG / Flash Condenser (2000-EA-03) and Butane BOG / Flash Condenser (2000-EA-04) to return header with reduced set point and LFL sensors at the outlet of the PSV
5. Consider providing discharge PT on 2000-GA-05/06 discharge common header with alarm provision
6. Revisit fail safe conditions of ROV-063/64 (considered as fail open) by HAZOP study
7. Consider additional PSV on Propane BOG / Flash Condensate Receiver (2000-FA-05) and Butane BOG / Flash Condensate Receiver (2000-FA-06) to increase the reliability and standby condition in case of maintenance of other PSV (same nozzle with separate isolation valves)
8. Consider providing remote operated sprinklers systems based on LFL sensors covering Propane BOG / Flash Condensate Receiver (2000-FA-05) and Butane BOG / Flash Condensate Receiver (2000-FA-06) and propane and butane handling pumps.
9. Consider trip logic for the steam boilers based LFL sensors on the tank farm
10. Consider shifting the PSV-063/PSV-034 provided downstream ROV-063 and ROV-064 relocated to Propane BOG / Flash Condensate Pumps (2000-GA-05) and Butane BOG / Flash Condensate Pumps (2000-GA-06) common discharge headers.

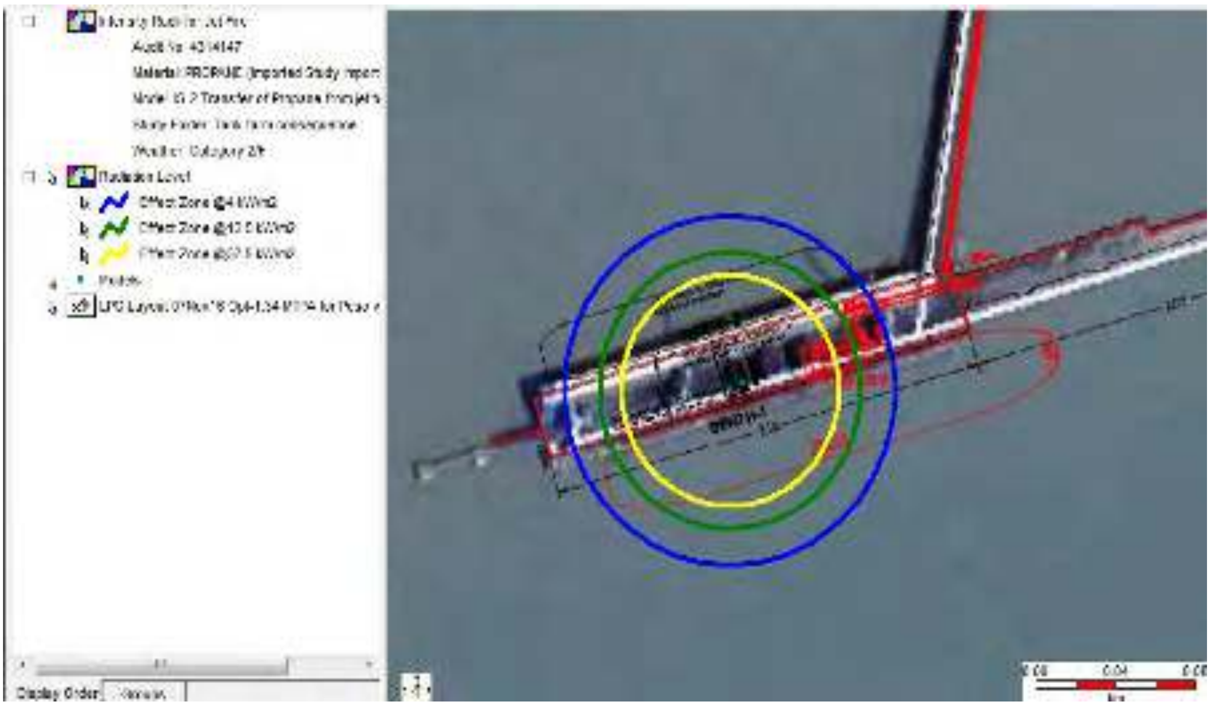
11. Consider voting logic between PT-016/017/018 for tripping on high and low pressure interlocks of the propane and butane tanks and MID point selection control philosophy for controlling the tank pressure to improve the reliability
12. Provide flow meters in N2 line to PSV headers to ensure continuous flow of N2
13. Ensure SOP developed and followed on all critical activities, interlocks checking before unloading operations
14. SOP and work instructions on display in local and English near the critical activity locations
15. Consider HAZOP and SIL study before commissioning the facility and concerns addressed
16. Ensure CCTV coverage of critical locations and remote monitoring is done continuously
17. Ensure all portable electrical equipment used in the location are Ex rated and covered under PTW systems, and certified
18. Selection of electrical and other instruments based on hazardous area classification (IS 5572: 2008)
19. All flanges shall be connected for bonding for electrical continuity and earthing of the equipment's to be ensured as per IS-3043
20. Lightning protection shall be provided as per the requirements of IS:2309
21. Periodical maintenance schedule should be implemented and meticulously followed
22. F&G systems management to be inspected periodically and availability ensured
23. Periodical inspection of pipeline and drain systems

APPENDIX 1 CONSEQUENCE CONTOURS

PROPANE PIPELINE FROM BERTH 1 - 25mm LEAK

FLASH FIRE

JET FIRE

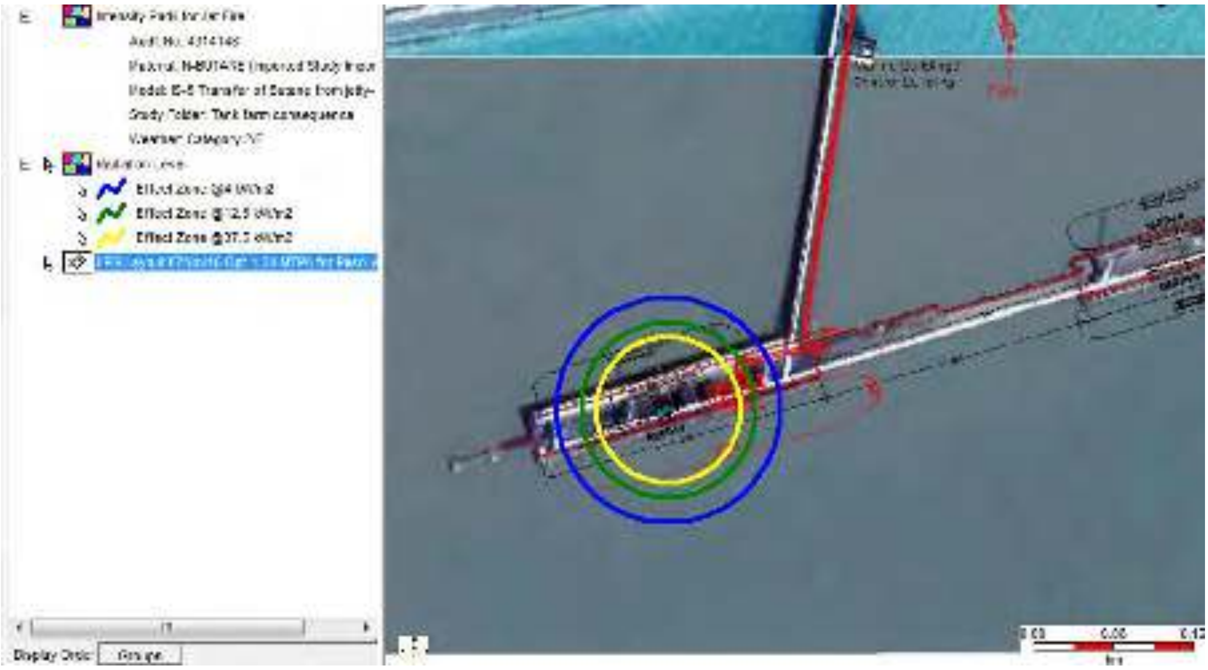


EXPLOSION

BUTANE PIPELINE FROM BERTH 1- 25mm LEAK

FLASH FIRE

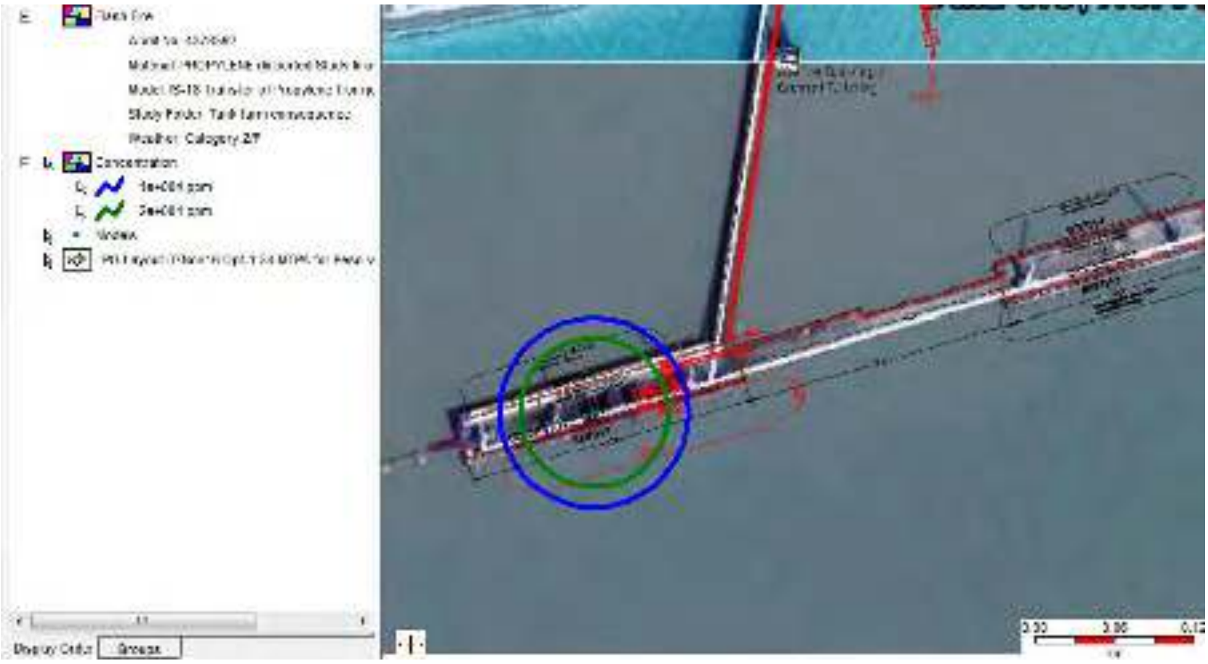
JET FIRE



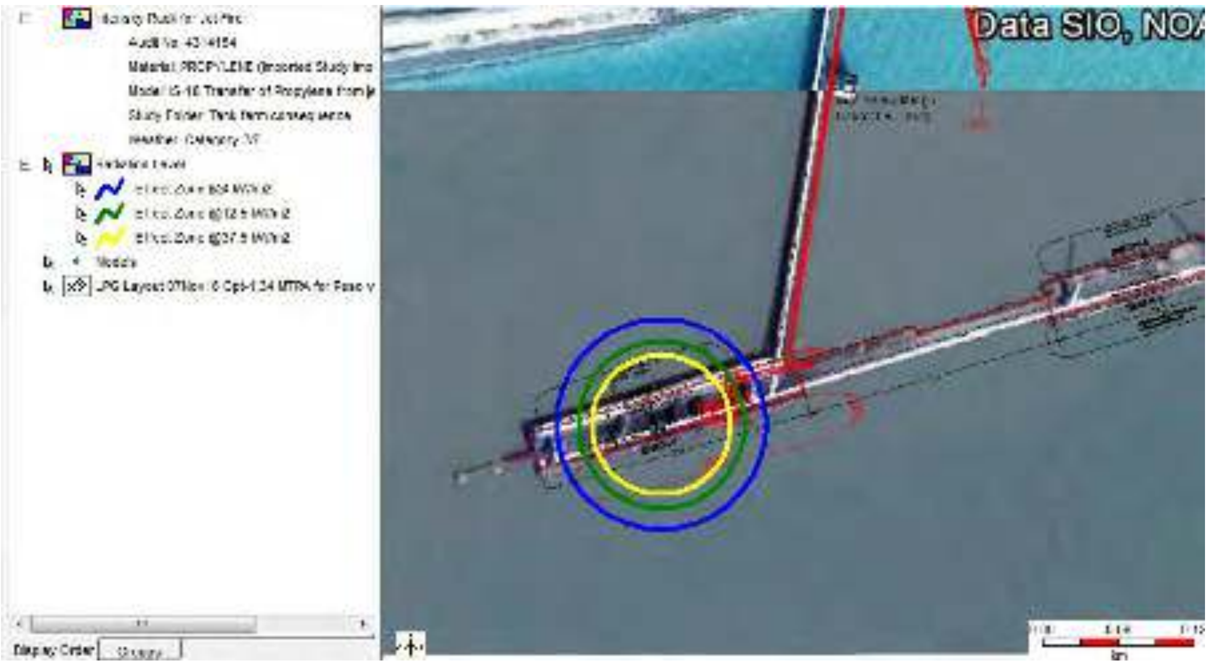
EXPLOSION

PROPYLENE PIPELINE FROM BERTH 1-25 mm LEAK

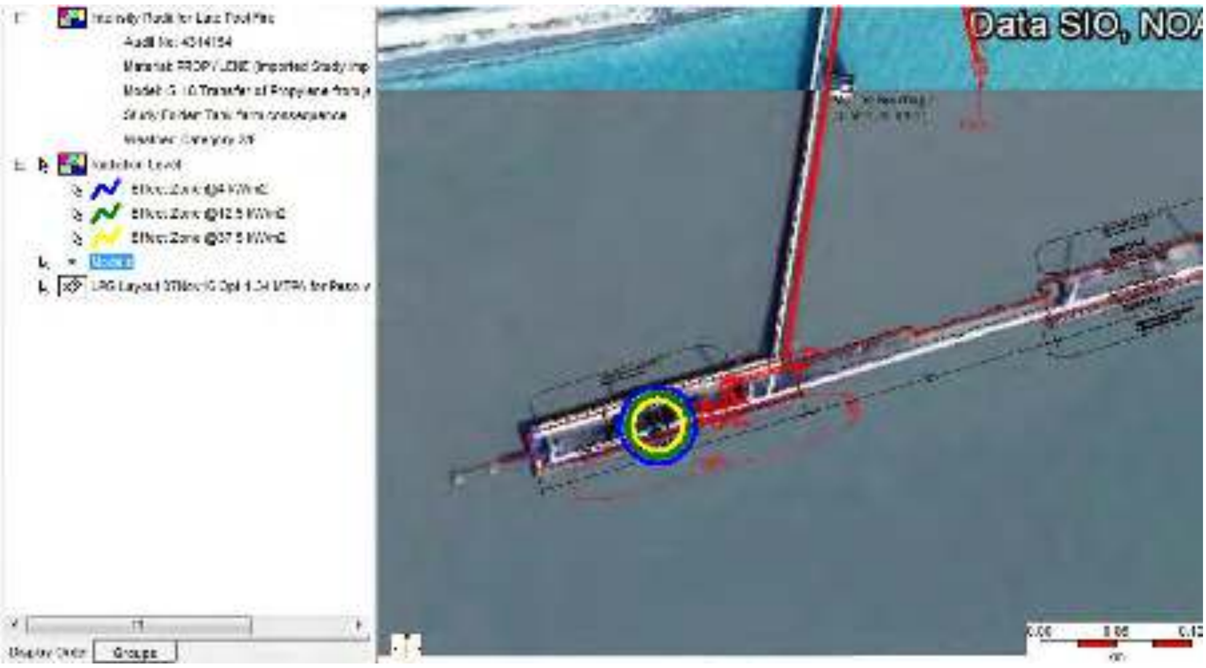
FLASH FIRE



JET FIRE



POOL FIRE



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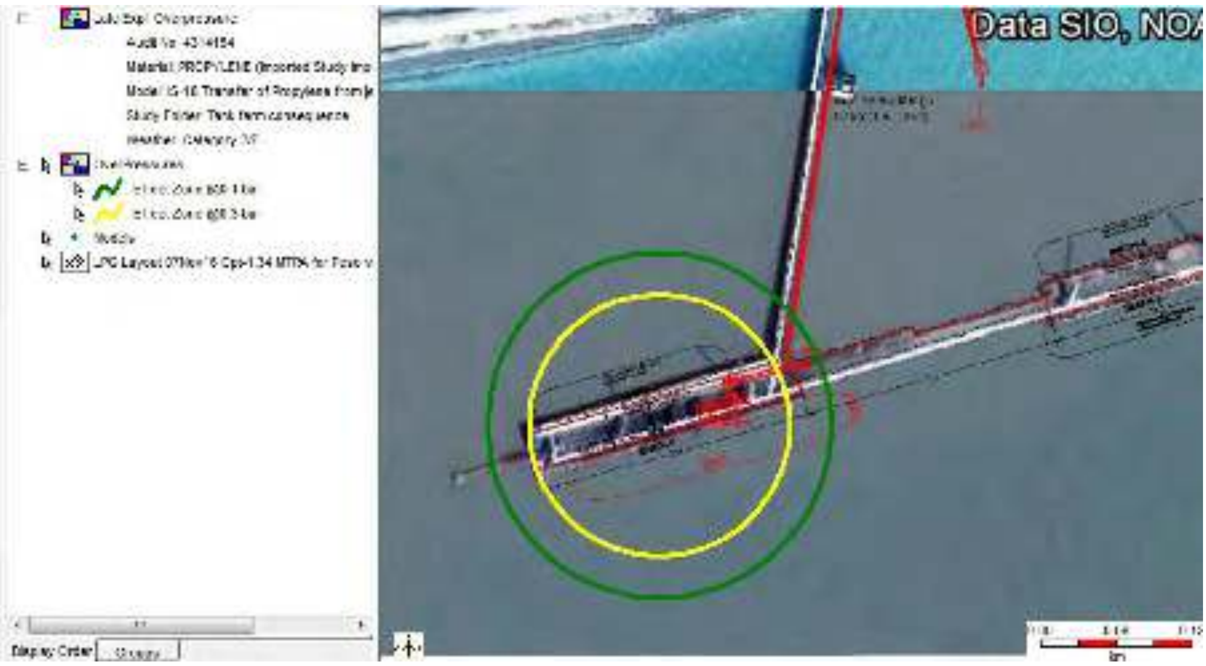
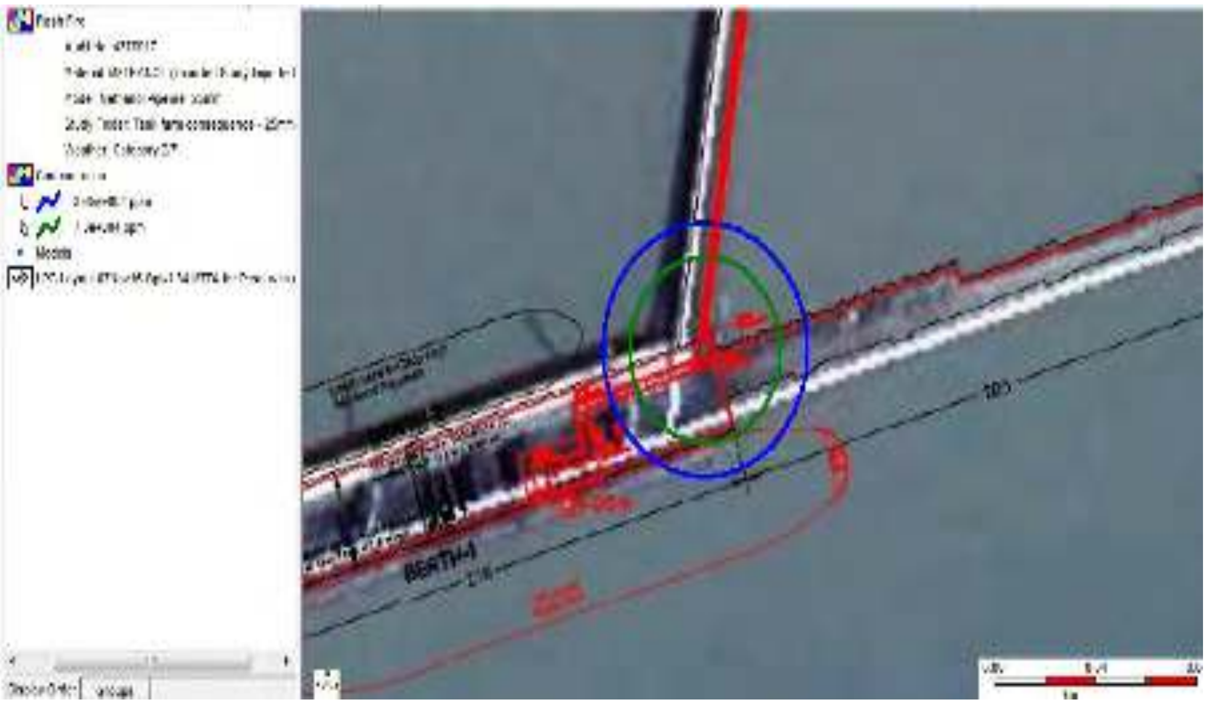
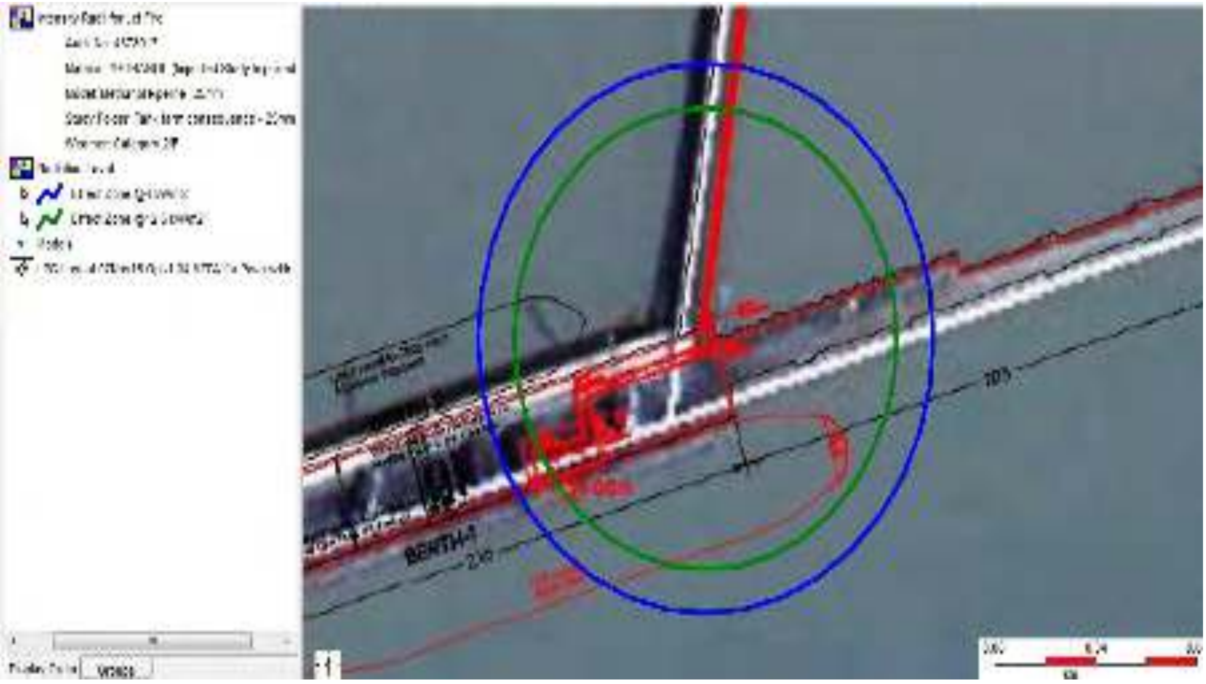


METHANOL PIPELINE FROM BERTH 2-25 mm LEAK

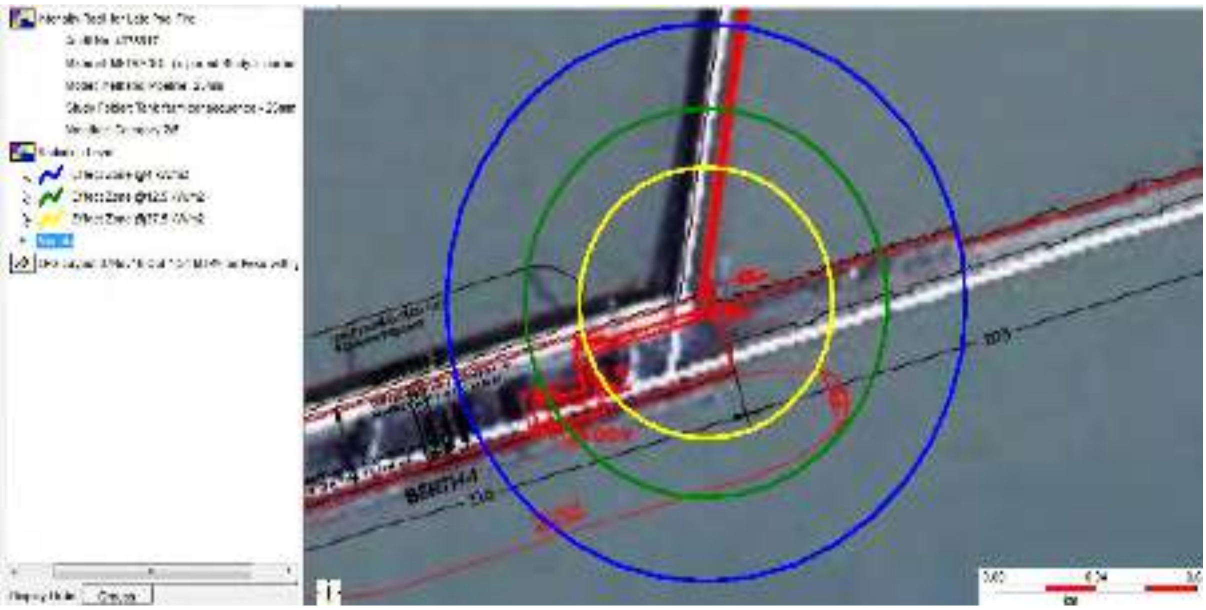
FLASH FIRE



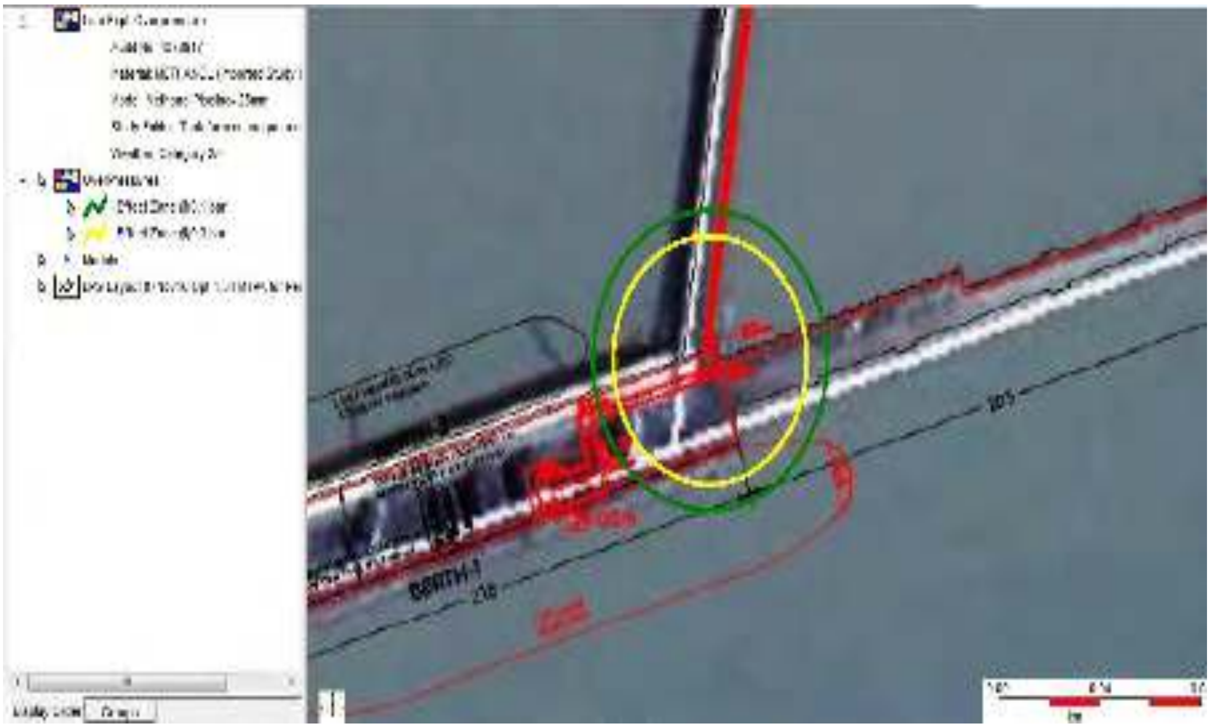
JET FIRE



POOL FIRE

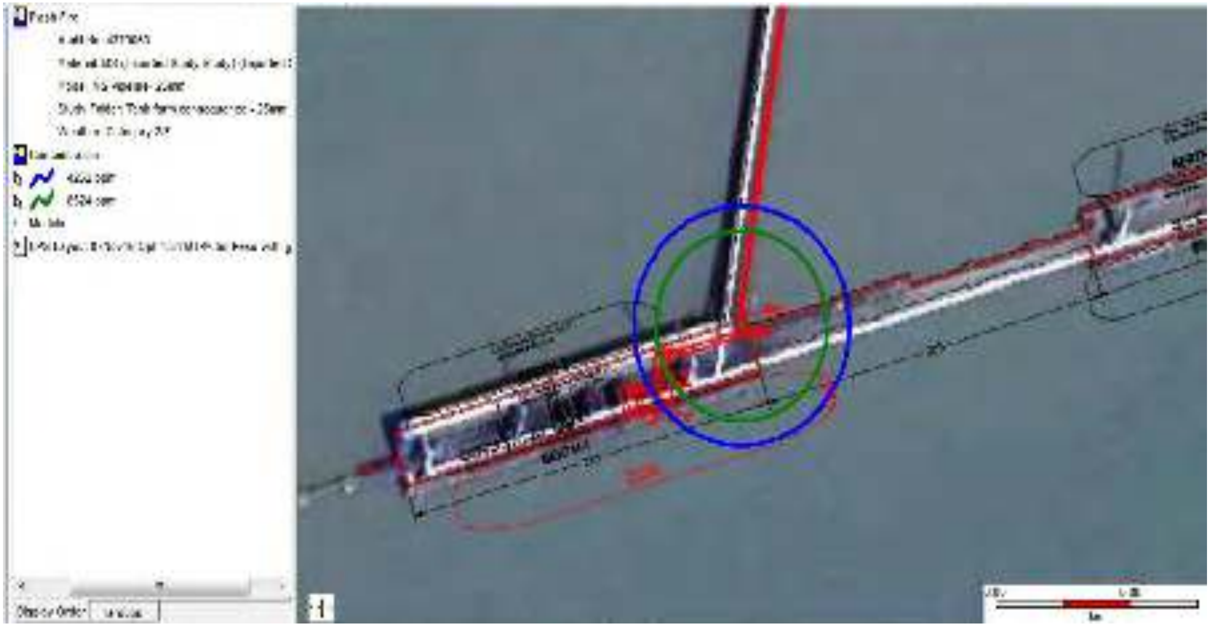


EXPLOSION

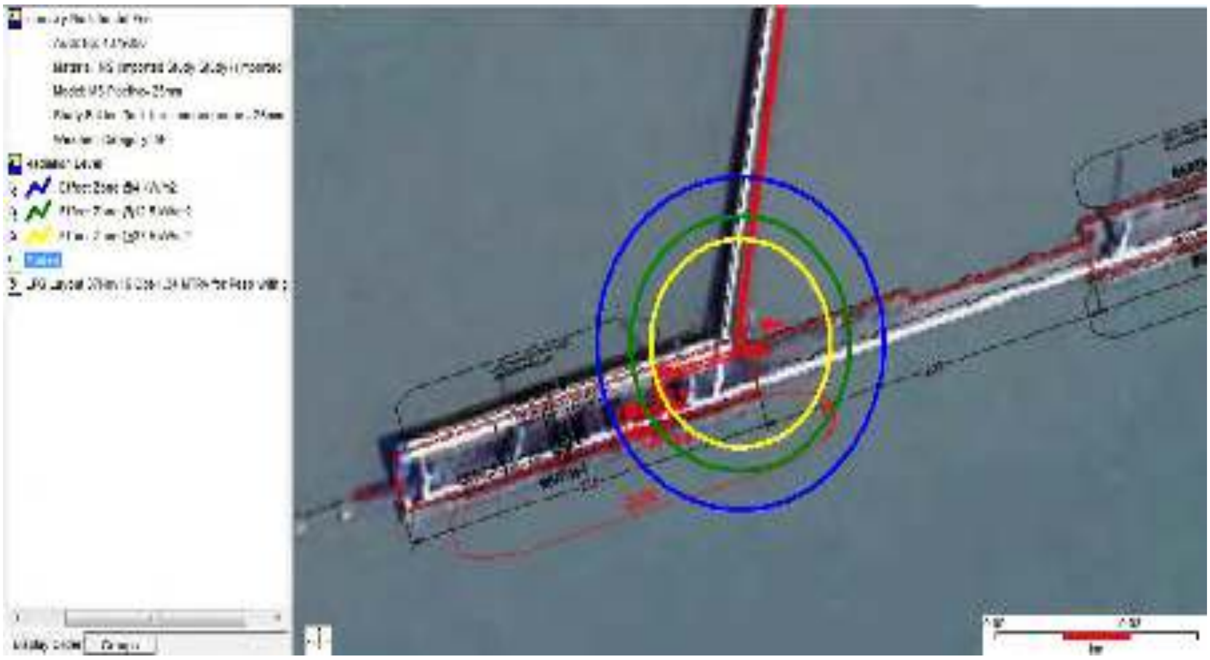


MS PIPELINE FROM BERTH 2-25 mm LEAK

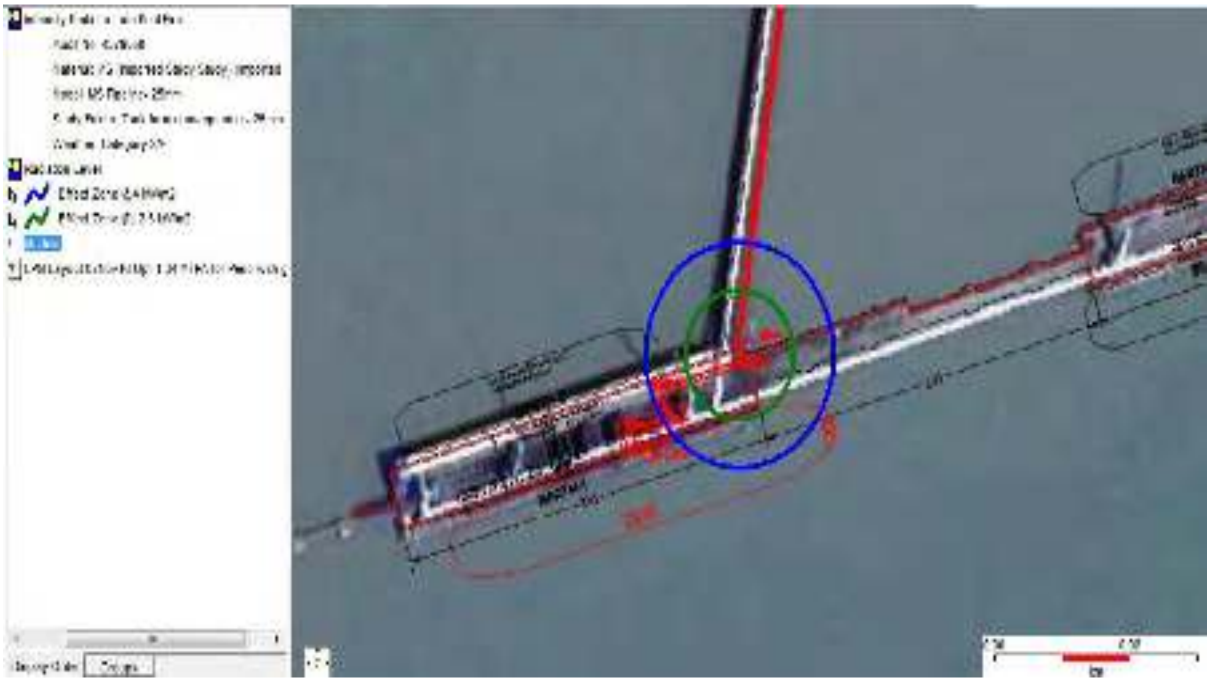
FLASH FIRE



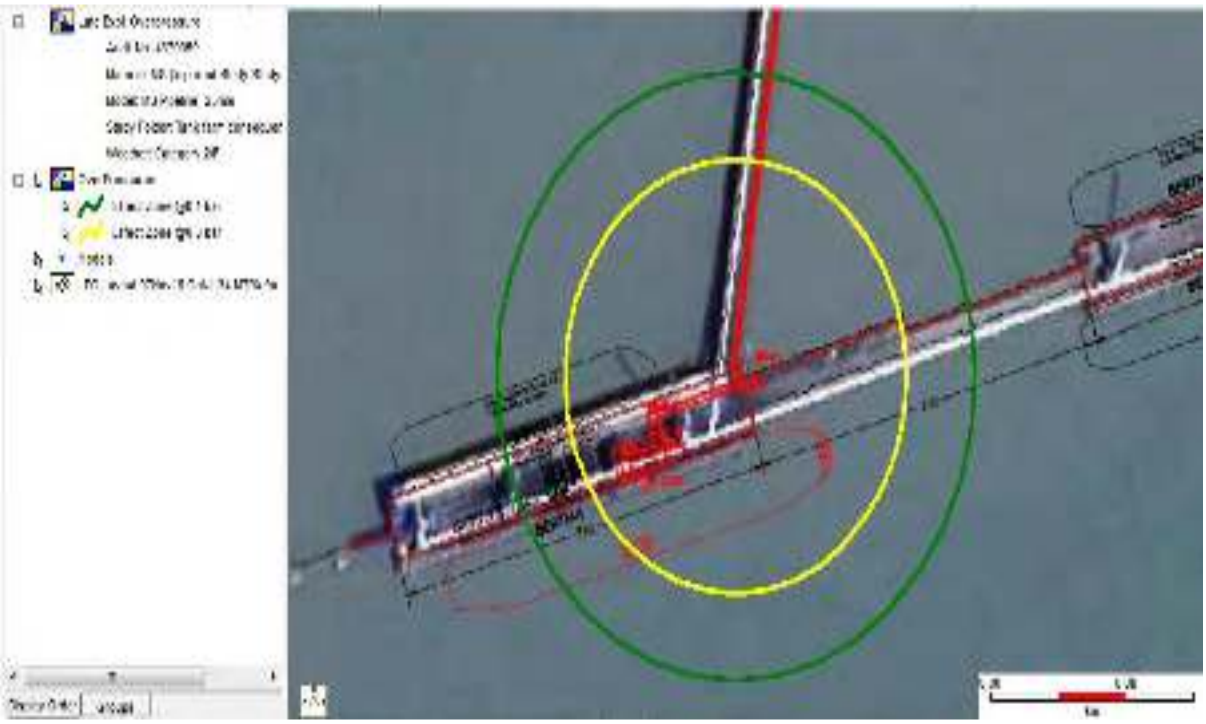
JET FIRE



POOL FIRE

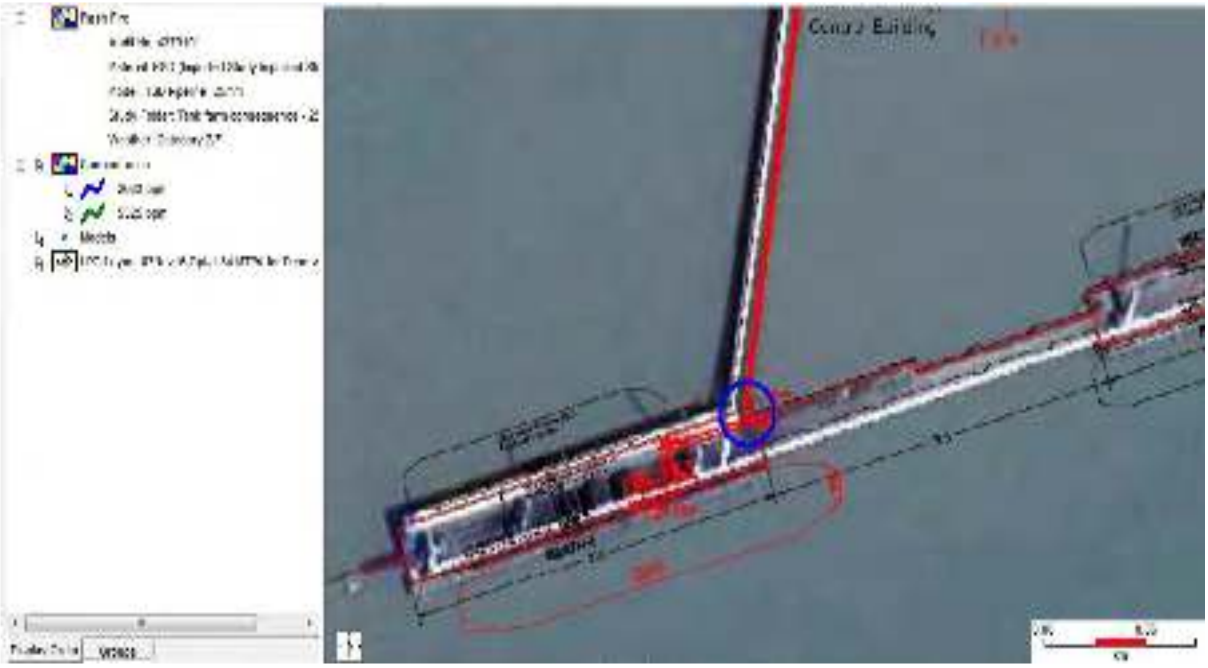


EXPLOSION

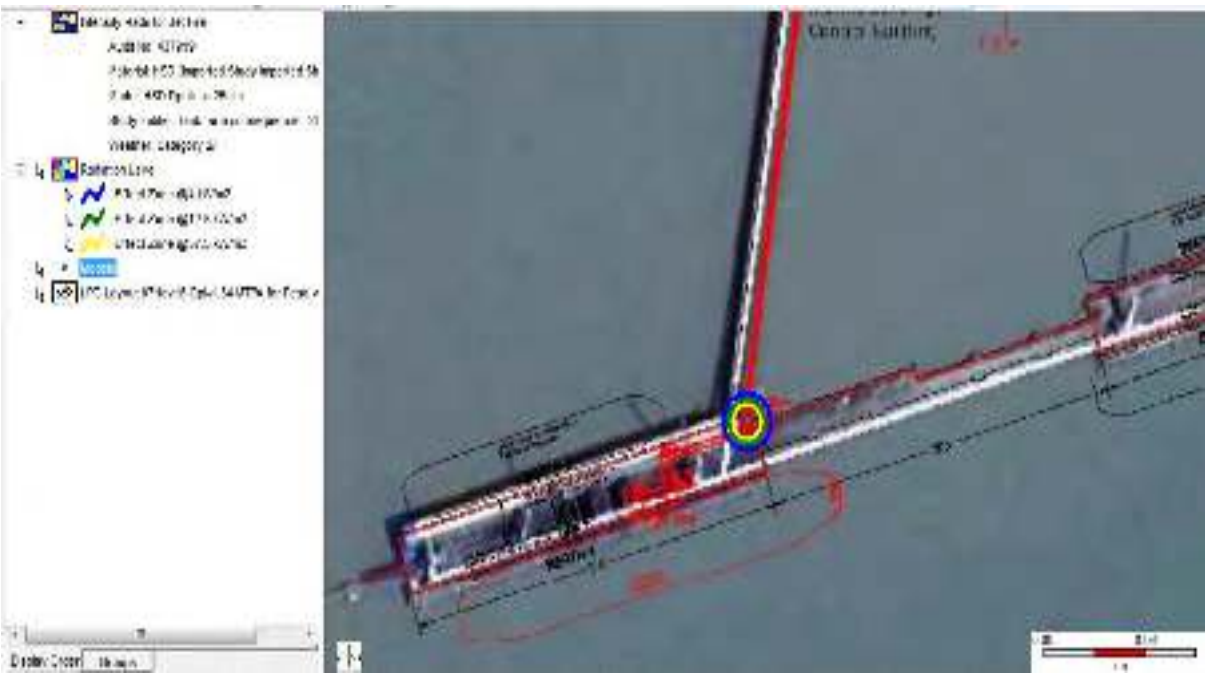


HSD PIPELINE FROM BERTH 2-25 mm LEAK

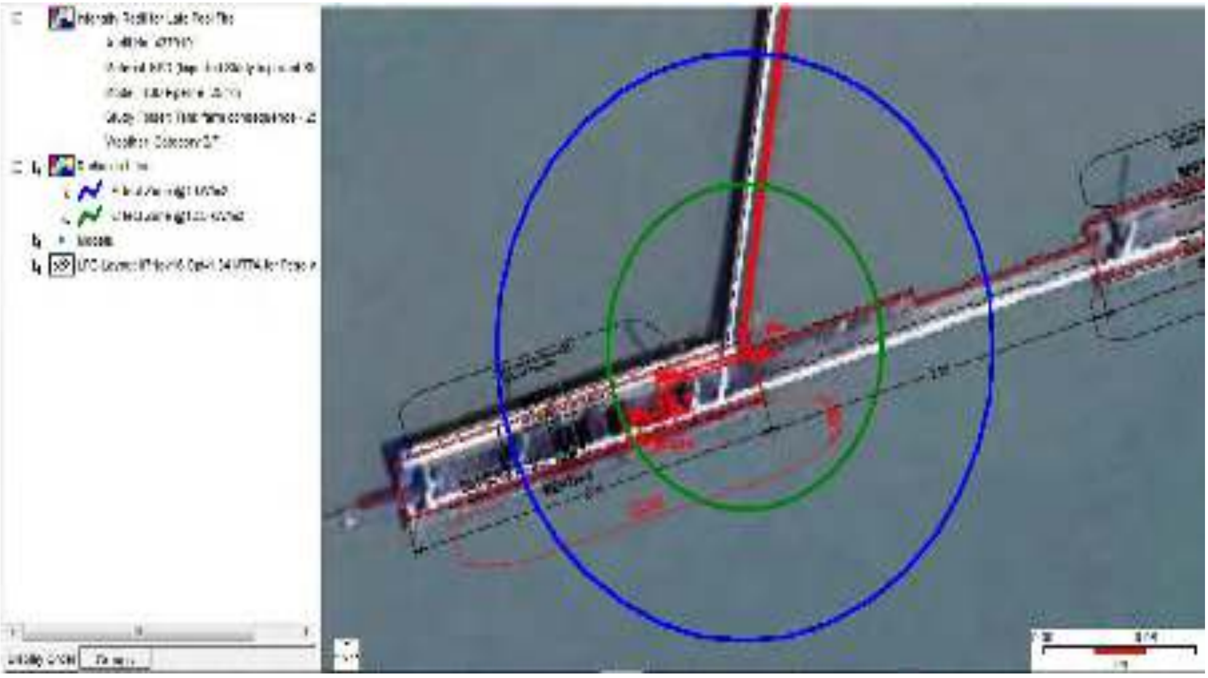
FLASH FIRE



JET FIRE



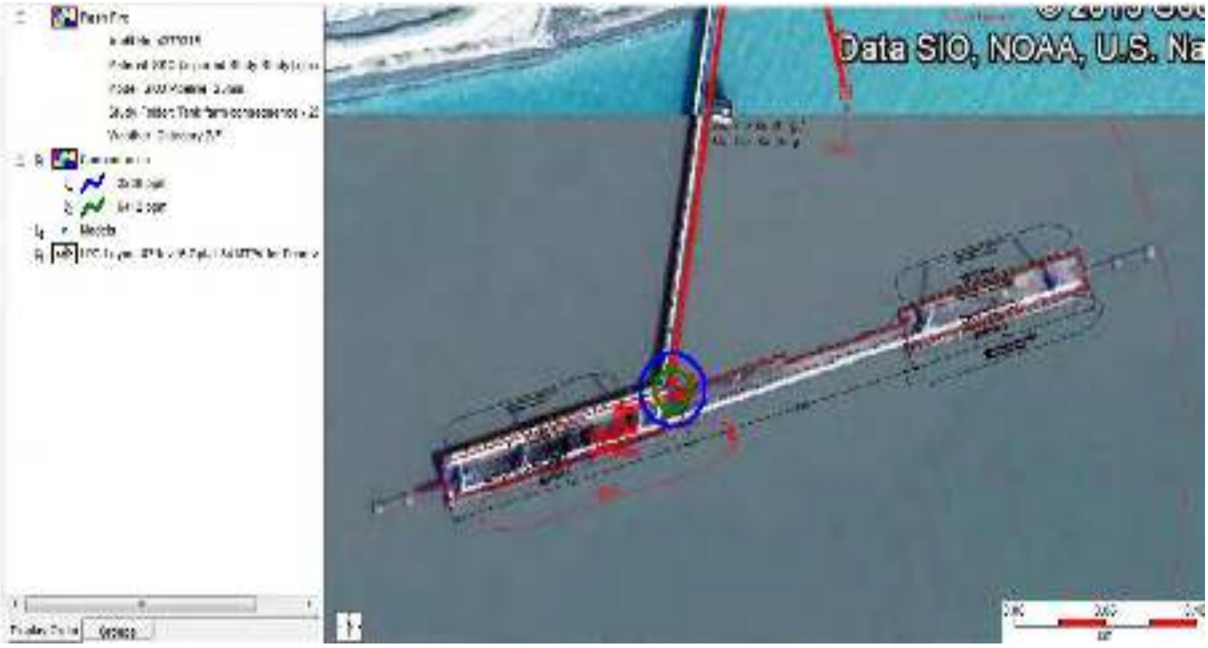
POOL FIRE



EXPLOSION

SKO PIPELINE FROM BERTH 2-25 mm LEAK

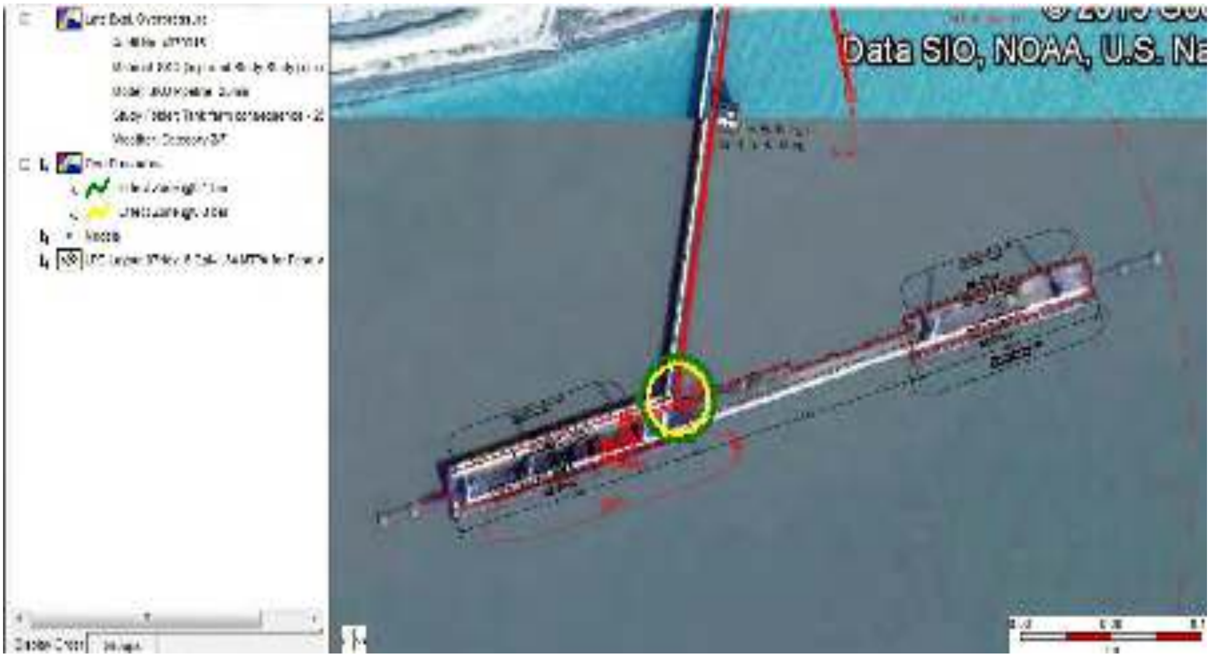
FLASH FIRE



JET FIRE

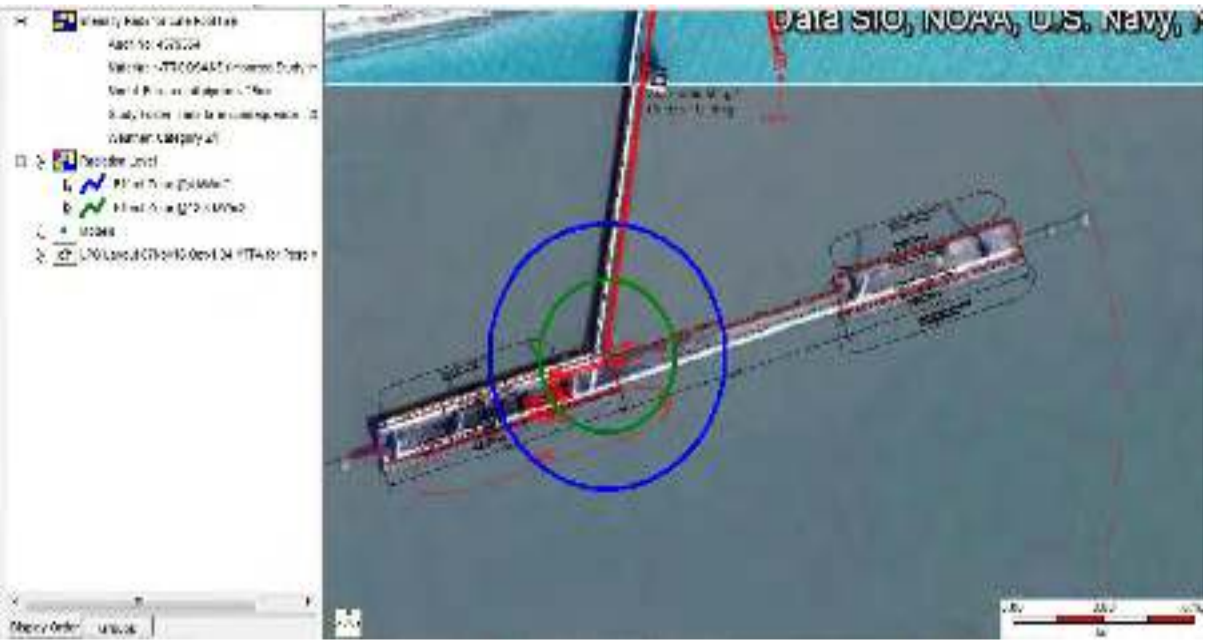
POOL FIRE

EXPLOSION



FURNACE OIL PIPELINE FROM BERTH 2-25 mm LEAK

POOL FIRE

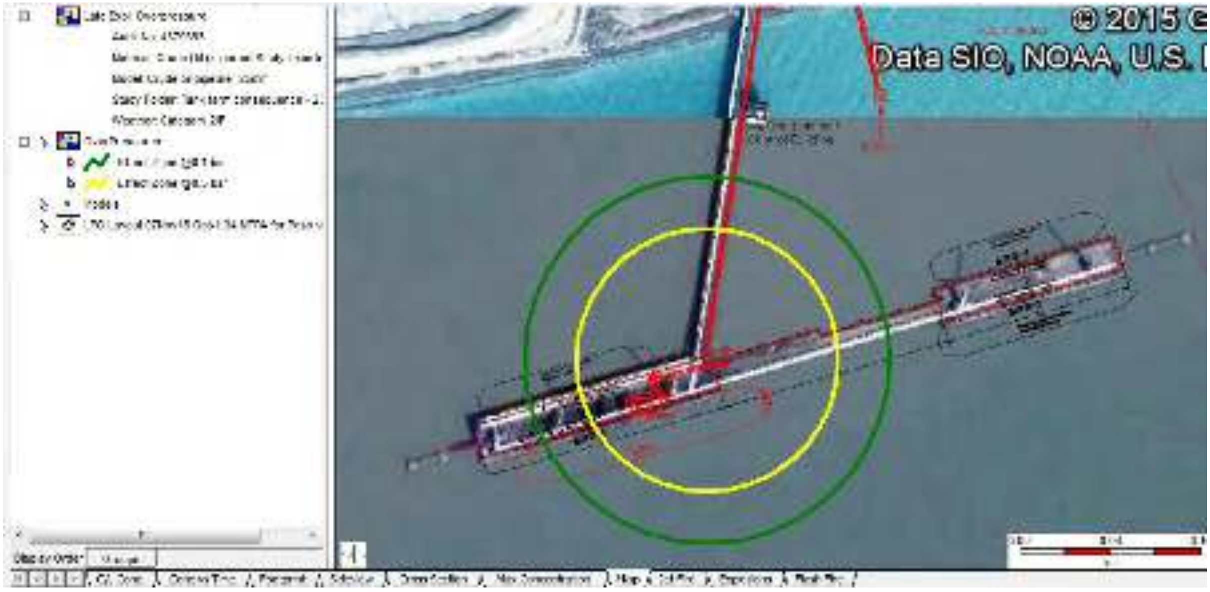


CRUDE OIL PIPELINE FROM BERTH 2-25 mm LEAK

FLASH FIRE

JET FIRE

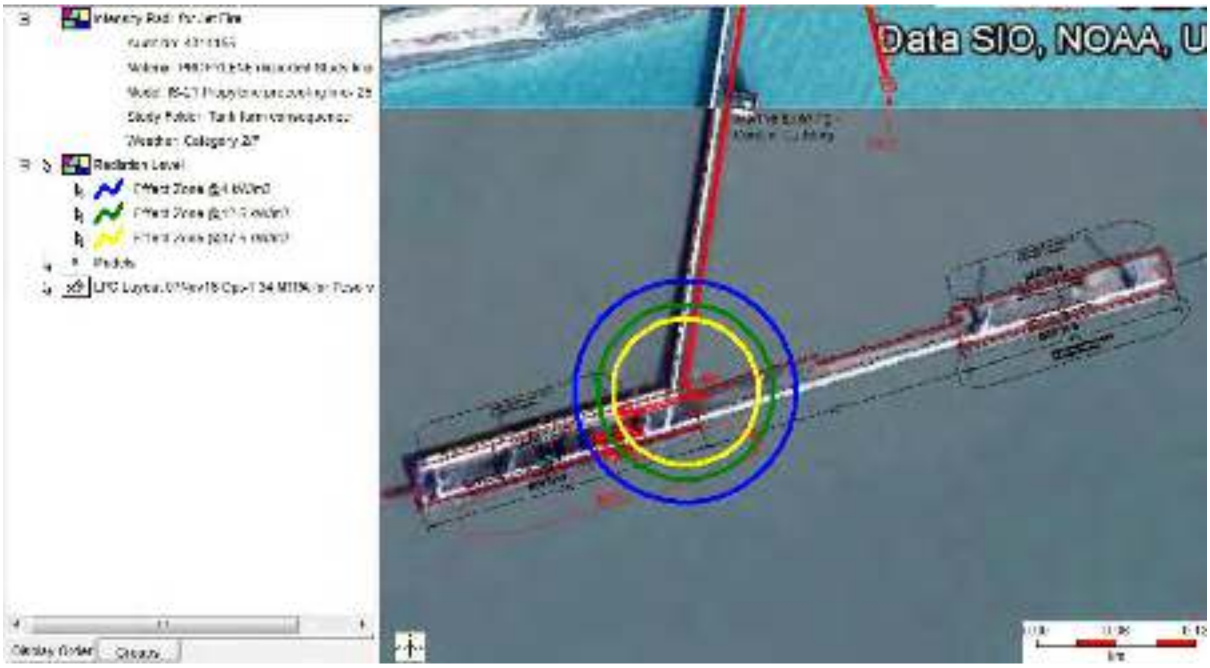
EXPLOSION



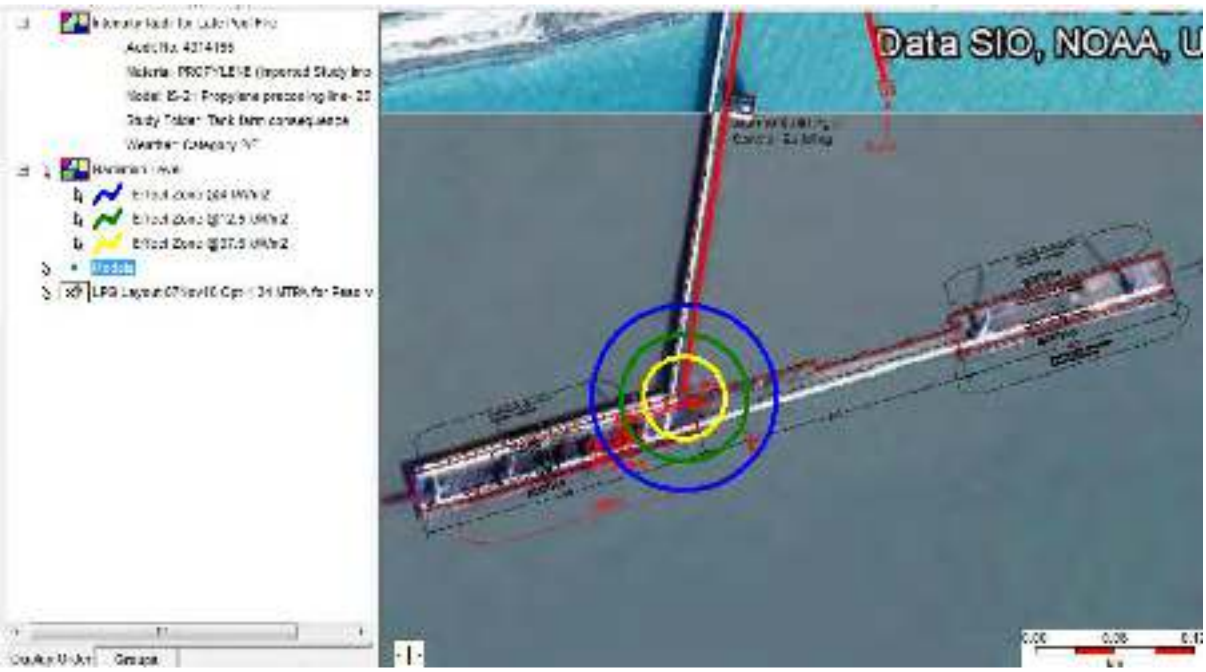
PROPYLENE PRECOOLING PIPELINE FROM BERTH 1-25 mm LEAK

FLASH FIRE

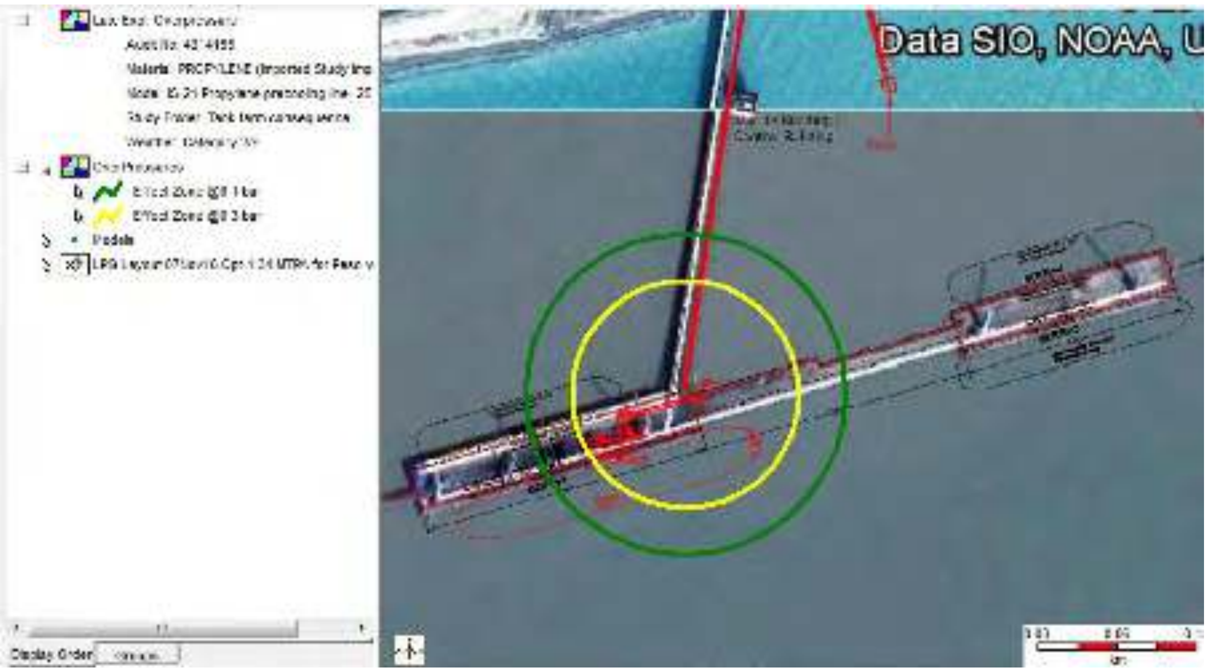
JET FIRE



POOL FIRE



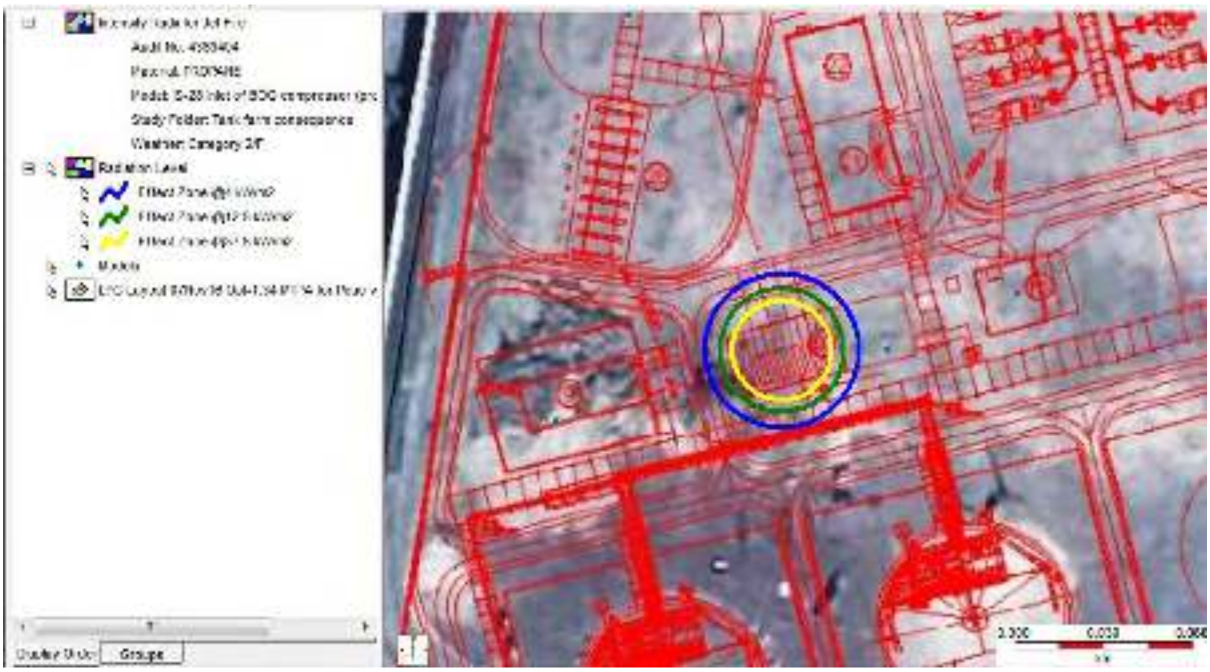
EXPLOSION



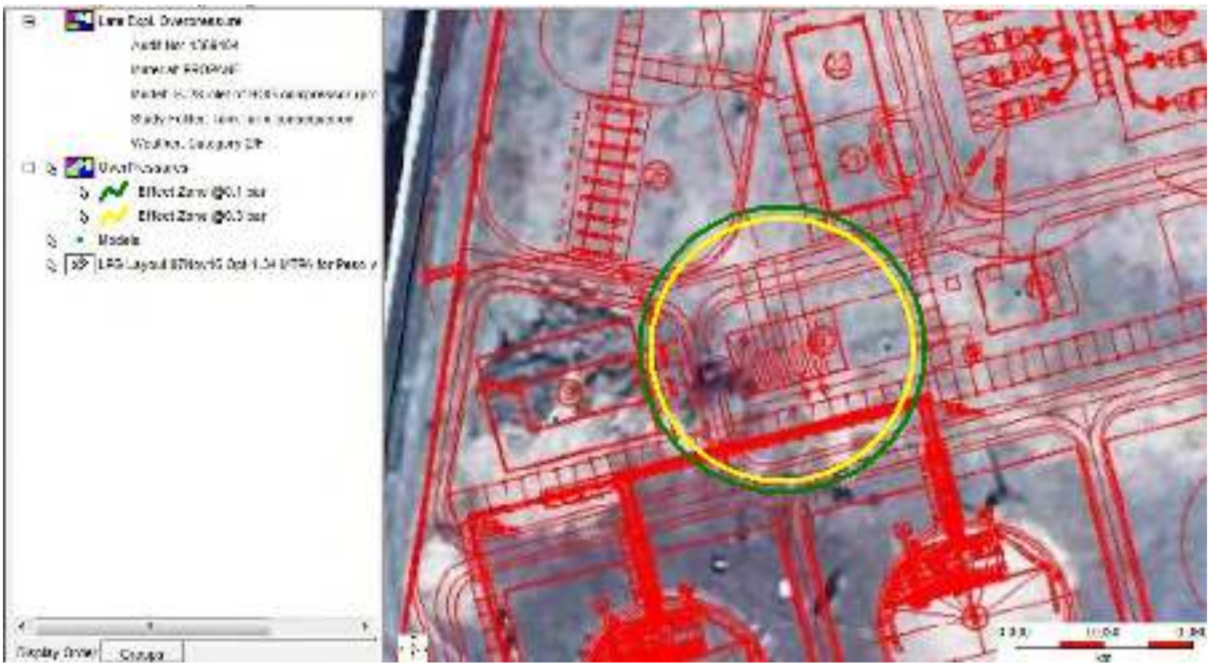
INLET OF BOIL OFF COMPRESSOR 2000-GB-01A/B(PROPANE RICH BOG)TO INLET OF BULLET 2000-FA-07 – 25 mm LEAK

FLASH FIRE

JET FIRE

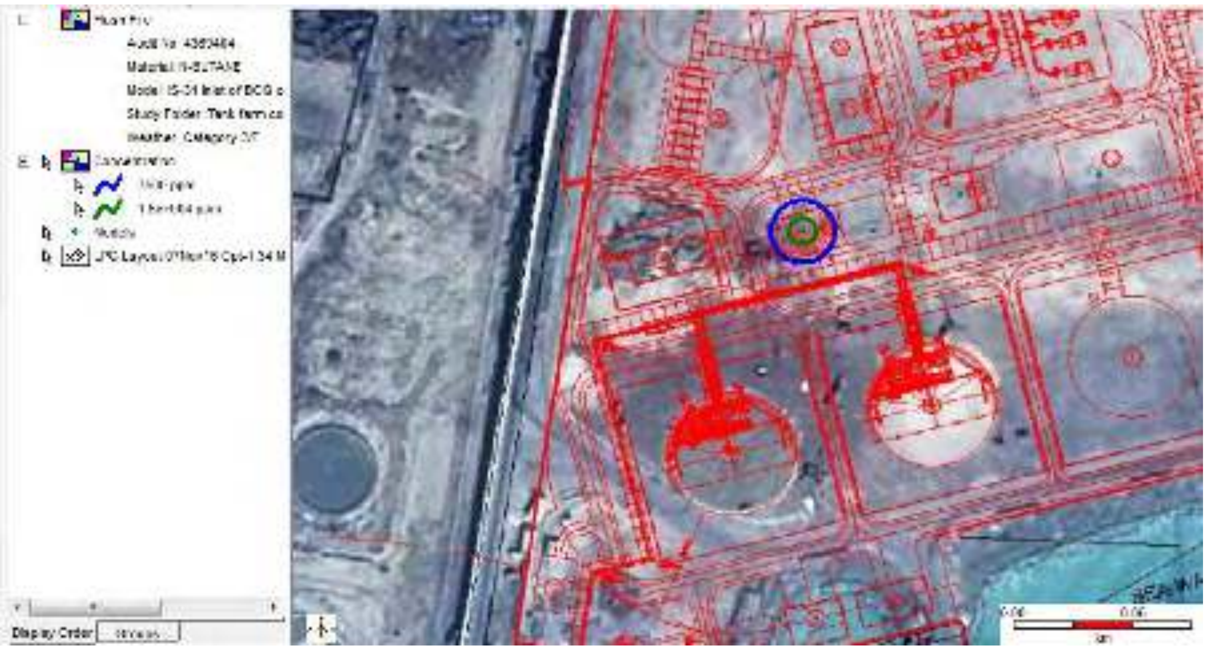


EXPLOSION

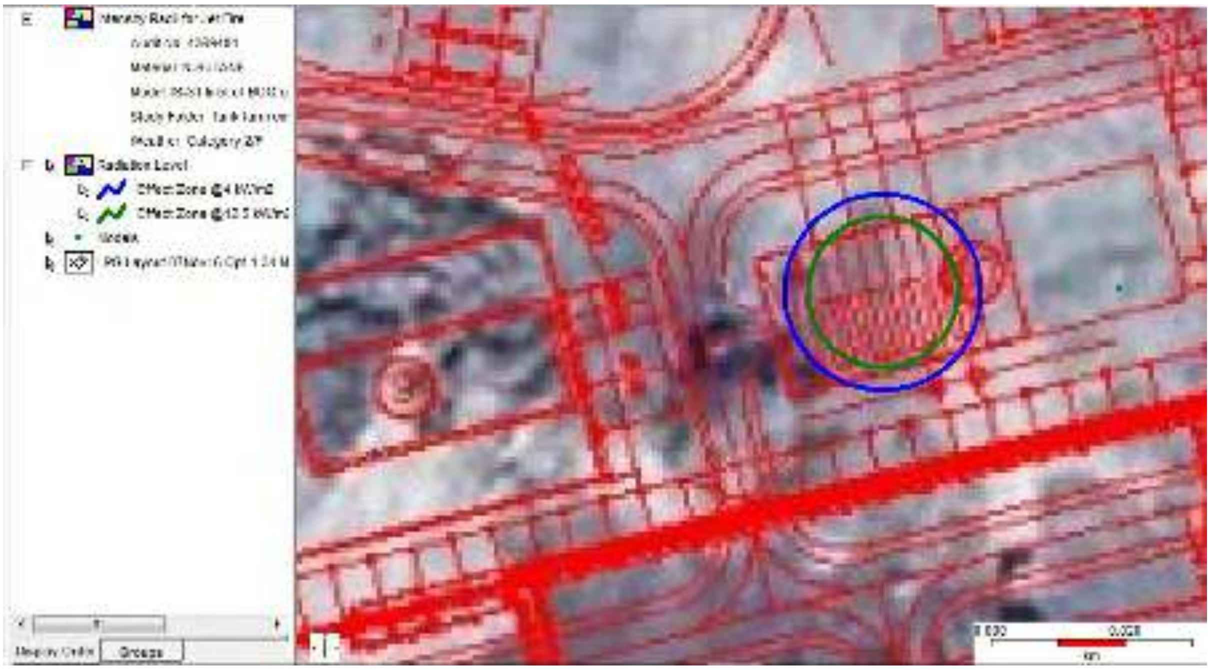


INLET OF BOIL OFF COMPRESSOR 2000-GB-02A/B (BUTANE RICH BOG) TO INLET OF BULLET 2000-FA-08 – 25 mm LEAK

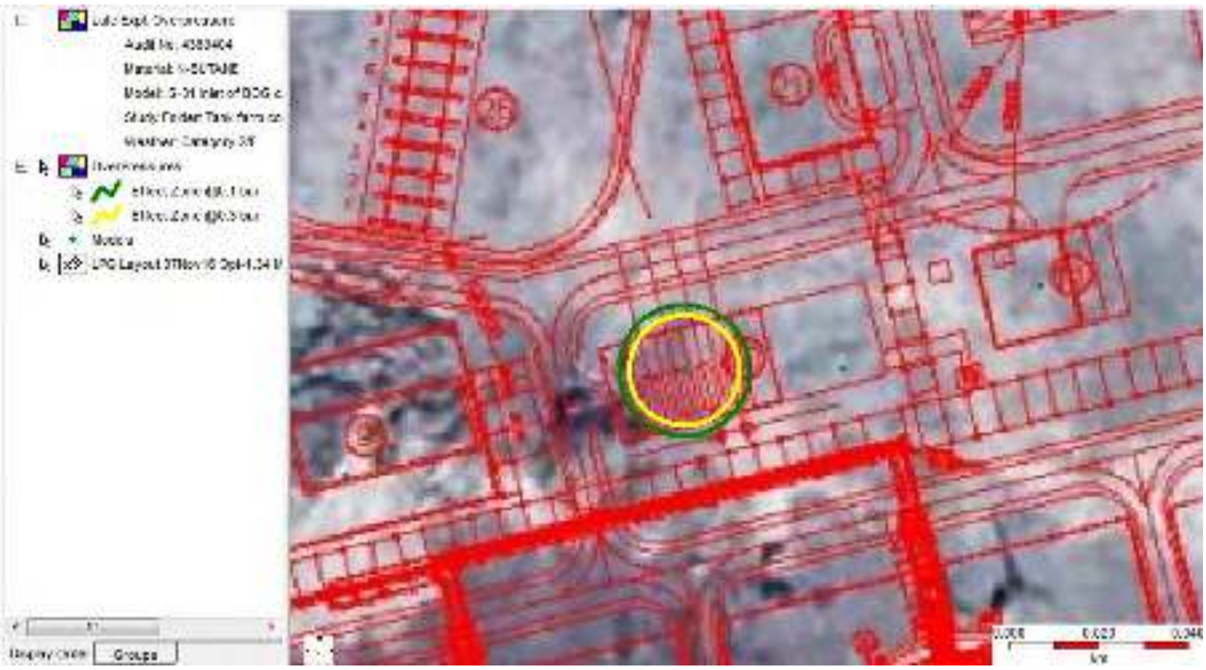
FLASH FIRE



JET FIRE



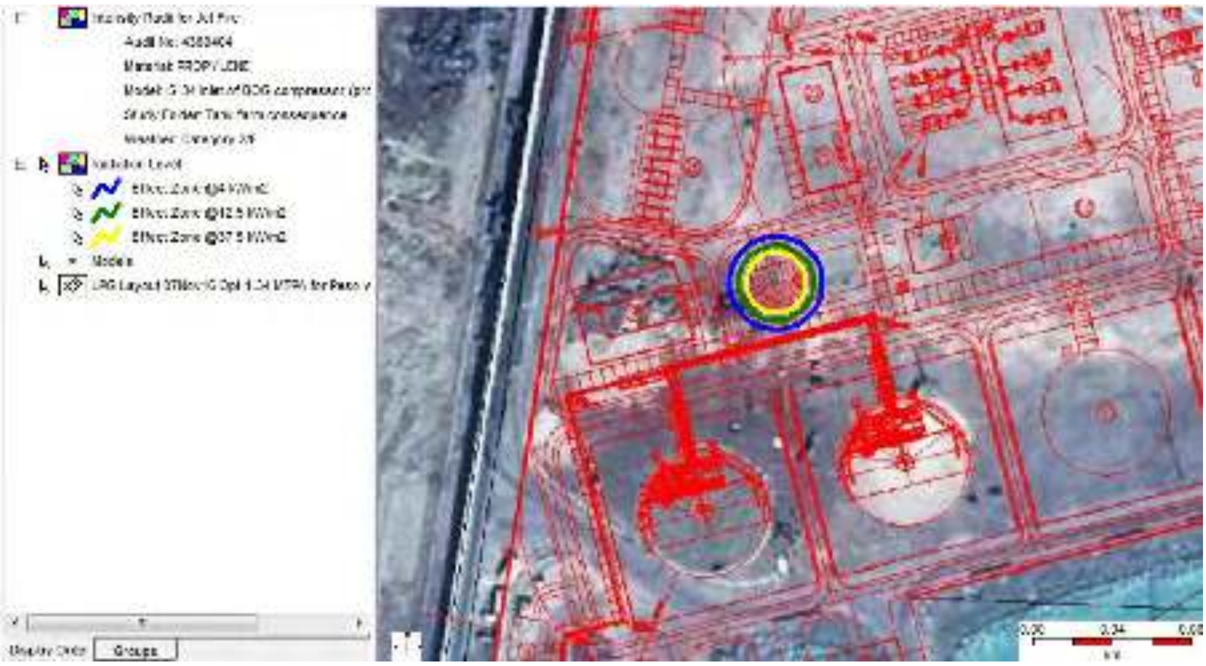
EXPLOSION



INLET OF BOIL OFF COMPRESSOR 2000-GB-02A/B (PROPYLENE RICH BOG) TO INLET OF BULLET 2000-FA-08 – 25 MM LEAK

FLASH FIRE

JET FIRE



EXPLOSION

Propane from 2000 -GA-01A/B/C to Propane heater I, 2000-EA-05 &Propane heater II, 2000-EA-07 to Static Blender - 25 mm LEAK

FLASH FIRE

JET FIRE

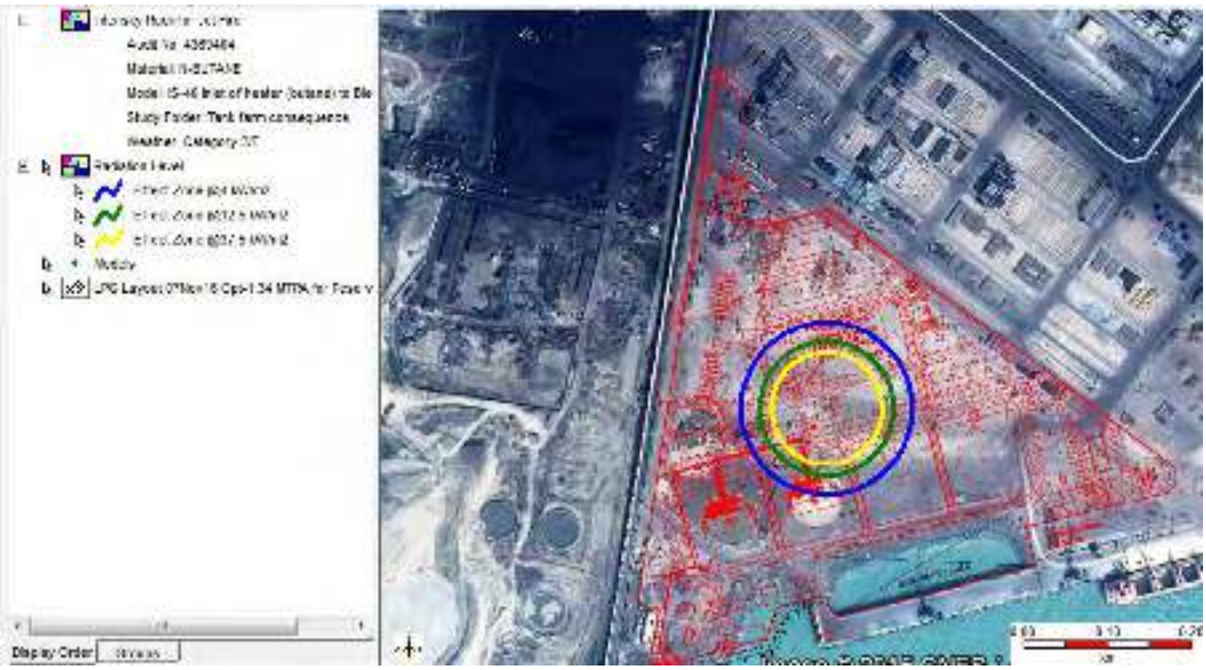
EXPLOSION

Groups
Image © 2015 CNES / Astrium
© 2015 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

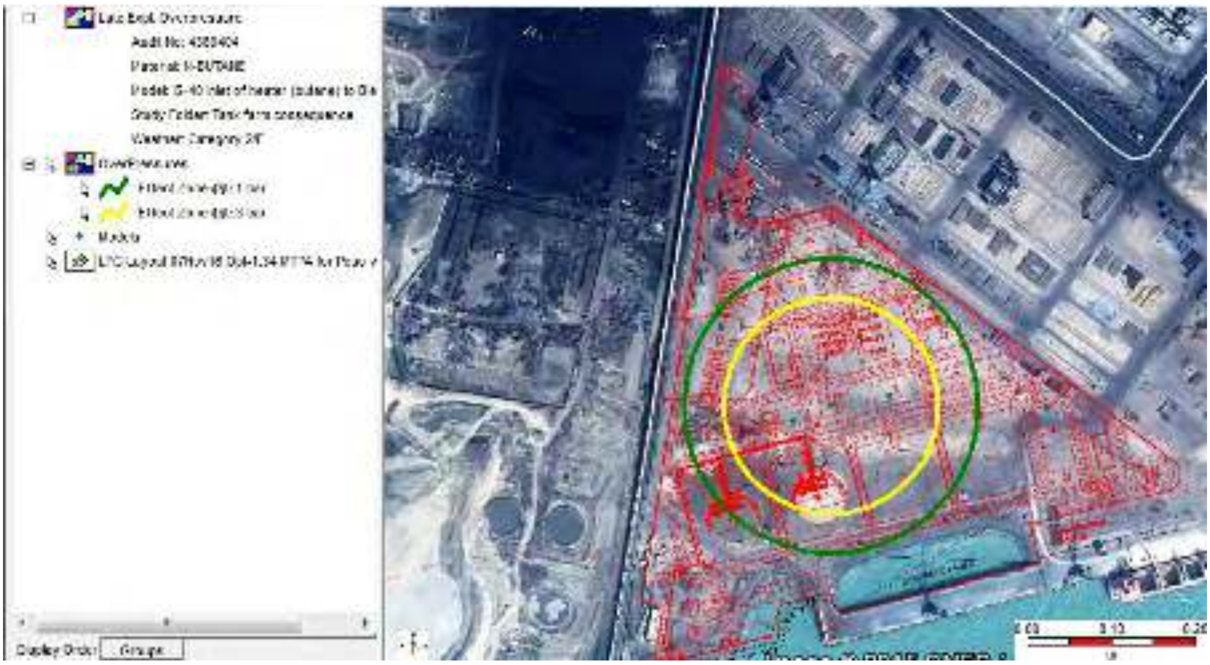
Butane from 2000-GA-02A/B/C to Butane heater I, 2000-EA-08 & Butane heater II, 2000-EA-10 to Static blender – 25 mm LEAK

FLASH FIRE

JET FIRE



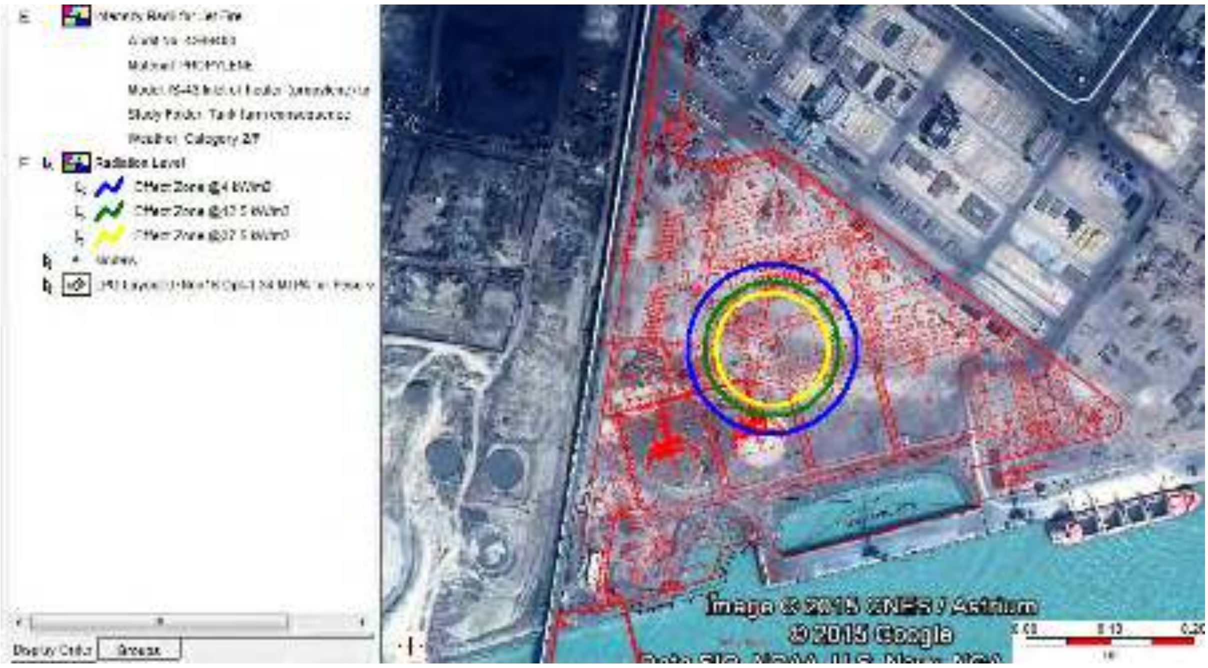
EXPLOSION



Propylene from 2000-GA-02A/B/C to heater I, 2000-EA-08 & Propylene heater II, 2000-EA-10 to Static blender – 25 mm LEAK

FLASH FIRE

JET FIRE



EXPLOSION

Study Folder: Tank farm consequence
Image © 2015 CNES / Astrium
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INLET OF FLASH & OFF GAS COMPRESSOR 2000-GB-03A/B(PROPANE RICH FOG)TO INLET OF BULLET 2000-FA-07 – 25 MM LEAK

FLASH FIRE

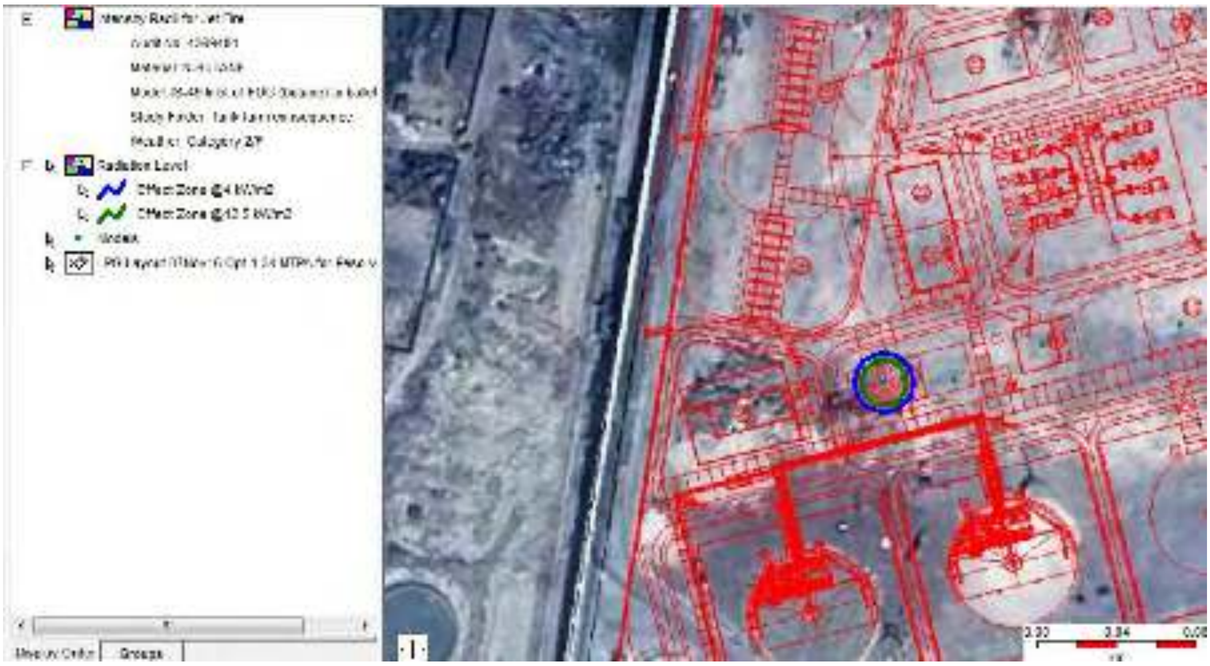
JET FIRE

EXPLOSION

INLET OF FLASH & OFF GAS COMPRESSOR 2000- GB-04A/B(BUTANE RICH FOG) TO INLET OF BULLET 2000-FA-08 – 25 MM LEAK

FLASH FIRE

JET FIRE



EXPLOSION

INLET OF FLASH & OFF GAS COMPRESSOR 2000-GB-04A/B(PROPYLENE RICH BOG) TO INLET OF BULLET 2000-FA-08 – 25 MM LEAK

FLASH FIRE

JET FIRE

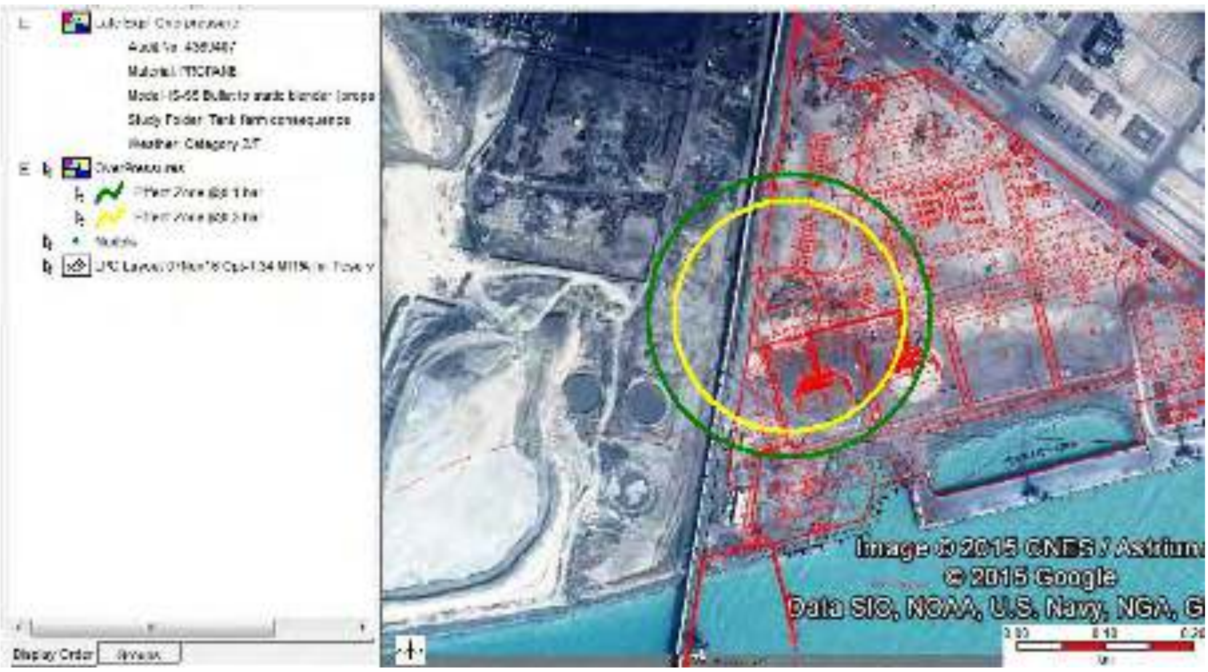
EXPLOSION

BULLET 2000-FA-07 THROUGH BULLET PUMP 2000-GA -07A/B TO STATIC BLENDER (PROPANE RICH STREAM) – 25 MM LEAK

FLASH FIRE

JET FIRE

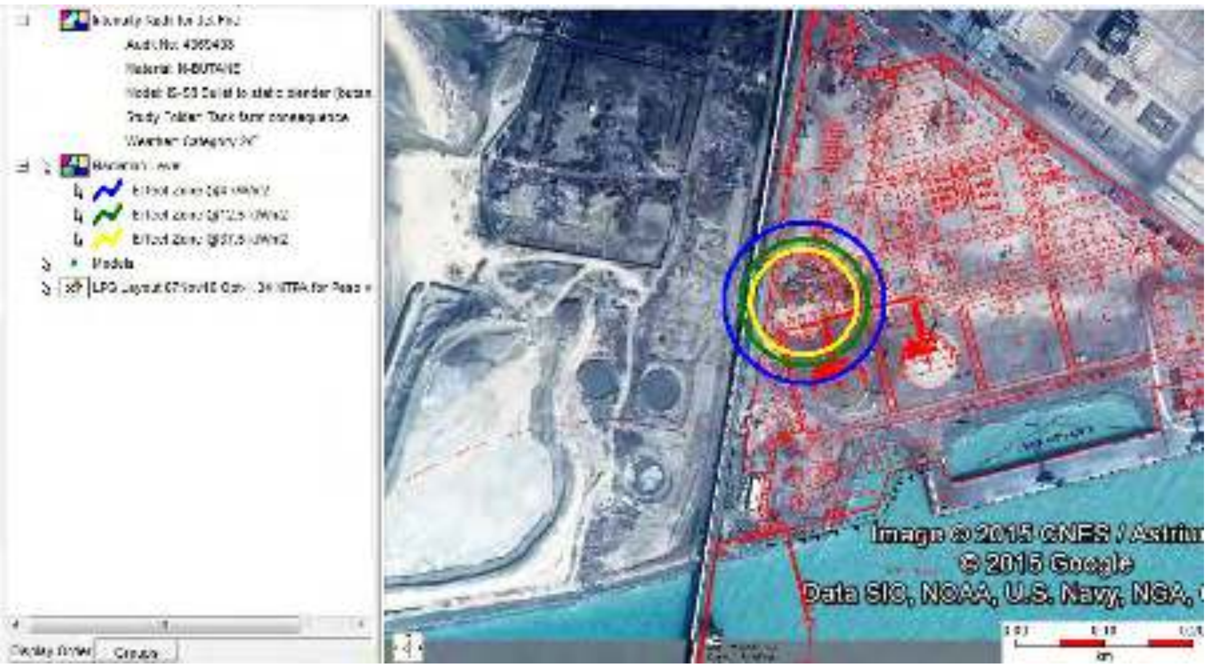
EXPLOSION



BULLET 2000-FA-08 THROUGH BULLET PUMP 2000-GA -08A/B TO STATIC BLENDER (BUTANE RICH STREAM) – 25 MM LEAK

FLASH FIRE

JET FIRE

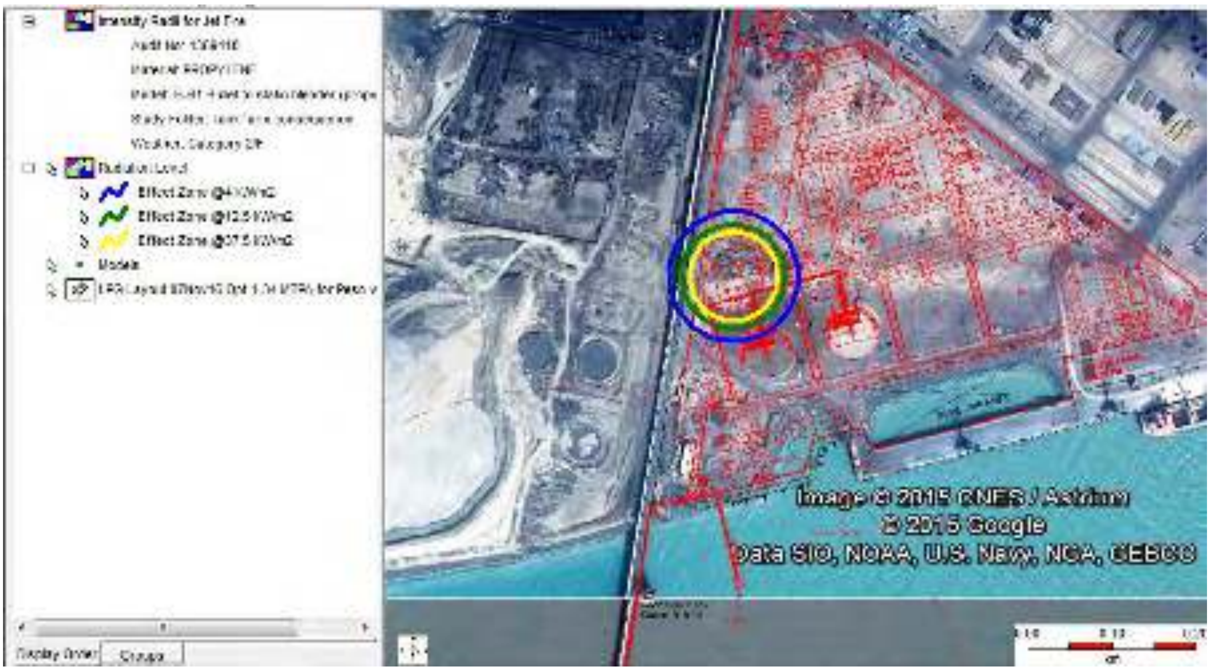


EXPLOSION

BULLET 2000-FA-08 THROUGH BULLET PUMP 2000-GA -08A/B TO STATIC BLENDER (PROPYLENE RICH STREAM) – 25 MM LEAK

FLASH FIRE

JET FIRE



EXPLOSION

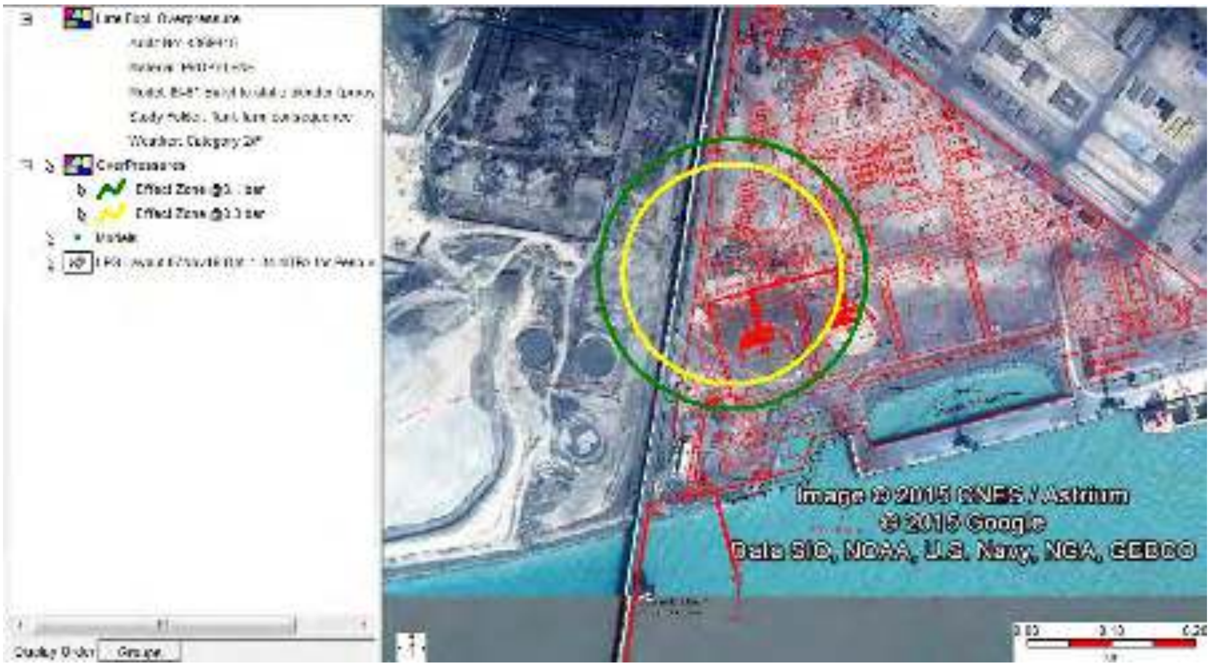
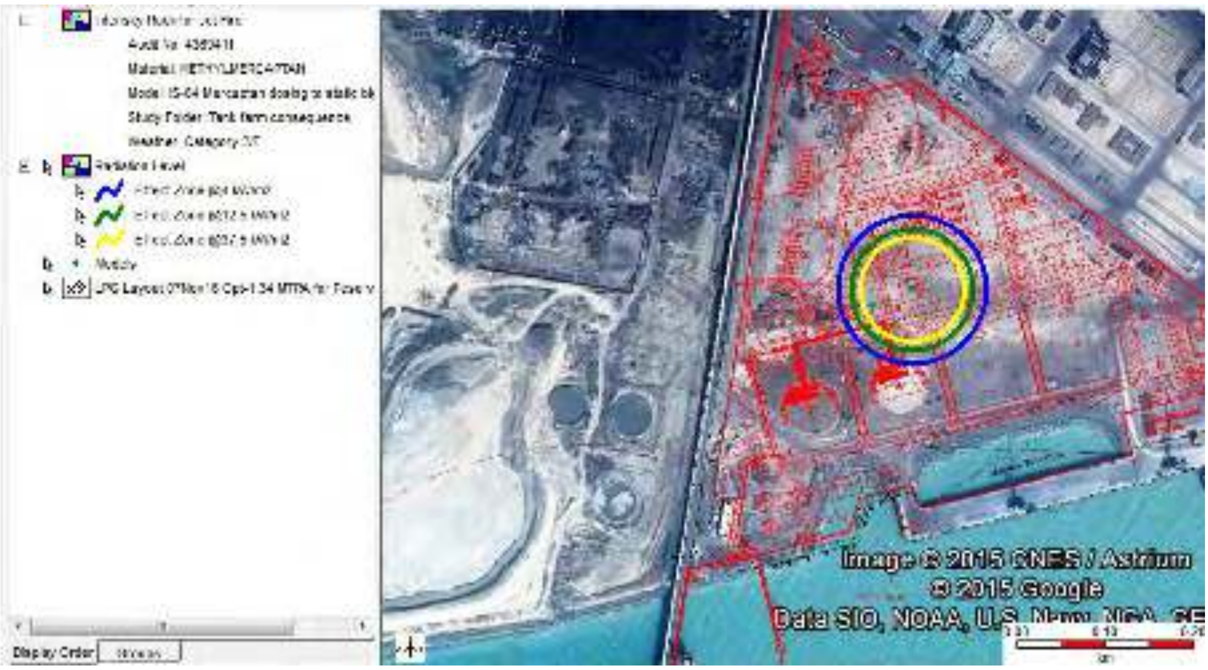


Image © 2015 CNES / Astrium
© 2015 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

MERCAPTAN DOSING SYSTEM 2000-CS-01 TO STATIC BLENDER – 25 MM LEAK

FLASH FIRE

JET FIRE



POOL FIRE

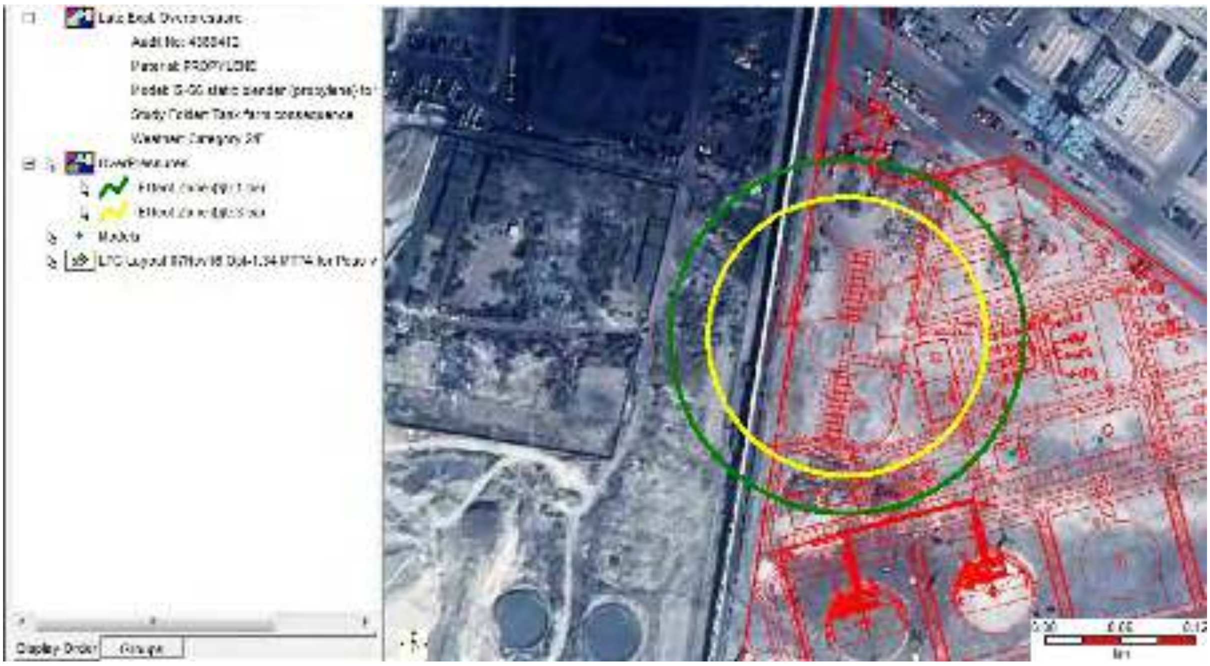
EXPLOSION

STATIC BLENDER OUTLET TO TANKER LOADING BAY – 25 mm LEAK

FLASH FIRE

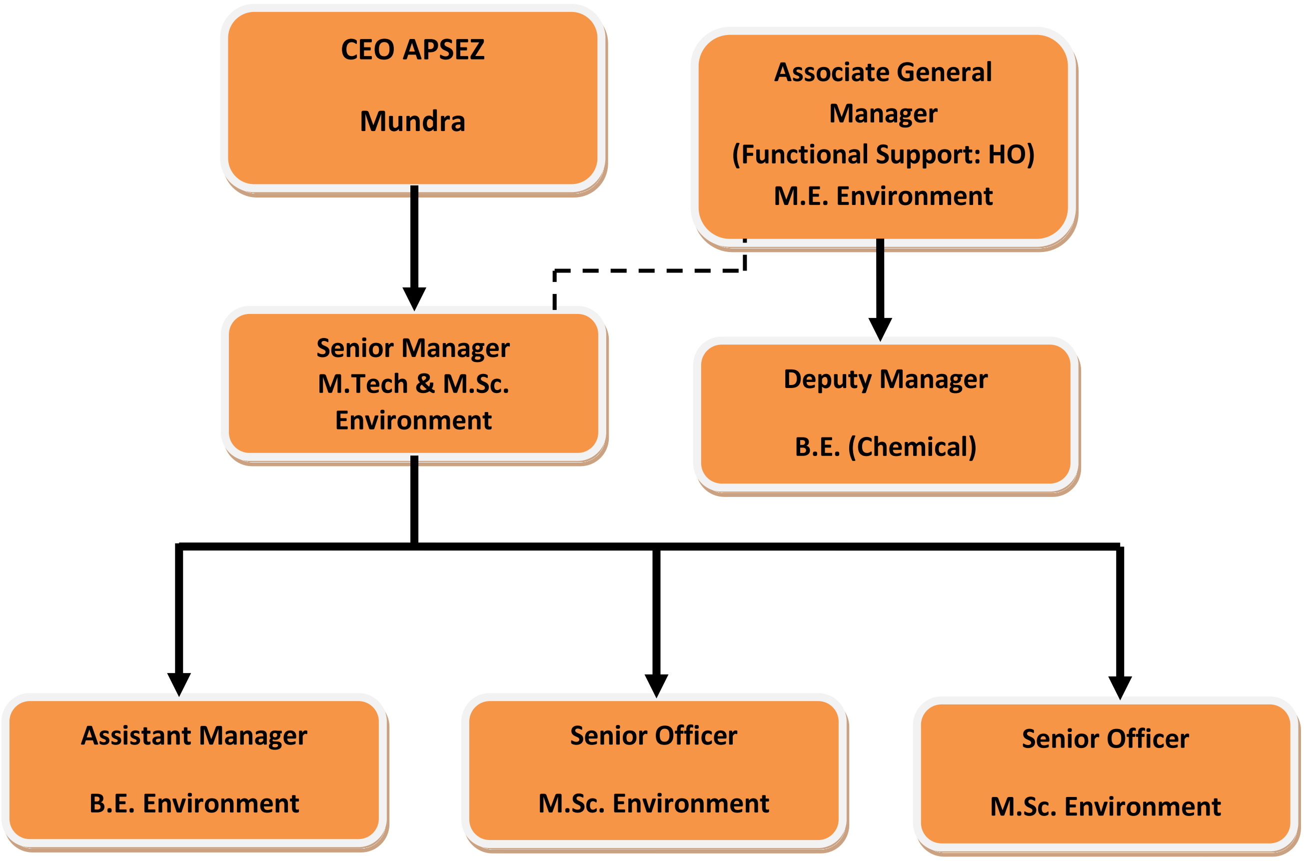
JET FIRE

EXPLOSION



Annexure – 5

Organogram of Environment Management Cell, APSEZ, Mundra



Annexure – 6

Cost of Environmental Protection Measures

Sr. No.	Activity	Cost incurred (INR in Lakh)			Budgeted Cost (INR in Lakh)
		2015 – 16	**2016 – 17**	**2017 – 18**	**2017 – 18**
1.	Environmental Study / Audit and Consultancy	45.45	36.78	9.00	21.00
2.	Legal & Statutory Expenses	3.30	4.76	9.48	16.00
3.	Environmental Monitoring Services	26.80	27.95	12.00	36.00
4.	Hazardous / Non Hazardous Waste Management & Disposal	34.56	12.52	31.9	90.84
5.	Environment Day Celebration	7.18	6.71	2.68	10.00
6.	Treatment and Disposal of Bio-Medical Waste	1.22	1.27	0.75	1.44
7.	Mangrove Plantation, Monitoring & Conservation	73.64	72.38	60.0	60.0
8.	Other Horticulture Expenses	434.72	555.00	494.0	556.5
9.	O&M of Sewage Treatment Plant and Effluent Treatment Plant (including STP, ETP of Port & SEZ & Common Effluent Treatment Plant)	18.18	61.50	39.89	69.35
10.	Expenditure of Environment Dept. (Apart from above head)	135.90	131.83	22.83	104.91
	Total	**837.73**	**910.70**	**682.53**	**966.04**

Annexure – 7

Adani Foundation Mundra

Adani Skill Development Center Activities

Adani Skill Development Center: Mundra

Along with computer related trainings, Stitching and Bagging training, Beauty Parlor and Mobile Repairing Training are also in full fledge at Gundala, Adani Ports, Navinal and Mundra

Soft Skill training					
Sr. No.	**Course Name**	**Location**	**Male**	**Female**	**No.of students**
1	Beautification training.	Mundra	0	20	20
2	Advance Excel training	Adani house	20	0	20
3	IT Basic Computer training	Navinal	13	7	20
4	IT Basic Computer training	ASDC	2	4	6
5	IT Basic computer-CRTG student training	ASDC	7	0	7
6	Wedding Mehnadi training	Gundala	0	16	16
7	Thread work training	Gundala	0	20	20
8	IT Basic computer-CRTG student training	ASDC	7	0	7
9	Spoken English	ASDC	13	3	16
10	IT Basic Computer training	Adani house	20	0	20
11	IT Basic Computer training	ASDC	0	7	7
12	IT Basic computer-CRTG student training	ASDC	7	0	7
13	Thread work training	Luni	0	14	14
14	Computer Excel training	Adani house	19	0	19
15	IT Basic Computer training	ASDC	7	0	7
		Total - A	**115**	**91**	**206**

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Adani Skill Development Center: Mundra

Technical Training					
1	Checker cum RTG crane operator training	APSEZ	21	0	21
2	Tailoring training	Borana	0	30	30
3	Tailoring training	ASDC	0	14	14
4	Tailoring training	Mundra	0	41	41
5	Vocational training	Zarpara	38	7	45
		Total - B	**59**	**92**	**151**
Carier Guidance and Knowlage bage training					
1	Personality Devlopment training	ASDC	23	4	27
2	Personality Devlopment training	ASDC	13	3	16
		Total - C	**36**	**7**	**43**
		Grand Total A + B+C =	**210**	**190**	**400**

Adani Foundation -Mundra
Education Budget Utilization - April to September 2017
F.Y. 2017-'18

(Rs. In Lacs)

Sr. No.	Budget Line Item	Budget F.Y. 2017-18	Budget Plan upto Sept.2017	Expenditure up to Sept.17	% of total Utilization against Planned budget	% of utilization from FY 2017-18 budget	Remarks
1	**Support to Government / Private Educational Institutes**						
1.1	Educational Support at various Govt. schools	8.00	4.00	3.55	88.79%	44.40%	
1.2	Support to ITI	2.00	1.00	0.00	0.00%	0.00%	
	Sub Total	**10.00**	**5.00**	**3.55**	**71.03%**	**35.52%**	
2	**Adani Shaikshanik Vikas Kendra (Strenghening Primary Education)**	**5.90**	**2.95**	**1.87**	**63.55%**	**31.78%**	
2.1	Coaching & project staff Exp.	4.60	2.30	1.75	76.09%	38.04%	
2.2	Housekeeping Exp.	0.60	0.30	0.00	0.00%	0.00%	
2.3	Teaching & Learning Material Exp.	0.50	0.25	0.07	27.20%	13.60%	
2.4	Other Administrative Exp.	0.20	0.10	0.06	56.77%	28.39%	
3	**Training and Development (Strenghening Teachers of High School)**	**0.95**	**0.48**	**0.17**	**36.33%**	**18.17%**	
3.1	Seminar on " Qualities of an effective teacher" (Quarterly)	0.50	0.25	0.17	69.04%	34.52%	
3.2	Workshop 1 : "Continuous and comprehensive evaluation"	0.15	0.08	0.00	0.00%	0.00%	
3.3	Workshop 2 : "Effective Lesson Planning"	0.15	0.08	0.00	0.00%	0.00%	
3.4	Workshop 3: " Effective Administrative Skills" for Principles	0.15	0.08	0.00	0.00%	0.00%	
4	**Educational Support to Migrated Labour Children**	**10.00**	**5.00**	**0.00**	**0.00%**	**0.00%**	
5	**Support for Higher secondary students of AVMB**	**3.75**	**1.88**	**1.03**	**54.79%**	**27.40%**	
6	**Education Project Staff Salary & TA (1 CM)**	**3.10**	**1.55**	**1.25**	**80.48%**	**40.24%**	
7	**Education for Fisher folk**						
9.1	Education Initiative for children at vasahat	22.00	11.00	7.56	68.73%	34.36%	
9.2	Exposure tour, Fee & Other Edu. Support to poor students and cycle support to Fishermen Students	4.00	2.00	0.89	44.67%	22.34%	
	SUB TOTAL :	**26.00**	**13.00**	**8.45**	**65.03%**	**32.51%**	
	GRAND TOTAL (BUDGETED) :	**59.70**	**29.85**	**16.33**	**54.70%**	**27.35%**	

Annexure – 8

GUJARAT POLLUTION CONTROL BOARD
PARYAVARAN BHAVAN
Sector-10-A, Gandhinagar 382 010
Phone : (079) 23222425
(079) 23232152
Fax : (079) 23232156
Website : www.gpcb.gov.in

GPCB

By R.P.A.D.

AMENDMENT OF CONSOLIDATED CONSENT AND AUTHORIZATION (C C & A)

GPCB/CCA-Kutch (39 (4)/ ID-17739/ 424578 **Date 27.9.2017**
03/10/17

To,
M/s. Adani Ports & Special Economic zone Limited,
Plot No: 169/P
At Navinal Island, Taluka: Mundra,
Dist: Kutch – 370 421

Sub: - Amendment of Consolidated Consent and Authorization (CC& A) of this Board under the provision the Water (Prevention and Control of Pollution) Act-1961, the air Prevention and Control of Pollution) 1981 and the Hazardous Waste (Management, Handling & Transboundary Movement) Rules 2008 framed under the Environmental (Protection) Act-1986.

Ref: -
1. Consent Renewal Order No: AWH-83561 dated 9.1.2017 validity up to 20.11.2021 issued vide letter No: GPCB/CCA-Kutch-39 (4)/ID-17739/403658 dated 9.2.2017
2. Your CCA- Amendment application Inward no-124026 dated 12.7.2017

The Board has granted Consolidated Consent (CC & A) vide order No: AWH-83561 dated 9.1.2017 validity up to 20.11.2021 issued vide letter No: GPCB/CCA-Kutch-39 (4)/ID-17739/403658 dated 9.2.2017 is amended as under:

1. The above referred CC&A order is amended as order **No: WH-88317** and issued dated 12.7.2017 and validity period i.e. up to 20.11.2021 & shall remains unchanged.

2. The Products mentioned at Condition No: 2 of the above said CCA order is amended as under:

No.	Name Of Product	Existing Quantity	Proposed Quantity	TOTAL Quantity
1.	General Cargo	4.0 Lac MT/Month	------	4.0 Lac MT/Month
2.	Liquid Cargo (Chemical/Poc Products	2.65 Lac MT/Month	------	2.65 Lac MT/Month
3.	Storage And Distribution Of Bitumen	26,400 MT/Month	------	26,400 MT/Month
4.	Dry Cargo Handling	9 MMT/Month	------	9 MMT/Month
5.	Container Terminal Handling Operation	4.5 Million TEUs/Annum	-----	4.5 Million TEUs/Annum
6.	Waste destruction system for decomposition/destruction of municipal solid waste	3.5 Cubic Meter (MSW Destruction Capacity @ 500 Kg/day)	-----	3.5 Cubic Meter (MSW Destruction Capacity @ 500 Kg/day)
7.	Oil water separate (Flame Proof) to remove –Oil portion from slope oil received from Vessels/Ships	25 M^3/Hr	---	25 M^3/Hr
8.	Import, Storage And Distribution Of Edible Oil	1.25 Lac MT/Month	0.6 Lac MT/ Month	1.85 Lac MT/Month

4.0 The condition No: 4.1 is amended as under:

4.1 The following shall be used as fuel in addition to Existing.

	FUEL DETAILS	Existing	Proposed	Total after expansion
1.	Furnace oil/LDO/HSD	860 Liter/Hour	115	975 Liter/Hour
2.	HSD	100 Liter/Hour	----	100 Ltr/ Hr

4.2 The condition No: 4.2 for flue gas emissions shall, confirm to the following standards as under:

Sr. no.	Stack attached to	Stack height in meters, Mtr	Parameter	Permissible limit
1.	Hot Water Generator --1	35	PM	150 mg/Nm^3
2.	Hot Water Generator ---2	35	SO_2	100 ppm
3.	Fuel Heater (Thermic) (2 Nos)	35	NOx	50 ppm
4.	D.G. Set – 9 Nos (500 KVA) (Stand By)	9 Meter Each		
5.	D.G. Set – 3 Nos (1250 KVA) (Stand By)	30 Meter common		
6.	D.G. Set – 6 Nos (1500 KVA) (Stand By)	30 Meter Each		

5.2 Condition NO 5.2 shall be amended for addition to existing waste as under, in accordance with the Hazardous Waste (Management, Handling & Transboundary Movement) Rules, 2016 as under:

Sr. No.	Waste	Existing Quantity	Proposed Quantity	Total Quantity	Cat.	Facility
1.	Used oil m	300 T/ Year	60 T/ year	360 T/ year	5.1	Collection, storage, Transportation, Disposal by reuse within premises and / or selling out to registered recyclers/ /reprocessers
2	Contaminated cotton rags or other cleaning material	100 T/ Year	5 T/ Year	105 T/ Year	33.2	Collection, storage, Transportation, Disposal by Co-processing at cement industries and / or incineration at CHWIF site.

3. Remaining all other conditions of Consolidated Consent (CC&A) vides order No: AWH-83561 dated 9.1.2017 validity up to 20.11.2021 issued vide letter No: GPCB/CCA-Kutch-39 (4)/ID-17738/403858 dated 9.2.2017 shall remains unchanged.

For and on behalf of
Gujarat Pollution Control Board

Vachhani

(P.J. Vachhani)
Sr. Environmental Engineer