

VISAKHAPATNAM PORT TRUST



RISK ASSESSMENT



IRCLASS

SYSTEMS AND SOLUTIONS PRIVATE LIMITED

MAY - 2018

This is to state that at the request of VISAKHAPATNAM PORT LTD (VPT), the undersigned surveyors have carried out a risk assessment and prepared Disaster management plan. The scope of the analysis and the work undertaken are given in the attached report.

CONFIDENTIALITY CLAUSE

This work has been carried out for VPT as per their work order dated 29th January, 2018 and is confidential. No part of this report may be released to any outside organization unless explicitly advised by the owners in writing.

ISSUED BY:

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INTRODUCTION OF IRCLASS SYSTEMS & SOLUTIONS PVT LTD (ISSPL)

IRCLASS Systems & Solutions Pvt. Ltd., promoted by Indian Register of Shipping - The Indian Ship Classification Society, providing Inspection Services since 1980. Indian Register of Shipping is recognized for its technical competency and experience in the maritime sector for more than 40 years. This expertise along with excellent safety record has enabled it to diversify in to Third Party Inspection and Certification Services under IRCLASS Systems & Solutions Pvt. Ltd.

At IRCLASS, we help our clients to find solutions to complexities associated with Quality, Health, Safety & Environment during CAPEX & OPEX stages of the entire project lifecycle starting from Planning, Designing, Procurement, Manufacturing, Construction, Testing, Commissioning & Operation.

DISCLAIMER

The tasks of preparation of DMP and related Risk Analysis have been done by ISSPL as a consulting service at the request of VPT.

Conclusions and recommendations resulting from the consulting services have been formed in good faith and on the basis of the best information available from sources believed to be reliable.

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ACRONYMS

ACDS	Advisory Committee on Dangerous Substances
ALARP	As Low As Reasonably Practicable
ATF	Aviation Turbine Fuel
BLEVE	Boiling Liquid Expanding Vapor Explosion
BPCL	Bharat Petroleum Corporation Ltd.
DMP	Disaster Management Plan
DWT	Deadweight Tons
ERDMP	Emergency Response Disaster Management Plan
ESD	Emergency Shut-Down
F	Frequency
F & EI	Fire and Explosion Index
GNOME	General NOAA Operational Modeling Environment
GPH	General Process Hazard
HAZID	Hazard Identification
HAZOP	Hazard & Operability Study
HPCL	Hindustan Petroleum Corporation Ltd.
HSD	High Speed Diesel
HSE	Health, Safety and Environment
IOCL	Indian Oil Corporation Limited
LFL	Lower Flammable Limit
LPG	Liquefied Petroleum Gas
LPM	Liters per minute
MCP	Manual Call Point
MF	Material Factor

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MoC	Material of Construction
MS	Motor Spirit
MSDS	Material Safety Data Sheet
MSIHC	Manufacture, Storage, Import of Hazardous Chemicals
MT	Metric Ton
NDMA	National Disaster Management Authority
N_F	Flammability Factor
NFPA	National Fire Protection Association, USA
N_H	Health Factor
N_R	Reactivity Factor
NOS-DCP	National Oil Spill Disaster Contingency Plan
OISD	Oil Industry Safety Directorate
OSCP	Oil Spill Contingency Plan
PHAST	Process Hazard Analysis Software Tool
PNGRB	Petroleum & Natural Gas Regulatory Board
POL	Petroleum Oil Lubricants
PPE	Personal Protective Equipment
QRA	Quantitative Risk Assessment
ROSOV	Remote Operated Shut Off Valve
SCBA	Self Contained Breathing Apparatus
SoP	Safe Operating Procedure
SPH	Special Process Hazard
TLV	Threshold Limit Values
UFL	Upper Flammable Limit.
UHF	Unit Hazard Factor
UVCE	Unconfined Vapor Cloud Explosion

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VTS	Vehicle Traffic System
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GLOSSARY OF TERMS

Acceptance Criteria	Defines the level of risk to which an individual is exposed, as either tolerable (negligible risk), intolerable or within the ALARP region.
Accident	An unintended event leading to loss of life, property, or damage to the environment. Examples of marine accidents include collisions, powered groundings, drift groundings, fire and explosion, and foundering.
ALARP	As Low As Reasonably Practicable. A concept where the balance between risk, cost and safety margin is reasonably achieved
Catastrophic Failure	The sudden opening up of a specified part of a containment system resulting in a rapid loss of contents.
Classification of Petroleum	Under The Petroleum Act, 1934 and The Petroleum Rules, 1976, the petroleum products are classified in to three classes as follows. a. "Petroleum Class A" means petroleum having a flash – point below 23 Deg C. b. "Petroleum Class B" means petroleum having a flash – point of 23 Deg C and above but below 65 Deg C. c. "Petroleum Class C" means petroleum having flash – point of 65 Deg C and above but below 93 Deg C.
Collision	Vessel to vessel impact – usually resulting in damage to one or other of the vessels.
Consequence	This is the severity associated with an event in terms of toxic doses, fire or explosion etc., i.e. the potential effects of a hazardous event.
Contact	Collision between a vessel and a wharf or other port structure.
Explosion	A sudden release of energy characterized by accompaniment of a blast wave.
Fire	A process of combustion characterized by heat or smoke or flame or any combination of these.
Frequency	The number of occurrences of an event per unit time.
Grounding	Action of a vessels hull, which has impacted with the sea bed/land.
Hazard	A characteristic of the system/plant process that represents a potential for an accident causing damage to people, property or the environment.
HAZID	Hazard Identification meeting. Structured meeting to achieve maximum information about hazards, causes and consequences.
IMO	International Maritime Organisation responsible for improving maritime safety and preventing pollution from ships.
Incident	Any occurrence, other than an accident, that is associated with the operation of a vessel and affects or could affect the safety of operation

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Initiating Event	The first event in an event sequence.
Lower Flammable Limit	Lower end of the concentration range over which a flammable mixture of gas or vapour in air can be ignited at a given temperature and pressure.
Mitigating System	Equipment and/or procedures designed to respond to an accident event sequence by interfering with accident propagation and/or reducing the accident consequence.
Most Credible Loss Scenario	The credible scenarios which can culminate into an accident out of several major and minor scenarios, possible for the release of material and energy.
Persistent oil	Oils and petroleum products such as crude oils, fuel oils and lubrication oils that, when spilt, remains after weathering in a residual form in the environment for an appreciable period.
Probability	The expression for the likelihood of an occurrence of an event or an event sequence or the likelihood of the success or failure of an event on test or demand. By definition, probability must be expressed as a number between 0 and 1.
Risk	A measure of both the likelihood and consequence, if a hazard manifests itself.
Scenario	A sequence of events leading to an accident.
Sensitivity maps	Indication of the vulnerability of a specific area. This could be ecological but may also include socio-economic aspects.
Stranding	The ship becomes fixed on an underwater feature or object such that the vessel cannot readily be moved by lightening, floating off or with assistance from other vessels (e.g. tugs).
Upper Flammable Limit	That concentration in air of a flammable material above which combustion will not propagate.
Vapour Cloud Explosion	The preferred term for an explosion in the open air of a cloud made up of a mixture of a flammable vapour or gas with air.
Vessel traffic system (VTS)	A vessel traffic system whereby authorities monitor vessel movements within a waterway by radar surveillance and disseminate navigational information with regard to potential hazards.
Vulnerability	Extent to which an individual, community, sub-group, structure, service, or geographic area is likely to be damaged or disrupted by the impact of a particular (disaster) hazard.
Worst Credible Loss Scenario	The incident, which has the highest potential to cause an accident of maximum damage.

1. INTRODUCTION

1.1 Background

VPT has approached ISSPL for carrying out Disaster Management Plan (DMP) and Risk Assessment (RA) of the operations within their port area.

1.2 Objectives and Scope

The objective of this project work is Preparation of DMP as per NDMA suggested structure.

The Risk assessment in this project covers consequences due to accidents only and does not address deliberate act of damage.

Note: This RA exercise has not considered the Crude Cavern area, LPG Cavern area and the Naval base and its ancillary unit area.

1.3 Methodology

The methodology/procedure used for the project is as follows:

- **Collection of the relevant information**
- **Hazard Analysis** – Identification of the fire and explosion hazards during handling of LPG (Propane/Butane), Motor Spirit, HSD, Crude oil, Naphtha, Ammonia and chemicals. Also, identification of the impact due to potential grounding & collision accidents using Brainstorming sessions and Bow-tie analysis;
- **Frequency Analysis** – Estimating the frequency based on data as available from published literature and VPT supplied data;
- **Consequence Analysis** – Consequence analysis for loss of containment from the unloading arm/hose, pipeline and storage tank has been done by the DNV-PHAST software. Oil spill trajectory analysis has been done using GNOME software;
- **Risk Analysis and Review** – Risk estimation has been done based on the consequence and frequency as assessed. The Societal and Individual risk estimation has been done by the DNV-SAFETI software. The estimated risks have been categorized as low, medium or high to enable identification of control measures accordingly in order to bring down the risk to the ALARP level;
- **Reporting** – On completion of the study, a draft report has been developed for review by the VPT. Comments on the draft report will be incorporated to finalise the report.

2. RELEVANT REGULATIONS

2.1 International Regulations

2.1.1 International Convention on Oil Pollution Preparedness Response and Cooperation (OPRC 90)

International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC) was adopted in London on 30 November 1990 and entered into force on May 13, 1995.

The OPRC Convention provides an international framework for cooperation in combating and responding to major incidents or threats of oil pollution. The Convention strives:

- to prevent marine pollution by oil, in accordance with the precautionary principle;
- to advance the adoption of adequate response measures in the event that oil pollution does occur;
- to provide for mutual assistance and cooperation between States for these aims.

2.1.2 International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 related thereto (MARPOL 73/78)

The MARPOL Convention is the main International convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively and updated by amendments through the years.

- MARPOL Annex II includes regulations for the control of pollution by noxious liquid substances in bulk. This mandatory technical annex details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk.

Table 2.1 - MARPOL Annex II: The new four-category categorization system for noxious liquid substances carried in bulk

Category	Description
Category X	Noxious Liquid Substances which, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a major hazard to either marine resources or human health and, therefore, justify the prohibition of discharge into the marine environment
Category Y	Noxious Liquid Substances which, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a hazard to either marine resources or human health or cause harm to amenities or other legitimate uses of the sea and therefore justify a limitation on the quality and quantity of the discharge into the marine environment
Category Z	Noxious Liquid Substances which, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a minor hazard to either marine resources or human health and

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	therefore justify less stringent restrictions on the quality and quantity of the discharge into the marine environment
Other Substances	Substances which have been evaluated and found to fall outside Category X, Y or Z because they are considered to present no harm to marine resources, human health, amenities or other legitimate uses of the sea when discharged into the sea from tank cleaning of deballasting operations. The discharges of bilge or ballast water or other residues or mixtures containing these substances are not subject to any requirements of MARPOL Annex II

Alongside the revision of Annex II, the marine pollution hazards of thousands of chemicals have been evaluated by the IMO's Evaluation of Hazardous Substances Working Group (GESAMP), giving a resultant new GESAMP Hazard Profiles List, which indexes the substance according to its bio-accumulation; bio-degradation; acute toxicity; chronic toxicity; long-term health effects; and effects on marine wildlife and on benthic habitats.

- b) MARPOL Annex III covers the prevention of pollution by harmful substances in packaged form. This optional technical annex contains general requirements for the issuing of detailed standards on packing, marking, labeling, documentation, stowage, quantity limitations, exceptions and notifications for preventing pollution by harmful substances.

2.1.3 Protocol on Preparedness, Response and Cooperation to Pollution Incidents by Hazardous and Noxious Substances, 2000 (OPRC-HNS Protocol)

The OPRC-HNS Protocol 2000 defines HNS as “*any substance other than oil which, if introduced into the marine environment, is likely to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the Sea*”.

Parties to the OPR-HNS Protocol 2000 are required to establish measures for dealing with pollution incidents by HNS and more specifically the following is required from them:

- National and regional systems for preparedness and responding effectively to pollution incidents and to establish a national contingency plan for preparedness and response. In addition, parties are required, either individually or through cooperation, to establish equipment stockpiles, training and response exercise programmes and to cooperate in the field of information exchange;
- Emergency plans and reporting: Ships carrying hazardous and noxious liquid substances are required to carry a shipboard pollution emergency plan to deal specifically with incidents involving HNS;
- Enhancement of international cooperation in pollution response, technical cooperation and assistance, cooperation in R&D and information services.

2.1.4 Convention on the International Regulations for Preventing Collisions at Sea 1972 (COLREGS)

The COLREGS are often compared to as the “rules of the road” and prescribe requirements for the navigation and safe conduct of all vessels and requirements for collision avoidance.

2.1.5 International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)

The purpose of the code is to provide an international standard for the safe transport by sea in bulk of liquefied gases and certain other substances, by prescribing the design and construction standards of ships involved in such transport and the equipment they should carry so as to minimize the risk to the ship, its crew and to the environment, having regard to the nature of the products involved. The layout of this code is in line with the International Code for the Construction of Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code).

2.1.6 International Code for the Construction of Equipment of Ships carrying Dangerous Chemicals in Bulk (IBC Code)

The IBC Code gives international standards for the safe transport by sea in bulk of liquid dangerous chemicals, by prescribing the design and construction standards of ships involved in such transport and the equipment they should carry so as to minimise the risks to the ship, its crew and to the environment, having regard to the nature of the products carried. The IBC Code lists chemicals and their hazards and gives both the ship type required to carry that product as well as the environmental hazard rating. Each of the products may have one or more hazard properties which include flammability, toxicity, corrosivity and reactivity.

2.1.7 International Maritime Dangerous Goods Code (IMDG Code)

The IMDG Code was developed as a uniform international code for the transport of dangerous packaged goods by sea covering such matters as packing, container traffic and stowage, with particular reference to the segregation of incompatible substances. The IMDG Code contains regulations for dangerous goods and marine pollutants.

2.1.8 The 1992 Civil Liability Convention (CLC)

The 1992 Civil Liability Convention and the 1992 Fund Convention apply to pollution damage caused by spills of persistent oil from ships carrying oil in bulk as cargo, i.e., generally laden tankers, and to spills of bunker fuel oil from unladen tankers in certain circumstances, suffered in the territory (including the territorial sea) of a State Party to the Conventions, or in the exclusive economic zone (EEZ) or equivalent area of such a state.

Pollution damage includes the cost of preventive measures, i.e., reasonable measures to prevent or minimize pollution damage, as well as loss or damage caused by preventive measures. Expenses incurred for preventive measures are recoverable even when no spill occurs, provided there was a grave and imminent threat of pollution damage.

2.1.9 International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS Convention, 1996)

The HNS Convention is based upon the two-tier systems developed for oil pollution compensation under the CLC and Fund Conventions. However, given the nature of

impacts from an HNS pollution incident, the HNS Convention goes further by not only covering pollution damage, but also risks of fire and explosion, including loss of life or personal injury as well as loss of or damage to property outside of the ship. It also covers loss or damage by contamination of the environment, costs of preventative measures and further loss or damage caused by them.

2.2 National Regulations

Key legislative provisions applicable to the coastal areas in India includes Indian Fisheries Act, 1897; Indian Ports Act, 1908; Coast Guard Act, 1950; Merchant Shipping Act, 1958; Major Port Trust Act, 1963; Wildlife Protection Act, 1972 (amended in 2001); Water (Prevention and Control of Pollution) Act, 1974; Forest Conservation Act, 1980 (amended in 1988); Environment (Protection) Act, 1986; Hazardous Wastes (Management and Handling) Rules, 1989; Coastal Regulation Zone Notification 1991; Biological Diversity Act 2002.

2.2.1 Indian Ports Act, 1908

The Indian Ports Act provides enactment relating to ports and port fees and rules for safety of shipping and conservation of ports.

2.2.2 Coastguard Act, 1978

The Coast Guard Act 1978 deals mainly with constitution of the Coast Guard, service conditions, offences, and punishment. Chapter III - 14.2 (c) under the title of duties of the Indian Coast Guard, however, mentions the preservation of the marine environment and prevention and control of marine pollution. The said provision lists, "Taking such measures as are necessary to preserve and protect the maritime environment and to prevent and control marine pollution". Similarly Chapter III - 14.3 states, "The Indian Coast Guard shall perform under this section in accordance with, and subject to, such rules as may be prescribed and such rules may, in particular, make provisions for ensuring that the Indian Coast Guard functions in close liaison with Union Agencies, institutions and authorities so as to avoid duplication of effort".

In order to implement the above provision, a National Oil Spill Disaster Contingency Plan (NOS-DCP), to combat oil spill disaster was formulated and the Indian Coast Guard was made coordinating agency in view of its operational capability. To facilitate the above process D. G. Shipping and the Ministry of Surface Transport delegated limited powers under Section 69, 356 G and 356 K (i) of the Merchant Shipping Act to the Indian Coast Guard.

2.2.3 Merchant Shipping Act, 1958

The Merchant Shipping Act 1958 of the Government of India is made to foster the development and ensure the efficient maintenance of Divisions Indian Mercantile Marine, in a manner best suited to serve the national interests, to provide for the registration of Indian ships and generally to amend and consolidate the laws relating to merchant shipping. The Directorate General of Shipping, on behalf of the Central Government (Ministry of Shipping), enacts the provisions under the Merchant Shipping Act. The said act governs all aspects of merchant shipping, including prevention and containment of pollution of the sea by oil, in Part XI A of the act.

By a Gazette notification, all aspects concerning marine pollution and control, under the provisions of Section 69, 356 G and K (i) have been delegated to the Indian Coast

Guard. So far as other powers with regard to oil pollution matters, it is for the Directorate General of Shipping to ensure compliance.

2.2.4 Major Port Trust Act, 1963

The Major Port Trusts Act is one under which major ports carry out their functions within their port limits. The above act enforces the responsibility for taking all necessary action, including pollution prevention within the conservancy limit of the port, on the conservator of the port.

2.2.5 The Indian Wild Life (Protection) Act, 1972, amended in 2002 and in 2006, provides for “the protection of wild animals, birds and plants, and for matters connected therewith or ancillary or incidental thereto, with a view to ensuring the ecological and environmental security of the country”. Under the Act, animals include “mammals, birds, reptiles, amphibians, fish, other chordates and invertebrates, and also includes their young and eggs”. Wildlife is defined to include “any animal, aquatic or land vegetation which forms part of any habitat”, which has been interpreted to imply that the destruction of habitat amounts to destruction of wildlife itself.

2.2.6 Water (Prevention & Control of Pollution) Act, 1974, Amended in 1988

The objectives of the Water (Prevention and Control of Pollution) Act are to provide for the Prevention and Control of Water Pollution and the maintenance or restoration of the wholesomeness of water for the establishment, with a view to carrying out the purposes aforesaid, of Boards for the prevention and control of water pollution, for conferring on and assigning to such Boards powers and functions relating thereto and for matters connected therewith.

2.2.7 Environmental Protection Act, 1986 (Amended 1991)

The Environment Protection Act (EP Act) 1986 is umbrella legislation on environment protection. The act has vested substantial powers in the Central Government with wide ranging aspects of environment protection including protection of the marine environment. Under the act, notifications and rules have been issued to regulate and control the pollution aspects of all industrial activities including offshore exploration and production activities. The Ministry of Environment and Forests (MoEF) however, while according clearance for industrial activities including offshore E&P activities in the country including the EEZ, makes stipulations on Environment Impact Assessment (EIA), Risk Analysis, Hazop Analysis, and Disaster Management Plan (DMP) for adherence, and monitors them for compliance.

2.2.8 Coastal Regulation Zones Notification –1991

MOEF has declared the coastal stretches of seas, bays, backwaters etc that are influenced by tidal action (in the landward side) up to 500 meters from the High Tide Line (HTL) and the land between the Low Tide Line (LTL) and the HTL as Coastal Regulation Zone (CRZ)

CRZ is classified into four categories i.e. CRZ-I, CRZ-II, CRZ-III, CRZ-IV

CRZ-I:

- i. Areas that are ecologically sensitive and important, such as, national parks/marine parks, sanctuaries, reserved forests, wildlife habitats, mangroves,

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corals/ coral reefs, areas close to breeding and spawning grounds of fish and other marine life, areas of outstanding natural beauty/ historical/ heritage areas, areas rich in genetic diversity, areas likely to be inundated due to rise in sea level consequent upon global warming and such other areas as may be declared by the Central Government or the concerned authorities at the State/ Union Territory level from time to time.

- ii. Area between the Low Tide Line and the High Tide Line.

CRZ-II: the area that has already been developed up to or close to the shoreline. For this purpose, “developed are” is referred to as that area within the municipal limits or in other legally designated urban area which is already substantially built up and which has been provided with drainage approach roads and other infrastructure facilities. Such as water supply and sewage mains.

CRZ-III: areas that are relatively undisturbed and those, which do not belong to either category or II. Theses will include coastal zone in the rural area (developed and underdeveloped) and also areas within Municipal limits or other legally designated urban areas, which are not substantially built.

CRZ-IV: Coastal stretches in the Andaman and Nicobar, Lakshadweep and small inlands except those designated as CRZ-I, CRZ-II OR CRZ-III.

The following statutory regulations have been also referred in this task: -

- i. The Factories Act, 1948 (amendment 1987) and rules.
- ii. Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 (MSIHC)
- iii. The Chemical Accidents (Emergency, Planning, Preparedness and Response), Rules, 1996.
- iv. The Petroleum Act, 1934 along with the Petroleum Rules, 1976.
- v. Explosive Act 1884 and explosive Rules 2008.
- vi. Dock workers Safety, Health and Welfare Act, 1986 along with Regulations, 1990.
- vii. Petroleum and Natural Gas Regulatory Board (PNGRB) Act, 2006.
- viii. ERDMP Regulations 2010.
- ix. Disaster Management Act 2005.
- x. The Motor Vehicles (Central) Rules, 1989 under the Motor Vehicles Act - 1988.
- xi. The Manufacture Storage, Import and trans boundary movement of Hazardous Chemicals Rules (2008 amended in 2009).
- xii. Central Electricity Authority (CEA) Regulations, 2010 made under Indian Electricity Act.
- xiii. Public Liability Insurance Act, 1991.
- xiv. National disaster management authority guidelines – Chemical (industrial) disasters.
- xv. OISD-STANDARD-114: Safe handling of hazardous chemicals.
- xvi. OISD-STANDARD-117: Fire protection facilities for Petroleum depots, Terminals, Pipeline installations and Lube oil installations.
- xvii. OISD-STANDARD-138: Inspection of Cross Country Pipelines – Onshore.

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- xviii. OISD-STANDARD-156: Fire protection facilities for ports handling hydrocarbons.
- xix. OISD-STANDARD-244: Storage and handling of petroleum products at depots and terminals including standalone crude oil storage facilities.

2.2.9 Factories Act, 1948 and Rules, the Major provisions are: -

- i. Constitution of Site Appraisal Committee by the State Governments.
- ii. Preparation of On-Site Emergency plans by the Occupier, detailing Disaster Control Measures.
- iii. Detailed Health and Safety policy to be laid down by the occupier.
- iv. Occupier to constitute a Safety Committee comprising of workers and management.
- v. Occupier to provide necessary training within the organization or at specialized institutions.
- vi. Occupier to disclose all relevant information to general public also.

2.2.10 Manufacture, Storage and Import of Hazardous Chemicals, Rules, 1989 as amended in 1994 – Excerpts of some salient points are given as below:

Rule 13 (1): An occupier shall prepare and keep up-to-date [an on-site emergency plan containing details specified in Schedule II and detailing] how major accidents will be dealt with on the site on which the industrial activity is carried on and that plan shall include the name of the person who is responsible for safety on the site and the names of those who are authorized to take action in accordance with the plan in case of an emergency.

Rule 13 (4): The occupier shall ensure that a mock drill of the on-site emergency plan is conducted every six months.

Rule 14 (1): It shall be the duty of the concerned authority as identified in Column 2 of Schedule 5 to prepare and keep up-to-date an adequate off-site emergency plan containing particulars specified in Schedule 12 and detailing how emergencies relating to a possible major accident on that site will be dealt with and in preparing that plan the concerned authority shall consult the occupier and such other persons as it may deem necessary.

Column 2 of Schedule 5; Sl. No. 9:

Concerned authority: District Collector or District Emergency Authority designated by the State Government (for preparation of off-site emergency plans as per rule 14).

Rule 14 (4): The concerned authority shall ensure that a rehearsal of the off-site emergency plan is concluded at least once in a calendar year.

2.2.11 Petroleum Rules, 2002

Rule 16 (3): Ports into which petroleum may be imported:

Adequate fire-fighting facilities as per OISD standard – 156 shall be provided at the ports handling petroleum.

Rule 32 (1): Restriction on loading and unloading by night:

Petroleum shall not be loaded into, or unloaded from, any ship, vessel or vehicle between the hours of sunset and sunrise, unless –

- a) Adequate electric lighting is provided at the place of loading or unloading.
- b) Adequate fire-fighting facilities with personnel are kept ready at the place of loading for immediate use in the event of fire.

3. BRIEF DESCRIPTION OF PORT FACILITIES AND OPERATIONS AT VPT

3.1 FACILITIES AND OPERATIONS

3.1.1 Area of Operation

The Visakhapatnam Port is a natural Harbour, situated on the East coast and it is located between Chennai Port and Paradip Port. It lies almost midway between Chennai and Kolkata. It possesses three international certifications viz., ISO 14001:2004 (Environment Management system) OHSAS 18001:2007 (Occupational Health and Safety Management System) and ISO 9001:2008 (Quality Management System) and also this port is ISPS complaint.

3.1.1.1 Location of Port

Latitude	17°42' N
Longitude	83°23' E

Refer **Figure 3.2** for Port limit.

3.1.2 Existing Berthing Facilities- Inner & Outer Harbour

Visakhapatnam Port has Inner and Outer Harbour. In Inner harbour of Northern arm 15 berths are in operation and in western arm, three berths are in operation. Outer Harbour has 8 berths (Ore Berth I&II, OSTT, LPG Jetty, GCB and Multipurpose berths I & II (containers)) as shown in **figure 3.1**-Port layout.

3.1.2.1 Inner Harbour

The entrance channel of Inner Harbour has a turning basin with a diameter of 440 m with a dredging depth of 12.35 m and forms three radial arms viz Northern, North Western and Western arms. The Northern arm contain the main commercial berths of the Port, handling various types of cargo, which consists of 17 berths viz., EQ1, EQ1A, EQ2 to EQ9 and WQ1 to WQ5 and WQ1RE and existing WQ7 which is not in operation.

North-western arm is exclusively allotted to Indian Navy/CG (Coast Guard services) for operation of their own facilities independent of the Port Trust.

In the Western arm, Southern side is presently used by Hindustan Shipyard and the Indian Navy, whereas in the Northern side two dedicated oil berths OR I & OR II are being used by oil companies. A dedicated fertilizer berth on the Western end with mechanical handling facilities to handle ammonia, molten Sulphur and fertilisers etc. is being used exclusively by M/s. Coromandal Fertilizers Ltd.

3.1.2.2 Outer Harbour

The Outer Harbour commissioned in 1976 with three break-waters with each having a length of 1543 m, 412 m and 1070 m respectively in South, North and East.

Outer Harbour has berthing facility for crude oil at offshore tanker terminal (OSTT), ore berths (OB I & OB II) and other raw materials like coal/ steam coal at General Cargo Berth (GCB). OSTT is situated parallel to south breakwater and GCB is located west of the ore berth.

Refer **3.1.7** for the Berth Particulars details.

3.1.3 Port Layout

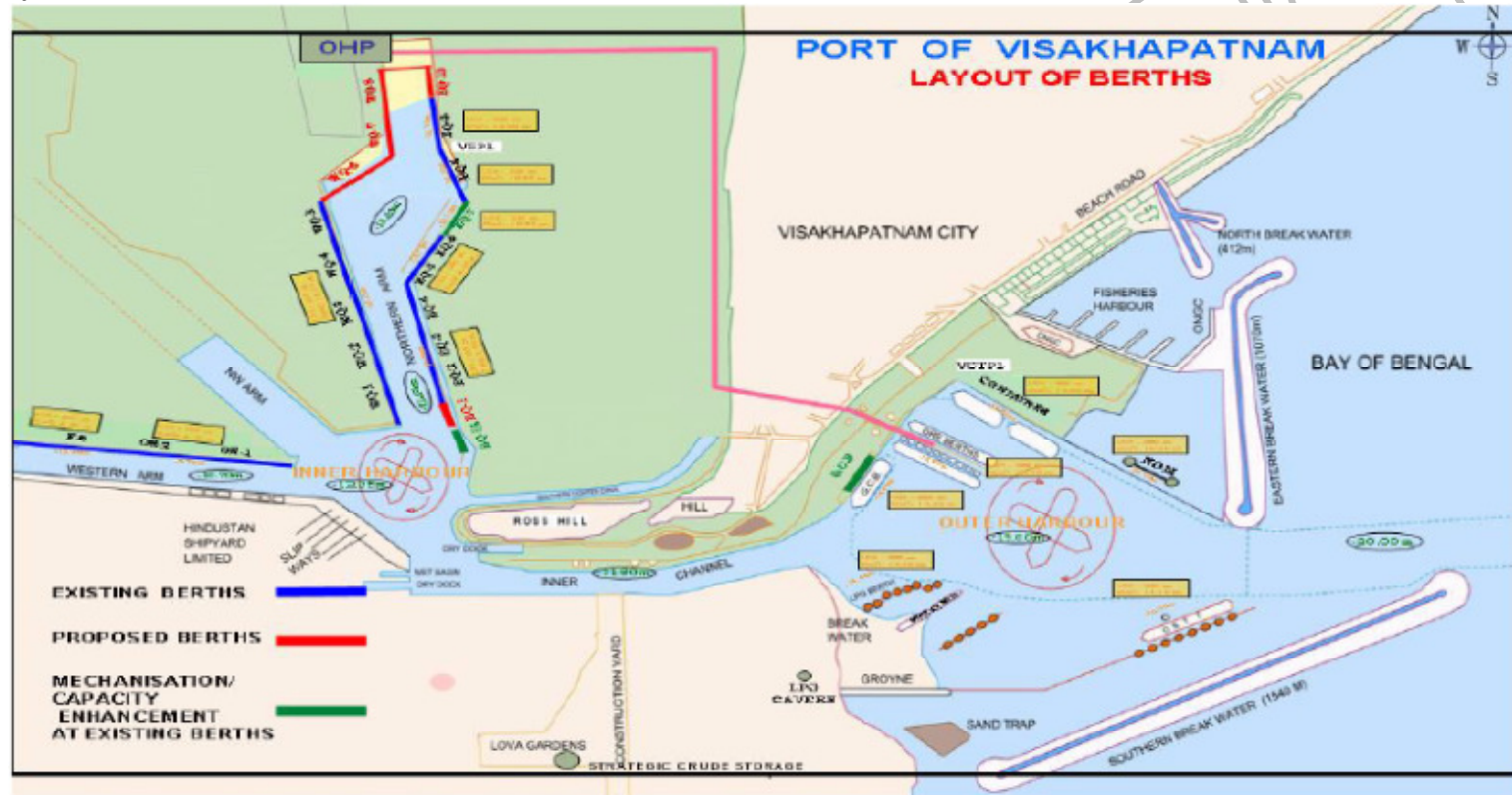


Figure 3.1: Port Layout

3.1.4 Port Limit

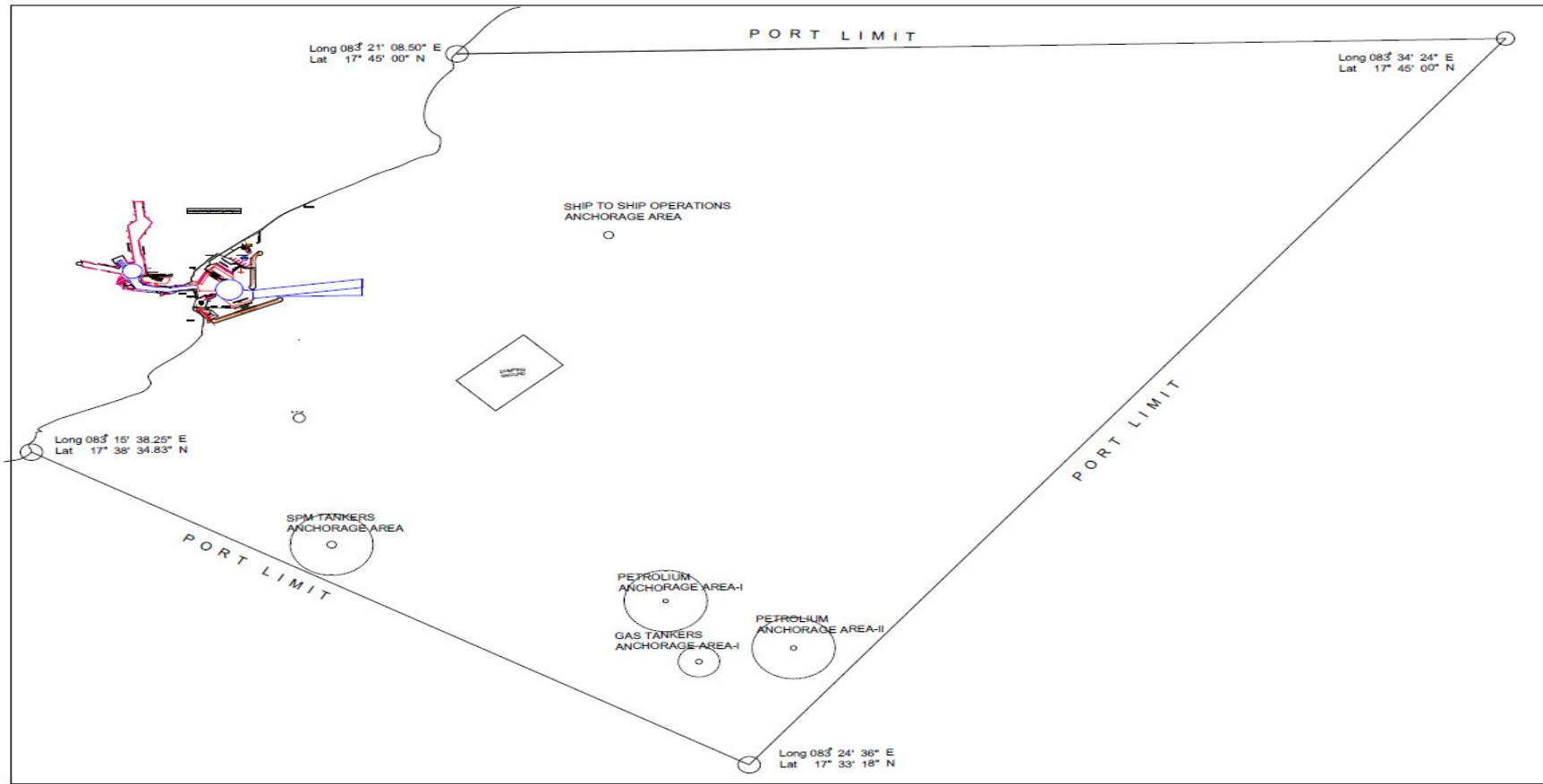


Figure 3.2: Port Limit

Risk Assessment Report**3.1.5 Port Area**

The details of which are as follows

Table 3.1: Port Area

Feature	Inner Harbour	Outer Harbour
Water Spread	100 hectares	200 hectares
Land Area	3083	--
Berths	18	6
Max. Draft (mtrs.)	14.5	18.1
Vessel	PANAMAX	Cape Size

3.1.6 Entrance Channel**Table 3.2: Entrance Channel**

Inner Harbour	
Turning Circle Diameter	: 440 m
Permissible draft	: 11 m
Length	: 1,672 km
Channel Width	: Varies from 97.5 to 122m
Outer Harbour	
Turning Circle Diameter	: 610 m
Dredging draft	: 17 m
Length	: 2,466 km
Channel Width	: 200m

3.1.7 Berth Particulars**Table 3.3: Berth Particulars**

INNER HARBOR NORTHERN ARM - EAST SIDE		
Quay Berths	Berth Length (m)	Permissible draft (m)
**East Quay-1	280.00	14.50
East Quay-2	-	-
East Quay-3	167.64	10.06
East Quay-4	231.00	10.06
East Quay-5	167.64	11.00
East Quay-6	182.90	11.00
East Quay-7	255.00	12.50
* East Quay-8	255.00	14.50
* East Quay-9	255.00	14.50
* B.O.T. Operator M/s. Vizag Seaport Pvt. Ltd.		
** M/s. Adani Vizag Coal Terminal Pvt. Ltd.		

Risk Assessment Report**INNER HARBOUR NORTHERN ARM - WEST SIDE**

Quay Berths	Berth Length (m)	Permissible draft (m)
West Quay-1	212.00	13.00
West Quay-2	226.70	13.00
West Quay-3	201.12	13.00
West Quay-4	243.00	11.00
West Quay-5	241.70	11.00
* West Quay-6	255.00	14.00
RE WQ-1	170.00	11.00

* M/s. West Quay Multi Port Pvt. Ltd. on DB FOT Basis

INNER HARBOUR NORTH WESTERN ARM

Quay Berths	Berth Length (m)	Permissible draft [#] (m)
Fertilizer berth	173.13	10.06
Oil Refinery Berth-1*	183	10.06
Oil Refinery Berth-2*	183	9.75

*Subject to a maximum 195m at one of the two berths

Permissible draft of vessels is subject to availability of tide

OUTER HARBOUR

Quay Berths	Berth Length (m)	Permissible draft (m)
Ore berth -1	270	16.5
Ore Berth -2	270	16.5
* General Cargo Berth	356	18.10
Offshore Tanker Terminal	408	17
LPG	370.92	14
**Container Terminal	451	14.5

* M/s. Vizag General Cargo Berth Pvt. Ltd.

** Operated by M/s. Visakha Container Terminal Pvt. Ltd.

3.2 Meteorological Parameters**3.2.1 Temperature**

The mean daily maximum and minimum temperatures are about 31°C and 23.5°C respectively.

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3.2.2 Wind

Table 3.4: Wind directions and Speeds

Months	Directions
March to May	Mainly from SW
May to October	Mainly from SW
October to November	Variable
December to February	Mainly from NE

The monthly variation in temperature and wind is as follows
(https://www.windfinder.com/windstatistics/visakhapatnam_port)

Month of year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	01	02	03	04	05	06	07	08	09	10	11	12	1-12
Dominant wind direction	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗
Wind probability >= 4 Beaufort (%)	1	1	3	4	6	4	4	4	1	4	10	8	4
Average Wind speed (kts)	5	5	6	7	7	6	6	6	5	6	7	6	6
Average air temp. (°C)	26	28	29	31	32	31	30	30	30	30	28	27	29

Figure 3.3: Monthly Variation of Temperature and Wind

3.2.3 Waves

Deep water waves: the predominant direction of waves during April to September (south west monsoon period) is south-west whereas, during the period from November to February (north-east monsoon period), the predominant direction is north east. The months of March and October are transition periods with no definite predominant direction for the wave approach. Highest wave occurred during April to September. The deep-sea waves with highest and lowest periods, frequent from south-west quadrant. Waves of over 1.5 mts. Height may be expected for 20% of the time. Wave periods of over 7 seconds may be expected 14 % of the time.

3.2.4 Tides

Table 3.5: Tidal Levels

Tide	Above (+) or Below (-) datum
Highest High Water recorded	+ 2.38 m
Mean High Water Spring Tides	+ 1.50 m
Mean High Water Neap Tides	+ 1.10 m
Mean Sea Level	+ 0.8 m
Mean Low Water Neap Tides	+ 0.5 m
Mean Low Water Spring Tides	+ 0.1 m
Lowest Low Water recorded	- 0.55 m

3.3 Sea Conditions

3.3.1 Cyclones

In the Bay of Bengal, depressions are likely to be encountered during all seasons of the year with a local fall in the pressure. On average 4 to 5 cyclones per annum may

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occur. Cyclones are frequent during the month of November. Cyclones are also likely to occur during the month of May.

The details of the history can be found in table 3.10.

3.3.2 Visibility

The visibility is good throughout the year, as fog is infrequent at sea in all seasons. The highest monthly average duration recorded fog is 0.1 day in some months from December to May.

3.3.2 Humidity

The humidity is comparatively high and fairly uniform during the year. The mean daily relative humidity over a year is about 76% at 0800 hours and 72% at 1700 hrs.

3.4 Meteorological Station

Meteorological Station at Port Control Station provides data on Air Quality, Pressure, Temperature, Humidity, Rainfall, Wind Speed and Direction and Tide level with the help of sensors as well as the forecast data and warning received from Regional Meteorological Centre (RMC) – Chennai.

3.5 ESTABLISHMENTS WITHIN THE PORT AREA

- IMC
- LPG Cavern
- Crude Cavern
- NALCO
- VCTPL
- Hindustan Shipyard Ltd.
- Indian Naval Base

3.5.1 Storage Facilities

Table 3.6: Storage facilities at VPT

Tank Farm	Product*	Storage Tank (nos.)	Total capacity in KL
IMC	Bio-diesel, Base Oil, Edible oil etc.	31	106000

* Data provided by the IMC.

3.6 STAKEHOLDERS at VPT

1. Port Authority,
2. Ship owners and operators,
3. Terminal Operators,
4. Railways,
5. Stevedores,
6. C & F agents,
7. Truck and Shipping agents,
8. Contractors to support the day- to day activities of the port,
9. Customs,
10. Ministry of Shipping.

Risk Assessment Report**3.7 POPULATION WITHIN PORT AREA****Table 3.7:** Population data (approximate)

Sr. No	Location	Population	
		Day	Night
1.	Port Quarters		
2.	Administration Building		
3.	VPT First Aid Facility		
4.	CISF Gate complex		
5.	Port Fire Stations		
6.	Port Operation Centers		
7.	Ships at all berths @15 Crew/Ship	15	15
8.	Port Yard		
9.	Fishing Harbour		
10.	Naval Dockyard		
11.	Hindustan Shipyard Ltd.		
12.	VCTPL		
13.	IMC		
14.	NALCO		
15.	Crude Cavern		
16.	LPG Cavern		

3.8 HISTORY OF DISASTERS IN ANDHRA PRADESH (as per NDMA)**3.8.1 Natural Disasters****Table 3.10:** Natural Disasters

Sr. No.	Name of Event	Year	State & Area	Fatalities
1.	Cyclone Hud Hud	Sept 2014	Andhra Pradesh & Odisha	
2.	Andhra Floods	Oct 2013	Andhra Pradesh	53
3.	Cyclone Phailin	Oct 2013	Odisha and Andhra Pradesh	23
4.	Krishna Floods	2009	Andhra Pradesh, Karnataka	300 people died
5.	Tsunami	2004	Coastline of Tamil Nadu, Kerala, Andhra Pradesh, Pondicherry and Andaman and Nicobar Islands of India.	10,749 deaths. 5,640 persons missing. 2.79 million people affected. 11,827 hectares of crops damaged. 300,000 fisher folk lost their livelihood.
6.	Cyclone	1996	Andhra Pradesh	1,000 people died, 5,80,000 housed destroyed,

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				Rs. 20.26 billion estimated damage.
7.	Cyclone	1990	Andhra Pradesh	967 people died, 435,000 acres of land affected
8.	Cyclone	1977	Andhra Pradesh	10,000 deaths, hundreds of thousands homeless 40,000 cattle deaths

3.8.2 Chemical Disasters**Table 3.11: Chemical Disasters**

Sr. No	Year	State & Area	Source	Death/injury/ Missing; Losses
1.	2003	IDL Gulf Oil, Kukkatpally, Hyderabad, Andhra Pradesh	Explosion	8/5/1
2.	2005	Matrix Laboratory Ltd. Unit 1, Kazipally, Medak District, Andhra Pradesh	Sodium Hydride	8/nil/nil
3.	2005	Gulf Oil Corporation Ltd., Sanathnagar, Hyderabad, Andhra Pradesh	Explosion/fire	2/2/nil
4.	2005	Aurobindo Pharma Ltd., Unit-V, IDA Pashamylaram, Medak Dist., Andhra Pradesh	Explosion while drying cloxaciline sodium	1/4/nil
5.	2006	Anjana Explosives Ltd., Peddakaparthi, Nalgonda District, Andhra Pradesh	Spillage of hazchem	5/nil/nil

4. RISK ASSESSMENT PRINCIPLES

4.1 Methodology

The present Risk Assessment (RA) exercise has been done in the following stages:

- Gathering of relevant information and Data
- Hazard Identification
- Frequency Estimation
- Consequence Estimation
- Risk Estimation
- Recommendations.

4.2 Gathering of relevant information and Data

Following data are collected and used for risk assessment study:

- Facility description
- Population data
- Meteorological data
- Generic failure rate data from published literature
- MSDS of Hazardous chemicals.

4.2.1 Meteorological data:

The consequences of releases of flammable and toxic materials into the atmosphere are strongly dependent upon the rate at which the released material is diluted and dispersed to safe concentrations.

Variation in wind direction defines the apparent orientation of consequences. SAFETI accounts for the different wind directions from the wind distribution probability input and combine the values into the risk calculation. Atmospheric conditions, which include temperature and humidity, are also addressed. Two sets of weather data were considered: One set for day-time and one set for night-time. Stability classes were finalized as per Pasquill-Gifford stability classes as mentioned in CPQRA.

Wind speed and stability class considered for this study: 5-D and 2-F.

The representative weather data used in present analysis are as follows:

Table 4.1: Weather conditions

Description	Weather Categories	
	Day	Night
Temperature (°C)	35	25
Relative humidity (%)	60	70
Atmospheric stability	D	F
Wind speed (m/s)	5	2

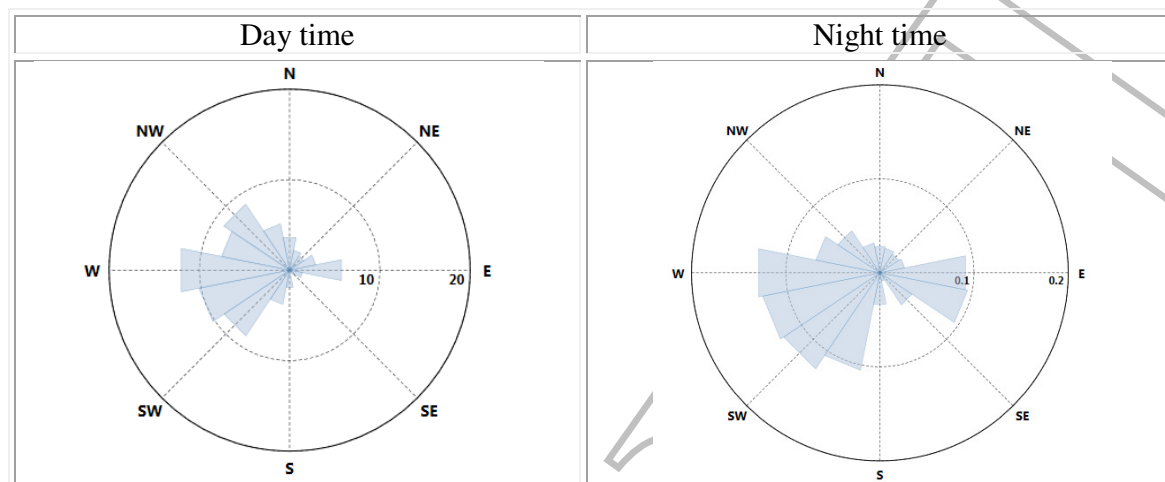


Figure 4.1: Wind rose for the Day & Night time

4.3 Hazard Identification

The first step in risk assessment is to identify hazards. Thereafter evaluate it in terms of the risk it imposes.

In order to rate the fire and explosion hazards for the chemicals handled and storage, the Dow's Fire & Explosion Index (F&EI) is used.

F&EI analysis is a step-by-step evaluation of the realistic fire, explosion and reactivity potential of processes, equipment and its contents. The F&EI is used for any operation in which flammable, combustible or reactive material is stored, handled or processed. It is a product of three attributes i.e. Material Factor (MF), General Process Hazards (GPH) and Special Process Hazards (SPH).

The MF is the starting value in computation of F & EI. MF is a measure of intrinsic rate of potential energy released from fire or explosion produced by combustion or other chemical reaction. The MF is obtained from Flammability factor and Reactivity factor i.e. N_F and N_R respectively given for various chemicals by National Fire Protection Association (NFPA).

Process hazards that contribute to the magnitude of losses have been quantified as penalties, which provide factors for computation. Every penalty may not be applicable to a specific situation and the same may have to be modified. The GPH and SPH are taken into account as penalties, which are applied, to MF.

The F & EI is defined as:

$$\mathbf{F \& EI = MF \times (GPH) (SPH)}$$

Wherein, the product of GPH and SPH is termed as the Unit Hazard Factor (UHF).

The degree of hazard is identified based on F & EI range as per the criteria given Table 4.2:

Table 4.2: F&EI

F & EI Range	Degree of Hazard
0 – 60	Light
61 – 96	Moderate
97 – 127	Intermediate
128 –158	Heavy
> 158	Severe

4.4 Frequency Estimation

There are various methodologies to derive the frequency or probability of occurrence of an incident such as historical incident data on failure frequencies, or from failure sequence models, such as fault trees and event trees.

Such an event tree analysis has been depicted in Fig 4.2 to determine failure frequency of *incident – outcomes*. The probability factors used in event tree analysis have been derived based on failure rate data available from published literature and application of judgment.

4.4.1 Event tree:

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

Following Event Trees will be considered for the Risk assessment study:

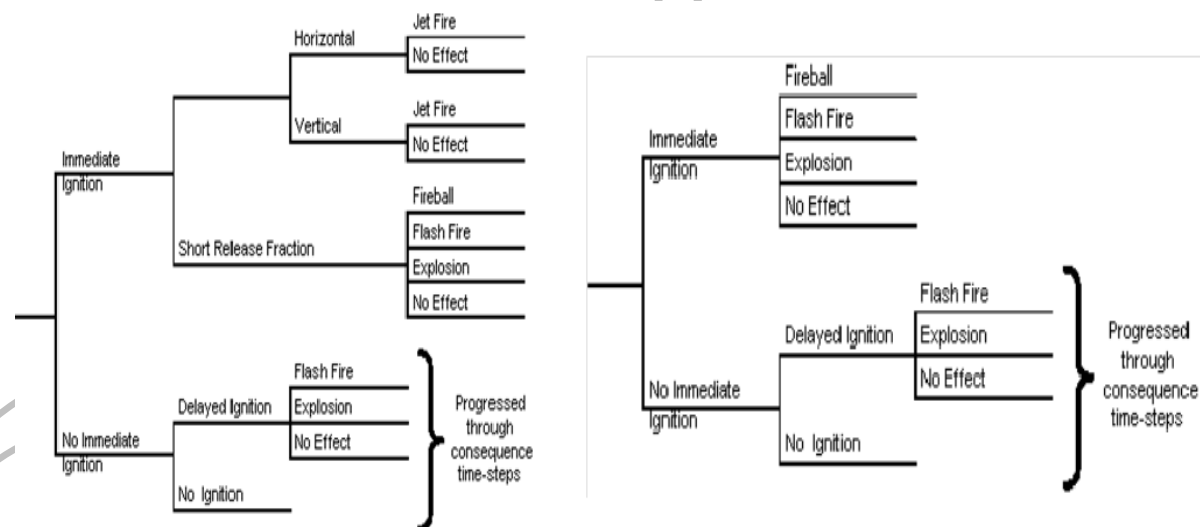


Figure 4.2 Event tree for Continuous & Instantaneous Release:

4.5 Consequence Estimation

Potential for damage of property, loss of lives and injury to health due to possibility of accidents has been estimated for various credible scenarios as mentioned in para 4.5.2.

4.5.1 Consequence modeling generally involves three distinct steps:

- i. Estimation of the source term, i.e., how much material in what form (gas/liquid/two-phase) is being released from containment as a function of time, and development of the release scenarios or possible hazard outcomes (cloud dispersion, fire, explosion, etc.) following the release.
- ii. Estimation of the hazard level (hazard modeling) as a function of time and at selected receptor locations, i.e., estimation of:
 - Ambient concentrations for a toxic or flammable gas release (for modeling the effects of a toxic cloud or flash fire),
 - Thermal radiation flux for fires (for a jet fire, pool fire, or fireball),
 - Overpressure for explosions (for a confined explosion, boiling liquid expanding vapour explosion [BLEVE], or vapour cloud explosion [VCE]).
- iii. Estimation of damage level on the selected receptor, based on the hazard level at the receptor location (vulnerability modeling).

4.5.2 Incident Outcomes - Definitions

4.5.2.1 Fireball

One of significant fire hazard related to liquefied gas. The fireball either results from the bursting of pressure vessel or from vapor cloud explosion. In the first case bursting may occur under fire conditions and be part of a BLEVE or it may occur in the absence of fire. Momentum forces predominate, if fireball is formed from the bursting of vessel, while buoyancy forces predominate, if it is formed from a vapor cloud.

4.5.2.2 Pool Fire

A pool fire occurs when a flammable liquid spills onto the ground and is ignited. A fire in a liquid storage tank is also a form of pool fire, as is a trench fire. A pool fire may also occur on the surface of flammable liquid spilled onto water.

4.5.2.3 Jet Fire

Normally on high-pressure release of pressurized vessel or pipelines on ignition, burn like a jet flames in open space. Any equipment can come in heavy thermal load if the flame jet impinges on it. The consequent radiation hazard is very small.

4.5.2.4 Unconfined Vapor Cloud Explosions (UVCE) and Flash Fire

When gaseous flammable material is released a vapor cloud forms and if it is ignited before it is diluted below its lower explosive limit, a vapor cloud explosion or a flash fire will occur. Insignificant level of confinement will result in flash fire. The vapor cloud explosion will result in overpressure.

4.5.2.5 Boiling Liquid Expanding Vapor Explosion (BLEVE)

A BLEVE occurs when there is a sudden loss of containment of a pressure vessel containing a superheated liquid or liquefied gas. It is sudden release of large mass of pressurized superheated liquid to atmosphere. The primary cause may be external flame impinging on the shell above liquid level weakening the vessel and leading to shell rupture.

4.5.2.6 Toxic Effect

The critical toxicity values which should be considered for evaluating effect on humans in the event of release of chemicals are:

- Permissible exposure limits
- Emergency response planning guidelines
- Lethal dose levels.

4.5.3 Damage Severity Criteria

The quantitative estimation of effects of Thermal radiations and overpressure on human population, process and equipment is given in following three tables.

Table 4.3: Exposure at different incident levels of Thermal radiation (Ref. 9, 20)

RADIANT HEAT (kW/m ²)	HUMAN EXPOSURE LIMITS*
35 to 37.5	100% lethality in 1 min; 1% lethality in 10 seconds
25	100% lethality in 1 min; significant injury in 10 seconds
12.5 to 15.0	1% lethality in 1 min; first degree burns in 10 seconds
9.5	Pain threshold reached after 8 seconds; second-degree burns after 20 seconds
4.0 to 5.0	Sufficient to cause pain to personnel if unable to reach cover within 20 seconds; However, blistering of the skin (second-degree burns) is likely; 0% lethality
1.6	Will cause no discomfort for long exposure

Table 4.4: Thermal radiation damage levels (Ref. 9, 20)

INCIDENT HEAT FLUX (Kw/m ²)	DAMAGE TO EQUIPMENT	REMARKS
35.0 to 37.5	Damage to process equipment	Generally includes steel tanks, chemical process

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		equipment, industrial machinery
25.0	Minimum energy to ignite wood at indefinitely long exposure without a flame	
18.0 to 20.0	Plastic cable insulation degrades	
12.5 to 15.0	Minimum energy to ignite wood with a flame; melts plastic tubing	
* Based on an average 10 min exposure time		

Table 4.5: Explosion overpressure damage impacts (Ref. 9, 20)

Overpressure (bar)	Mechanical Damage to equipment	Damage to people
0.3	Heavy damage to plant & structure	Fatality probability = 1 for humans indoor as well as outdoor >50% eardrum damage >50% serious wounds from flying objects
0.1	Repairable damage	1% death >1% eardrum damage >1% serious wounds from flying objects
0.03	Major glass damage/10% glass damage	Slight injury from flying glass

4.5.4 Software used for consequence assessment

Analysis of liquid/gaseous release events are made by analytical methods, like computer dispersion models PHAST which will predict real time scenario of the situations. The values of downwind concentration of vapor clouds are determined by the physical properties of the dangerous substances, meteorological data, leakage rate, etc. PHAST & SAFETI software is developed by DNV and is used for both consequence and risk calculations. It contains a series of up to date models that allow detailed modeling and quantitative assessment of release rate pool evaporation, atmospheric dispersion, Vapour Cloud Explosion, Combustion, heat radiation effects from fires etc.,

4.6 Risk Estimation

Risk Estimation combines the severity and likelihood of all incident outcomes from all considered incidents/scenarios to derive quantity of risk in terms of Individual Risk and Societal risk. **These estimated risks are shown in para 4.6.1 and 4.6.2.**

4.6.1 Individual Risk

The individual risk is as risk to the person located in the vicinity of a hazard. Individual Risk Criteria (IRC) is used to ensure that individuals living or working near a hazardous activity do

not bear an excessive risk. Individual risk can be estimated for the most exposed individual, for groups of individuals at particular places or for an average individual in an effect zone.

4.6.1.1 Individual Risk Criteria

The most comprehensive and widely – used criteria for Individual Risks are the ones proposed by the UK-HSE as follows.

Table 4.6: Individual Risk Criteria

Maximum tolerable risk for workers	:	10^{-3} per year
Maximum tolerable risk for members of the public	:	10^{-4} per year
Broadly acceptable risk	:	10^{-6} per year

In between the maximum tolerable and broadly acceptable levels, the risk should be reduced to a level which is as low as reasonably practicable (ALARP), taking account of the cost and benefits of any further risk reduction.

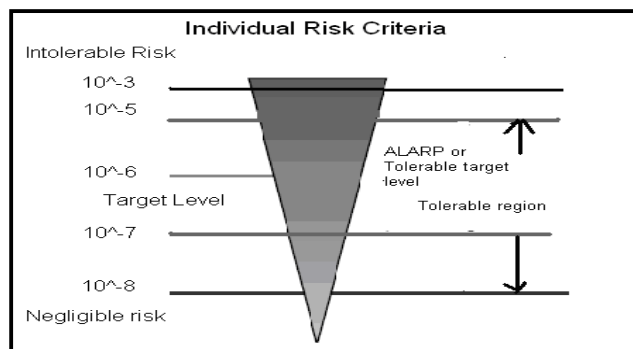


Figure 4.3: Individual Risk Criteria

Figure 4.3 show the zone between the unacceptable and broadly acceptable regions is called the tolerable region. Risks in that region are typical of the risks from activities that people are prepared to tolerate in order to secure benefits in the expectation that the nature and level of the risks are properly assessed and the results used properly to determine control measures; the residual risks are not unduly high and kept as low as reasonable practicable (the ALARP principle); and the risks are periodically reviewed to ensure that they still meet the ALARP criteria.

4.6.2 Societal Risk

Some major incidents have the potential to affect many people. Societal risk is a measure of risk to a group of people. It is most often expressed in terms of the frequency distribution of multiple casualty events (F-N curve) as shown in figure 4.4. However, societal risk can also be expressed in terms similar to individual risk. For example, the likelihood of 10 fatalities at a specific location x, y is a type of societal risk measure. The calculation of societal risk requires the same frequency and consequence information as individual risk. Additionally, societal risk estimation requires a definition of the population at risk around the facility (e.g. residential, industrial, school).

4.6.2.1 FN Curve

An F-N curve is a plot of cumulative frequency versus consequences (expressed as number of fatalities). A logarithmic plot is usually used because the frequency and number of fatalities range over several orders of magnitude. It is also common to show contributions of selected incidents to the total F-N curve as this is helpful for identification of major risk contributors.

4.6.2.2 Societal Risk Criteria

The criteria shown in Figure 4.4 are used here for calculation of Societal Risk. The acceptance criteria for F-N curve based on HSE UK Guideline are presented below:

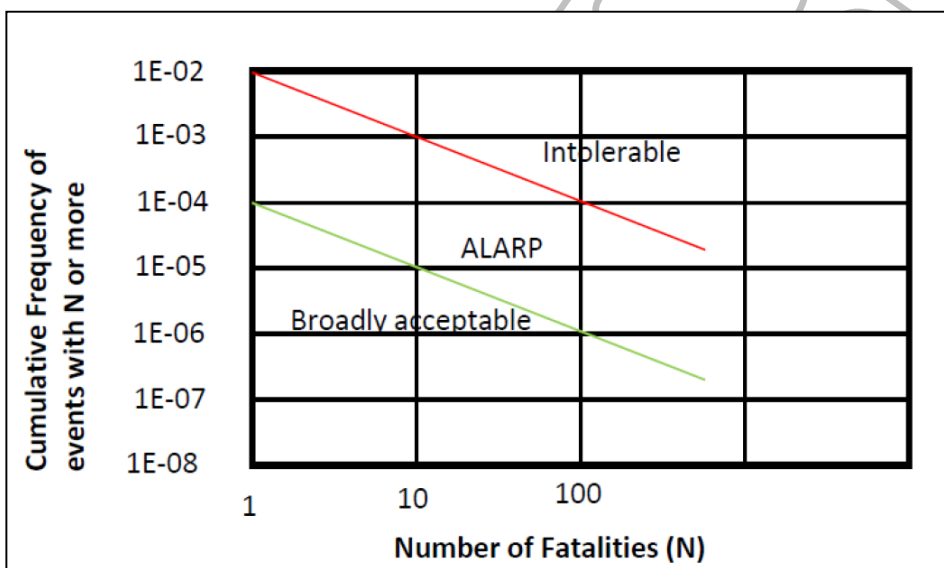


Figure 4.4: Societal Risk Criteria

5.0 RISK ASSESSMENT OF HAZARDOUS CARGO HANDLED AT VPT

5.1 Material handling and Storage Facility at VPT

Port has a facility for storing different types of materials within the Port area by outside agencies as well as on its own. Also VPT has given its land to different major industrial units close to Port area. The details of agencies occupied within Port area for storage of hazardous chemicals are shown in Table 5.1. The details of land allotted to existing industries in outside port area are given in Table 5.2. Agencies occupied in Exim Park area for storage of hazardous chemicals are reported in Table 5.3. The details of the pipeline and unloading arm/hose are given in table 5.4 and table 5.7 below.

Table 5.1 Details of Storages within the port area:

Sr. No.	Agency	Area in Hectares (Acres)
1	CIL fertilisers & chemicals ltd.	3.92 (9.8)
2	NALCO	9.11 (22.49)
3	Indian Molasses co. Ltd. (IMC)	0.81 (2.0)
4	AVR & Co.	0.81 (2.0)
5	JRE & Co.	0.81 (2.0)
Total		15.87 (38.3)

Table 5.2 Details of Industries Outside the port area:

Sr. No.	Agency	Purpose	Area in Hectares (Acres)
1	HPCL	Visakha Refinery	206.89 (511.03)
2	IOCL	Storage Terminal	18.21 (45.0)
3	CIL fertilisers & chemicals ltd.	Fertiliser Plant	195.75 (483.52)
4	Defence Estates officer	Naval Command	57.7 (142.57)
5	Hindustan Ship Yard	Ship building	121.46 (300.0)
Total			611.50 (1510.42)

Table 5.3 Details of Agencies occupied in Exim Park area:

Sr. No.	Agency	Purpose	Area in Hectares (Acres)
1	Rain Calcining Ltd.	Calcined Petroleum coke	17.21 (42.5)

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2	Andhra Petrochemicals Ltd.	Petrochemical Plant	30.36 (75.0)
3	BPCL	Petroleum Storage	16.19 (40.0)
4	East India Petroleum Ltd.	Petroleum Storage	20.24 (50.0)
5	HPCL (ATP)	Additional Tankage	85.95 (212.31)
6	HPCL – Marketing (LPG & POL)	Pipeline & Petroleum Storage	1.66 (4.08)
7	GAIL	Pumping Station	16.96 (41.9)
		Total	188.57 (465.8)

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5.2 Details of Hazardous material transferring through pipeline:

Table 5.4 Inner Harbour:

Chemical	Dia. of pipeline	Flow rate	Quantity handled (MT)	Length of pipeline		Operating conditions		Operator
				Inside port area (m)	Outside port area (m)	Temp (⁰ c)	Pressure (Kg/cm ²)	
Western Arm								
1. Oil Wharf (OR – 1 & OR – 2)								
Styrene (OR – 2)	14"	400 m ³ /hr	8,446	500	4150	28	5.5	EIPL
Naphtha	14"	600 MT/hr	31,476	500	3000	35-40	7.0	HPCL
	12"	400 T/hr	6,462	500	4150	28	5.5	EIPL
MS	14"	800 KL/hr	30,724	800	3700, 4150	28	7.5	BPCL
	12"	500 KL/hr	30,094	500	3000	35-40	6.4	HPCL
ATF	8"	300 T/hr	---	500	3500	35-40	4.0	HPCL
SKO	14"	650 T/hr	8,086	500	3500	35-40	7.5	HPCL
LDO	8"	300 T/hr	4,057	900	3500	35-40	4.0	HPCL
	14"	400 T/hr	32,118	800	3700	30-35	7.0	BPCL
FO	12"*	430 T/hr	34,604	500	3000	80-100	5.0	HPCL
	14"*	500 T/hr	---	400	2800	60	7.0	IOCL
	14"	400 T/hr	---	800	3700	30-35	7.0	BPCL
LSHS	12"	430 T/hr	6,000	400	2800	35	7.0	IOCL
Bitumen	16"	430 T/hr	---	500	3000	35-40	7.5	HPCL
HSD	16"	700 T/hr	41,309	800	3700	30-35	6.7	BPCL
	14"	750 T/hr	---	500	3000	35-40	7.0	HPCL

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	24"*	1000 T/hr	2,000	400		37	10.0	IOCL
Methanol	14"	400 m ³ /hr	9,072	500	4150	Ambient	5.5	EIPL
IPA	14"	400 m ³ /hr	1,221	500	4150	Ambient	5.5	EIPL
Acetone	14"	400 m ³ /hr	989	500	4150	Ambient	5.5	EIPL
Toluene	14"	400 m ³ /hr	8,014	500	4150	Ambient	5.5	EIPL
Bio-Diesel	12"	400 m ³ /hr	25,040	---	---	Ambient	5.5	EIPL
Caustic Soda	12"	250 m ³ /hr	---	---	---	Ambient	5.5	EIPL
2. Fertilizer Berth (FB)								
Liquid Ammonia	16"	500 MT/hr	10,000	500	4700	-33	4.0	CFL
Molten Sulphur	8"/10"	500 MT/hr	10,000	500	4500	135-140	5.5	CFL
3. Northern Arm								
Palm Oil	10"	400	10,000	1360	---	Ambient	Atm.	IMC
Bio Diesel	10"	250	12,000	1360	---	Ambient	Atm.	IMC
Caustic Lye	12"	400	16,289	1360	---	Ambient	Atm.	IMC
Sulphuric acid	8"	200	18,844	355	---	Ambient	Atm.	IMC
Bio Diesel	18"	400	10,000	355	---	Ambient	Atm.	IMC

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Alumina powder	conveyor	2×1000 3×2200	36,600	600	---	Ambient	Atm.	NALCO
Caustic Soda	12"	550	14,100	1000	---	Ambient	4.5	NALCO
Phosphoric acid	10"	500 T/hr	10,000	800	---	Ambient	4.5	CIL

* for bunker jetty for HPCL & IOCL

Table 5.5 Outer Harbour:

Chemical	Dia. of pipeline	Flow rate	Quantity handled (MT)	Length of pipeline		Operating conditions		Operator
				Inside port area (m)	Outside port area (m)	Temp (°c)	Pressure (Kg/cm ²)	
LPG Jetty								
LPG (Propane / Butane)	2 × 14"	300 T/hr	30,000	500	7300	0-20	4.0	HPCL
LPG	10"	450 m ³ /hr	---	---	6300	25-28	16.0	EIPL
HSD	24"	1150 T/hr	33,000	500	7300	37	7.5	BPCL
	24"	1150 T/hr	60,000	500	7300	37	7.5	HPCL
OSTT								
Crude Oil	36"	6600 T/hr	1,50,000	800 ⁺	8900	Atm.	6.0	HPCL

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SPM								
Crude Oil	48"	6600 T/hr	2,50,000	5300 [^]	8900	Atm.	6.0	HPCL
+ 400 meters under sea,		^ 5000 meters under sea,						

Table 5.6 Details of Hazardous material Transshipment - Outer Harbour:

Location of Transshipment	Crude Oil			Naphtha			Diesel		
	No. of ships	Total Quantity (MT)	Max quantity (MT)	No. of ships	Total Quantity (MT)	Max quantity (MT)	No. of ships	Total Quantity (MT)	Max quantity (MT)
OSTT	20	9,09,150	1,40,372	12	2,46,334	1,90,106	--	---	---
ANCH	21	14,64,840	2,62,354	--	---	---	--	---	---
LPG Jetty	4	1,28,644	33,358	8	1,74,964	26,587	11	1,12,104	21,169

Table 5.7 Unloading arm and flexible hose details:

Berth	Cargo	Manifold	Discharge rate
SPM	Crude Oil	2 × 16" floating hose	6000 MT/hr
LPG Berth	Naphtha (STS)	2 × 10" flexible hose	2000 - 2500 MT/hr
	HSD & SKO	2 × 12" Unloading arm	800 MT/hr
	LPG (Propane + Butane)	2 × 10" Unloading arm	500 - 600 MT/hr to cavern
			250 - 350 MT/hr storage tanks
OR - I	HSD/SKO/Naphtha/FO/MS/chemicals	2 × 8" flexible hose	250 - 500 MT/hr
FB	Anhydrous Ammonia / Molten sulphur	1 × 8" Unloading arm	400 - 500 MT/hr
EQ - 6	PA / Caustic lye / Bio Diesel / Palm oil	2 × 8" flexible hose	250 - 800 MT/hr

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EQ - 10	Caustic lye / Bio Diesel	1 × 8" flexible hose	500 MT/hr
WQ - 1	Sulphuric Acid	1 × 8" flexible hose	400 MT/hr
WQ - 5	Caustic lye	1 × 10" Unloading arm	500 MT/hr

5.3 QRA study methodology

The study consists of the following steps

- Hazard identification
- Failure frequency estimation
- Consequence estimation
- Risk assessment
- Recommendations

5.3.1 Hazard Identification for handling of POL at LPG Jetty

The chemical properties of POL as handled at LPG Jetty are shown in table 5.8 below.

Table 5.8: Chemical properties

Sr. No.	Petroleum product	Flash point (°C)	NFPA rating		
			N _F	N _H	N _R
1	Motor Spirit (MS)	---	3	1	0
2	High Speed Diesel (HSD)	52	3	1	0
3	Propane	-104	4	1	0
4	Butane	-60	4	1	0

5.3.1.1 Hazards of LPG (Propane/Butane)

LPG is mixture of propane and butane. LPG is colorless and odorless. An odorizing agent is added before distribution to give its characteristic smell. LPG is easily liquefied under pressure, it expands by volume 1:250 when converted from liquefied to gaseous.

LPG is approximately twice as heavy as air when in gas form. LPG in liquid form can cause severe cold burns to the skin owing to its rapid vaporization. LPG forms a flammable mixture with air in concentrations of between 1.9% and 10%. It can be a fire and explosion hazard. Vapor/air mixtures arising from leakages may be ignited some distance from the point of escape and the flame can travel back to the source of the leak. At very high concentrations when mixed with air, vapor is an anesthetic and subsequently an asphyxiant by diluting the available oxygen. LPG is having the flammability (N_F) classification as 4, Health hazard (N_H) classification as 1 and reactivity (N_R) classification as 0.

5.3.1.2 Dow's Fire & Explosion index of LPG

In order to rate Fire and Explosion hazards of handling of LPG (Propane/Butane) at LPG jetty, the Dow's Fire & Explosion Index (F&EI) is used.

*Risk Assessment Report***Table 5.9:** NFPA hazard ranking of LPG

Chemical	N _F	N _H	N _R
Propane	4	1	0
Butane	4	1	0

5.2.1.3 Summary of DOW's Index For the LPG handling, F&EI have been worked with conservative estimation as given in table 5.10 below:

Table 5.10: Summary of DOW's F&EI for LPG, MS & HSD

Chemical	MF	GPH	SPH	UHF	F&EI	Rating
LPG (Propane/Butane)	21	2.45	2.70	6.615	138.91	HEAVY
MS	16	2.45	1.95	4.78	76.44	Moderate
HSD	16	2.45	1.90	4.65	74.48	Moderate

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Location LPG Jetty	Plant -	PROCESS UNIT LPG (Propane/Butane) unloading and transfer
STATE OF OPERATION LPG unloading and transfer		BASIC MATERIAL(S) FOR MATERIAL FACTOR Liquefied Petroleum Gas
MATERIAL FACTOR		21
1. General Process Hazards		
	Penalty Factor Range	Penalty Factor Used
Base Factor	1.00	1.00
A. Exothermic Chemical Reactions	0.30 to 1.25	----
B. Endothermic Processes	0.20 to 0.40	----
C. Material Handling and Transfer	0.25 to 1.05	0.85
D. Enclosed or Indoor Process Units	0.25 to 0.90	----
E. Access	0.20 to 0.35	0.35
F. Drainage and Spill Control	0.25 to 0.50	0.25
General Process Hazards Factor (F₁)		2.45
2. Special Process Hazards		
Base Factor	1.00	1.00
A. Toxic Material(s)	0.20 to 0.80	0.20
B. Sub-Atmospheric Pressure (< 500 mm Hg)	0.50	----
C. Operation In or Near Flammable Range		----
1. Tank Farms Storage Flammable Liquids	0.50	----
2. Process Upset or Purge Failure	0.30	----
3. Always in Flammable Range	0.80	0.50
D. Dust Explosion	0.25 to 2.00	----
E. Pressure	Operating Pressure 7 bar Relief Setting --- bar	From Figure 0.5
F. Low Temperature	0.20 to 0.30	0.3
G. Quantity of Flammable/Unstable Material:	Quantity = ---- lb H _C = ---- BTU/lb	---- ----
1. Liquids or Gases in Process		From Figure 0.10
2. Liquids or Gases in Storage		From Figure ----
3. Combustible Solids in Storage, Dust in Process		From Figure ----
H. Corrosion and Erosion	0.10 to 0.75	----
I. Leakage – Joints and Packing	0.10 to 1.50	0.10
J. Use of Fired Equipment	From Figure	----
K. Hot Oil Heat Exchange System	0.15 to 1.15	----
L. Rotating Equipment	0.50	----
Special Process Hazards Factor (F₂)		2.70
Process Unit Hazards Factor (F₁ x F₂) = F₃		6.615
Fire and Explosion Index (F₃ x MF = F&EI)		138.91
FIRE & EXPLOSION INDEX (RATINGS)		HEAVY

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Location LPG Jetty	Plant -	PROCESS UNIT MS Handling & transfer
STATE OF OPERATION MS Handling & transfer		BASIC MATERIAL(S) FOR MATERIAL FACTOR MS
MATERIAL FACTOR		16
1. General Process Hazards		Penalty Factor Range
Base Factor		Penalty Factor Used
Base Factor		1.00
A. Exothermic Chemical Reactions		0.30 to 1.25
B. Endothermic Processes		0.20 to 0.40
C. Material Handling and Transfer		0.25 to 1.05
D. Enclosed or Indoor Process Units		0.25 to 0.90
E. Access		0.20 to 0.35
F. Drainage and Spill Control		0.25 to 0.50
General Process Hazards Factor (F₁)		2.45
2. Special Process Hazards		
Base Factor		1.00
A. Toxic Material(s)		0.20 to 0.80
B. Sub-Atmospheric Pressure (< 500 mm Hg)		0.50
C. Operation In or Near Flammable Range		0.50
1. Tank Farms Storage Flammable Liquids		0.50
2. Process Upset or Purge Failure		0.30
3. Always in Flammable Range		0.80
D. Dust Explosion		0.25 to 2.00
E. Pressure		Operating Pressure -- bar Relief Setting -- bar
F. Low Temperature		From Figure
G. Quantity of Flammable/Unstable Material:		Quantity = --- lb H _C = --- BTU/lb
1. Liquids or Gases in Process		From Figure
2. Liquids or Gases in Storage		From Figure
3. Combustible Solids in Storage, Dust in Process		0.15
H. Corrosion and Erosion		From Figure
I. Leakage – Joints and Packing		0.10 to 0.75
J. Use of Fired Equipment		0.10 to 1.50
K. Hot Oil Heat Exchange System		From Figure
L. Rotating Equipment		0.15 to 1.15
Special Process Hazards Factor (F₂)		0.50
Process Unit Hazards Factor (F₁ x F₂) = F₃		1.95
Fire and Explosion Index (F₃ x MF = F&EI)		4.78
FIRE & EXPLOSION INDEX (RATINGS)		76.44
		MODERATE

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Location LPG Jetty	Plant -	PROCESS UNIT HSD handling & transfer
STATE OF OPERATION HSD handling & transfer		BASIC MATERIAL(S) FOR MATERIAL FACTOR HSD
MATERIAL FACTOR		16
1. General Process Hazards		Penalty Factor Range
Base Factor		Penalty Factor Used
A. Exothermic Chemical Reactions		1.00
B. Endothermic Processes		0.30 to 1.25
C. Material Handling and Transfer		0.20 to 0.40
D. Enclosed or Indoor Process Units		0.25 to 1.05
E. Access		0.25 to 0.90
F. Drainage and Spill Control		0.20 to 0.35
F. Drainage and Spill Control		0.25 to 0.50
General Process Hazards Factor (F₁)		0.85
2. Special Process Hazards		
Base Factor		1.00
A. Toxic Material(s)		1.00
B. Sub-Atmospheric Pressure (< 500 mm Hg)		0.20 to 0.80
C. Operation In or Near Flammable Range		0.50
1. Tank Farms Storage Flammable Liquids		0.50
2. Process Upset or Purge Failure		0.30
3. Always in Flammable Range		0.80
D. Dust Explosion		0.25 to 2.00
E. Pressure		Operating Pressure -- bar Relief Setting -- bar
F. Low Temperature		From Figure
G. Quantity of Flammable/Unstable Material:		0.20 to 0.30
1. Liquids or Gases in Process		Quantity = --- lb H _C = --- BTU/lb
2. Liquids or Gases in Storage		---
3. Combustible Solids in Storage, Dust in Process		From Figure
H. Corrosion and Erosion		From Figure
I. Leakage – Joints and Packing		From Figure
J. Use of Fired Equipment		0.10 to 0.75
K. Hot Oil Heat Exchange System		0.10 to 1.50
L. Rotating Equipment		0.15 to 1.15
Special Process Hazards Factor (F₂)		0.50
Process Unit Hazards Factor (F₁ x F₂) = F₃		1.90
Fire and Explosion Index (F₃ x MF = F&EI)		4.165
Fire and Explosion Index (F₃ x MF = F&EI)		74.48
FIRE & EXPLOSION INDEX (RATINGS)		MODERATE

5.3.2 Failure leak scenarios

Failure cases for jetty pipelines, unloading arm and hoses will include two leak sizes, one is a small leak and the other is a large or a full-bore release. The same is tabulated below:

Table 5.11: failure leak scenarios

Leak category	Representative hole size
Small leak	20% of nominal diameter
Rupture	Nominal diameter (FBR)

5.3.2.1 Failure frequency estimation

The failure frequency for loading/unloading and transfer activities is as follows:

Double wall refrigerated storage vessel:

- Catastrophic failure rate : 5.0×10^{-7} (per vessel per year)
- Major failure : 1.0×10^{-5} (per vessel per year)
- Minor failure : 3.0×10^{-5} (per vessel per year)
- Failure with a release of vapor only : 4.0×10^{-4} (per vessel per year)

Vessel connection failure:

- 25 mm dia. leak : 3.0×10^{-5} /yr
- 50 mm dia. leak : 7.5×10^{-6} /yr
- 100 mm dia. leak : 4.0×10^{-6} /yr
- 150 mm dia. leak : 3.0×10^{-6} /yr

Above ground pipeline failure:

- Rupture (> 110 mm dia.) : 6.5×10^{-9} /(m.yr)
- Large hole (>75 - < 110mm) : 3.3×10^{-8} /(m.yr)
- Small hole (>25 - < 75mm) : 6.7×10^{-8} /(m.yr)
- Pin hole (<25 mm) : 1.6×10^{-7} /(m.yr)

Flexible hose failure (failure rates – HSE-UK):

- Full Bore Rupture : 1.2×10^{-7} (per transfer operation)
- Hose leak : 1.0×10^{-6} (per transfer operation)

Loading/unloading arm failure (failure rates – HSE-UK):

- Full Bore Rupture : 3.4×10^{-7} (per transfer operation)
- Hose leak : 3.1×10^{-6} (per transfer operation)

5.3.3 Consequence analysis handling of POL at LPG jetty

5.3.3.1 Consequence results for the Jet fire:

Chemical handled	Leak scenarios	Weather conditions	Jet fire radiation distances (m)		
			4.0 kW/m ²	12.5 kW/m ²	37.5 kW/m ²
Propane	Leak from unloading arm	2-F	259	197	155
		5-D	233	172	133
	FBR of unloading arm	2-F	137	104	82
		5-D	136	102	81
	Leak from Pipeline	2-F	268	205	163
		5-D	243	179	139
	FBR of Pipeline	2-F	450	344	276
		5-D	409	302	234
Butane	Leak from unloading arm	2-F	264	198	156
		5-D	239	174	134
	FBR of unloading arm	2-F	94	74	60
		5-D	87	67	55
	Leak from Pipeline	2-F	225	170	134
		5-D	204	149	115
	FBR of Pipeline	2-F	403	304	240
		5-D	359	262	202
Naphtha-STS	Leak	2-F	267	200	157
		5-D	239	174	133
	Full Bore Rupture	2-F	396	295	229
		5-D	359	262	202
	Leak from Pipeline	2-F	271	203	159
		5-D	242	176	135
	FBR of Pipeline	2-F	53	42	35
		5-D	48	38	31
MS	Leak	2-F	269	202	159
		5-D	245	178	136
	Full Bore Rupture	2-F	442	329	257
		5-D	403	295	227
	Leak from Pipeline	2-F	273	205	161
		5-D	248	180	138
	FBR of Pipeline	2-F	61	48	40
		5-D	54	42	35

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HSD	Leak	2-F	154	115	90
		5-D	166	120	92
	Full Bore Rupture	2-F	32	24	19
		5-D	35	26	21
	Leak from Pipeline	2-F	149	111	87
		5-D	160	115	88
FBR of Pipeline	2-F	19	15	13	
	5-D	29	23	18	
Crude Oil	Leak	2-F	267	199	157
		5-D	239	173	133
	Full Bore Rupture	2-F	472	351	272
		5-D	409	301	233

5.3.3.2 Consequence results for the Pool fire:

Chemical handled	Leak scenarios	Weather conditions	Pool fire radiation distances (m)		
			4.0 kW/m ²	12.5 kW/m ²	37.5 kW/m ²
Propane	Leak from unloading arm	2-F	145	97	59
		5-D	145	102	67
	FBR of unloading arm	2-F	128	80	42
		5-D	131	87	50
	Leak from Pipeline	2-F	124	88	58
		5-D	117	88	63
FBR of Pipeline	2-F	217	148	95	
	5-D	213	154	106	
Butane	Leak from unloading arm	2-F	136	95	63
		5-D	110	85	64
	FBR of unloading arm	2-F	111	68	35
		5-D	114	74	43
	Leak from Pipeline	2-F	120	82	51
		5-D	119	85	59
FBR of Pipeline	2-F	209	139	85	
	5-D	211	147	99	
Naphtha-STS	Leak	2-F	82	52	---
		5-D	89	65	52
	Full Bore	2-F	110	58	---

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	Rupture	5-D	130	60	---
	Leak from Pipeline	2-F	83	53	---
		5-D	90	66	53
	FBR of Pipeline	2-F	41	17	9
5-D		47	21	9	
MS	Leak	2-F	81	52	---
		5-D	83	66	51
	Full Bore Rupture	2-F	111	60	---
		5-D	131	62	---
	Leak from Pipeline	2-F	83	53	---
		5-D	83	67	52
	FBR of Pipeline	2-F	41	17	9
		5-D	47	21	9
HSD	Leak	2-F	98	60	---
		5-D	116	66	---
	Full Bore Rupture	2-F	76	34	---
		5-D	90	34	---
	Leak from Pipeline	2-F	96	58	---
		5-D	113	63	---
FBR of Pipeline	2-F	74	31	---	
	5-D	88	31	---	
Crude Oil	Leak	2-F	160	112	80
		5-D	114	90	73
	Full Bore Rupture	2-F	577	366	230
		5-D	564	368	248

5.3.3.3 Consequence results for the Flash fire:

Chemical handled	Leak scenarios	Weather conditions	Flash fire (m)	
			LFL	½ LFL
Propane	Leak from unloading arm	2-F	408	552
		5-D	250	344
	FBR of unloading arm	2-F	316	397
		5-D	177	250
	Leak from Pipeline	2-F	525	794
		5-D	315	439
	FBR of Pipeline	2-F	688	1190

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		5-D	562	786
Butane	Leak from unloading arm	2-F	478	644
		5-D	286	387
	FBR of unloading arm	2-F	218	283
		5-D	118	173
	Leak from Pipeline	2-F	454	618
		5-D	229	318
FBR of Pipeline	2-F	719	1026	
	5-D	427	592	
Naphtha-STS	Leak	2-F	390	582
		5-D	293	398
	Full Bore Rupture	2-F	232	361
		5-D	286	384
	Leak from Pipeline	2-F	644	890
		5-D	306	417
FBR of Pipeline	2-F	140	190	
	5-D	63	104	
MS	Leak	2-F	402	594
		5-D	299	406
	Full Bore Rupture	2-F	238	362
		5-D	318	426
	Leak from Pipeline	2-F	643	888
		5-D	309	421
FBR of Pipeline	2-F	142	192	
	5-D	66	107	
HSD	Leak	2-F	19	33
		5-D	19	44
	Full Bore Rupture	2-F	73	150
		5-D	112	189
	Leak from Pipeline	2-F	98	273
		5-D	189	328
FBR of Pipeline	2-F	99	214	
	5-D	15	60	
Crude Oil	Leak	2-F	513	726
		5-D	297	404
	Full Bore Rupture	2-F	262	416
		5-D	311	409

*Risk Assessment Report***5.3.3.4 Consequence results for the Explosion:**

Chemical handled	Leak scenarios	Weather conditions	Explosion distances (m)		
			0.03 bar	0.1 bar	0.3 bar
Propane	Leak from unloading arm	2-F	1430	616	567
		5-D	945	457	428
	FBR of unloading arm	2-F	1169	509	469
		5-D	756	340	315
	Leak from Pipeline	2-F	1955	1016	959
		5-D	1085	557	525
FBR of Pipeline	2-F	2620	1331	1253	
	5-D	1970	1011	953	
Butane	Leak from unloading arm	2-F	1529	692	641
		5-D	1038	507	475
	FBR of unloading arm	2-F	936	383	350
		5-D	565	246	227
	Leak from Pipeline	2-F	1666	815	763
		5-D	849	414	388
FBR of Pipeline	2-F	2494	1177	1098	
	5-D	1593	776	727	
Naphtha-STS	Leak	2-F	1373	628	583
		5-D	1049	518	486
	Full Bore Rupture	2-F	985	401	365
		5-D	986	453	429
	Leak from Pipeline	2-F	2239	1144	1078
		5-D	1101	544	510
FBR of Pipeline	2-F	715	283	257	
	5-D	310	140	130	
MS	Leak	2-F	1421	646	600
		5-D	1078	531	498
	Full Bore Rupture	2-F	1038	419	381
		5-D	1063	489	464
	Leak from Pipeline	2-F	2234	1143	1077
		5-D	1127	557	523
FBR of Pipeline	2-F	745	297	270	
	5-D	318	142	131	
HSD	Leak	2-F	268	165	158

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		5-D	342	211	203
	Full Bore Rupture	2-F	79	39	37
		5-D	84	48	46
	Leak from Pipeline	2-F	484	303	292
		5-D	720	397	378
	FBR of Pipeline	2-F	490	255	244
		5-D	172	81	76
Crude Oil	Leak	2-F	1741	853	800
		5-D	1078	531	498
	Full Bore Rupture	2-F	1343	583	537
		5-D	1012	457	430

*Risk Assessment Report***5.3.4 Hazard Identification for handling of POL/Chemicals at OR (I & II) jetties**

The chemical properties of POL/Chemicals are handled & transferred from OR-I/OR-II jetty as shown in table 5.12 below.

Table 5.12: Chemical properties

Sr. No.	Petroleum product / Chemical	Flash point (°c)	NFPA rating		
			N _F	N _H	N _R
1	Motor Spirit (MS)	---	3	1	0
2	High Speed Diesel (HSD)	52	3	1	0
3	Aviation Turbine Fuel (ATF)	37	3	1	0
4	Acetone	-20	3	1	0
5	Toluene	6	3	2	0
6	Isopropyl Alcohol	13	3	1	0
7	Methanol	12	3	1	0
8	Styrene	31	3	2	2

5.3.4.1 Dow's Fire & Explosion index

In order to rate Fire and Explosion hazards of handling and transfer of chemicals from OR-I/OR-II jetty, the Dow's Fire & Explosion Index (F&EI) is used.

5.3.4.2 Summary of DOW's Index

For the chemicals handling, F&EI have been worked with conservative estimation as given in table below:

Table 5.13: Summary of DOW's F&EI for

Chemical	MF	GPH	SPH	UHF	F&EI	Rating
Methanol	16	2.45	1.80	4.41	70.56	Moderate
Styrene	24	2.45	2.10	5.14	123.48	Intermediate
Acetone	16	2.45	1.80	4.41	70.56	Moderate
Toluene	16	2.45	2.00	4.90	78.40	Moderate

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Location OR-I/OR-II jetty	Plant -	PROCESS UNIT Methanol Handling & transfer
STATE OF OPERATION Methanol Handling & transfer		BASIC MATERIAL(S) FOR MATERIAL FACTOR Methanol
MATERIAL FACTOR		16
1. General Process Hazards		
		Penalty Factor Range
		Penalty Factor Used
Base Factor	1.00	1.00
A. Exothermic Chemical Reactions	0.30 to 1.25	-----
B. Endothermic Processes	0.20 to 0.40	-----
C. Material Handling and Transfer	0.25 to 1.05	0.85
D. Enclosed or Indoor Process Units	0.25 to 0.90	-----
E. Access	0.20 to 0.35	0.35
F. Drainage and Spill Control	0.25 to 0.50	0.25
General Process Hazards Factor (F₁)		2.45
2. Special Process Hazards		
Base Factor	1.00	1.00
A. Toxic Material(s)	0.20 to 0.80	0.20
B. Sub-Atmospheric Pressure (< 500 mm Hg)	0.50	-----
C. Operation In or Near Flammable Range		-----
1. Tank Farms Storage Flammable Liquids	0.50	0.50
2. Process Upset or Purge Failure	0.30	-----
3. Always in Flammable Range	0.80	-----
D. Dust Explosion	0.25 to 2.00	-----
E. Pressure	Operating Pressure -- bar Relief Setting -- bar	From Figure -----
F. Low Temperature		0.20 to 0.30 -----
G. Quantity of Flammable/Unstable Material:	Quantity = ---- lb H _C = ---- BTU/lb	--- -----
1. Liquids or Gases in Process		From Figure -----
2. Liquids or Gases in Storage		From Figure -----
3. Combustible Solids in Storage, Dust in Process		From Figure -----
H. Corrosion and Erosion		0.10 to 0.75 -----
I. Leakage – Joints and Packing		0.10 to 1.50 0.10
J. Use of Fired Equipment		From Figure -----
K. Hot Oil Heat Exchange System		0.15 to 1.15 -----
L. Rotating Equipment		0.50 -----
Special Process Hazards Factor (F₂)		1.80
Process Unit Hazards Factor (F₁ x F₂) = F₃		3.92
Fire and Explosion Index (F₃ x MF = F&EI)		70.56
FIRE & EXPLOSION INDEX (RATINGS)		MODERATE

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Location OR-I/OR-II jetty	Plant -	PROCESS UNIT Styrene Handling & transfer	
STATE OF OPERATION Styrene Handling & transfer		BASIC MATERIAL(S) FOR MATERIAL FACTOR Styrene	
MATERIAL FACTOR			24
1. General Process Hazards		Penalty Factor Range	Penalty Factor Used
Base Factor		1.00	1.00
A. Exothermic Chemical Reactions		0.30 to 1.25	-----
B. Endothermic Processes		0.20 to 0.40	-----
C. Material Handling and Transfer		0.25 to 1.05	0.85
D. Enclosed or Indoor Process Units		0.25 to 0.90	-----
E. Access		0.20 to 0.35	0.35
F. Drainage and Spill Control		0.25 to 0.50	0.25
General Process Hazards Factor (F₁)			2.45
2. Special Process Hazards			
Base Factor		1.00	1.00
A. Toxic Material(s)		0.20 to 0.80	0.40
B. Sub-Atmospheric Pressure (< 500 mm Hg)		0.50	-----
C. Operation In or Near Flammable Range			-----
1. Tank Farms Storage Flammable Liquids		0.50	0.50
2. Process Upset or Purge Failure		0.30	-----
3. Always in Flammable Range		0.80	-----
D. Dust Explosion		0.25 to 2.00	-----
E. Pressure		Operating Pressure -- bar Relief Setting -- bar	From Figure -----
F. Low Temperature		0.20 to 0.30	-----
G. Quantity of Flammable/Unstable Material:		Quantity = ---- lb H _C = ---- BTU/lb	--- -----
1. Liquids or Gases in Process		From Figure	-----
2. Liquids or Gases in Storage		From Figure	-----
3. Combustible Solids in Storage, Dust in Process		From Figure	-----
H. Corrosion and Erosion		0.10 to 0.75	-----
I. Leakage – Joints and Packing		0.10 to 1.50	0.10
J. Use of Fired Equipment		From Figure	-----
K. Hot Oil Heat Exchange System		0.15 to 1.15	-----
L. Rotating Equipment		0.50	-----
Special Process Hazards Factor (F₂)			2.10
Process Unit Hazards Factor (F₁ x F₂) = F₃			5.14
Fire and Explosion Index (F₃ x MF = F&EI)			123.5
FIRE & EXPLOSION INDEX (RATINGS)			INTERMEDIATE

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Location OR-I/OR-II jetty	Plant -	PROCESS UNIT Acetone Handling & transfer
STATE OF OPERATION Acetone Handling & transfer		BASIC MATERIAL(S) FOR MATERIAL FACTOR Acetone
MATERIAL FACTOR		16
1. General Process Hazards		
	Penalty Factor Range	Penalty Factor Used
Base Factor	1.00	1.00
A. Exothermic Chemical Reactions	0.30 to 1.25	-----
B. Endothermic Processes	0.20 to 0.40	-----
C. Material Handling and Transfer	0.25 to 1.05	0.85
D. Enclosed or Indoor Process Units	0.25 to 0.90	-----
E. Access	0.20 to 0.35	0.35
F. Drainage and Spill Control	0.25 to 0.50	0.25
General Process Hazards Factor (F₁)		2.45
2. Special Process Hazards		
Base Factor	1.00	1.00
A. Toxic Material(s)	0.20 to 0.80	0.20
B. Sub-Atmospheric Pressure (< 500 mm Hg)	0.50	-----
C. Operation In or Near Flammable Range		-----
1. Tank Farms Storage Flammable Liquids	0.50	0.50
2. Process Upset or Purge Failure	0.30	-----
3. Always in Flammable Range	0.80	-----
D. Dust Explosion	0.25 to 2.00	-----
E. Pressure	Operating Pressure --- bar Relief Setting -- bar	From Figure -----
F. Low Temperature		0.20 to 0.30 -----
G. Quantity of Flammable/Unstable Material:	Quantity = ---- lb H _C = ---- BTU/lb	198 x 10 ⁶ -----
1. Liquids or Gases in Process		From Figure -----
2. Liquids or Gases in Storage		From Figure -----
3. Combustible Solids in Storage, Dust in Process		From Figure -----
H. Corrosion and Erosion		0.10 to 0.75 -----
I. Leakage – Joints and Packing		0.10 to 1.50 0.10
J. Use of Fired Equipment		From Figure -----
K. Hot Oil Heat Exchange System		0.15 to 1.15 -----
L. Rotating Equipment		0.50 -----
Special Process Hazards Factor (F₂)		1.80
Process Unit Hazards Factor (F₁ x F₂) = F₃		4.41
Fire and Explosion Index (F₃ x MF = F&EI)		70.56
FIRE & EXPLOSION INDEX (RATINGS)		MODERATE

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Location OR-I/OR-II jetty	Plant -	PROCESS UNIT Toluene Handling & transfer
STATE OF OPERATION Toluene Handling & transfer		BASIC MATERIAL(S) FOR MATERIAL FACTOR Toluene
MATERIAL FACTOR		16
1. General Process Hazards		
	Penalty Factor Range	Penalty Factor Used
Base Factor	1.00	1.00
A. Exothermic Chemical Reactions	0.30 to 1.25	-----
B. Endothermic Processes	0.20 to 0.40	-----
C. Material Handling and Transfer	0.25 to 1.05	0.85
D. Enclosed or Indoor Process Units	0.25 to 0.90	-----
E. Access	0.20 to 0.35	0.35
F. Drainage and Spill Control	0.25 to 0.50	0.25
General Process Hazards Factor (F₁)		2.45
2. Special Process Hazards		
Base Factor	1.00	1.00
A. Toxic Material(s)	0.20 to 0.80	0.40
B. Sub-Atmospheric Pressure (< 500 mm Hg)	0.50	-----
C. Operation In or Near Flammable Range		-----
1. Tank Farms Storage Flammable Liquids	0.50	0.50
2. Process Upset or Purge Failure	0.30	-----
3. Always in Flammable Range	0.80	-----
D. Dust Explosion	0.25 to 2.00	-----
E. Pressure	Operating Pressure --- bar Relief Setting -- bar	From Figure -----
F. Low Temperature		0.20 to 0.30 -----
G. Quantity of Flammable/Unstable Material:	Quantity = ---- lb H _C = ---- BTU/lb	--- -----
1. Liquids or Gases in Process		From Figure -----
2. Liquids or Gases in Storage		From Figure -----
3. Combustible Solids in Storage, Dust in Process		From Figure -----
H. Corrosion and Erosion		0.10 to 0.75 -----
I. Leakage – Joints and Packing		0.10 to 1.50 0.10
J. Use of Fired Equipment		From Figure -----
K. Hot Oil Heat Exchange System		0.15 to 1.15 -----
L. Rotating Equipment		0.50 -----
Special Process Hazards Factor (F₂)		2.00
Process Unit Hazards Factor (F₁ x F₂) = F₃		4.90
Fire and Explosion Index (F₃ x MF = F&EI)		78.40
FIRE & EXPLOSION INDEX (RATINGS)		MODERATE

5.3.5 Consequence analysis of handling of POL/Chemicals at OR (I & II) Jetty

5.3.5.1 Consequence results for the Jet fire:

Chemical handled	Leak scenarios	Weather conditions	Jet fire radiation distances (m)		
			4.0 kW/m ²	12.5 kW/m ²	37.5 kW/m ²
MS	Leak from unloading hose	2-F	269	202	159
		5-D	245	178	136
	FBR of unloading hose	2-F	442	329	257
		5-D	403	295	227
	Leak from Pipeline	2-F	273	205	161
		5-D	248	180	138
	FBR of Pipeline	2-F	61	48	40
		5-D	54	42	35
ATF	Leak from unloading hose	2-F	230	172	134
		5-D	220	159	122
	FBR of unloading hose	2-F	55	42	33
		5-D	58	45	36
	Leak from Pipeline	2-F	231	172	134
		5-D	220	160	122
	FBR of Pipeline	2-F	55	42	33
		5-D	58	45	36
HSD	Leak from unloading hose	2-F	154	115	90
		5-D	166	120	92
	FBR of unloading hose	2-F	32	24	19
		5-D	35	26	21
	Leak from Pipeline	2-F	149	111	87
		5-D	160	115	88
FBR of Pipeline	2-F	19	15	13	
	5-D	29	23	18	
Naphtha	Leak from unloading hose	2-F	267	200	157
		5-D	239	174	133
	FBR of unloading hose	2-F	124	94	73
		5-D	127	95	75
	Leak from Pipeline	2-F	271	203	159
		5-D	242	176	135
FBR of Pipeline	2-F	53	42	35	
	5-D	48	38	31	

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Methanol	Leak from unloading hose	2-F	171	136	---
		5-D	167	129	118
	FBR of unloading hose	2-F	159	130	---
		5-D	143	111	105
	Leak from Pipeline	2-F	152	121	---
		5-D	145	112	105
FBR of Pipeline	2-F	59	54	---	
	5-D	63	50	---	
Ethanol	Leak from unloading hose	2-F	158	124	106
		5-D	159	121	95
	FBR of unloading hose	2-F	142	109	98
		5-D	129	99	79
	Leak from Pipeline	2-F	139	108	94
		5-D	137	104	82
FBR of Pipeline	2-F	49	38	---	
	5-D	53	41	36	
Toluene	Leak from unloading hose	2-F	157	118	93
		5-D	160	117	90
	FBR of unloading hose	2-F	127	95	74
		5-D	118	87	67
	Leak from Pipeline	2-F	133	101	79
		5-D	134	98	75
FBR of Pipeline	2-F	44	34	27	
	5-D	48	37	29	
Acetone	Leak from unloading hose	2-F	254	196	156
		5-D	245	184	143
	FBR of unloading hose	2-F	250	191	151
		5-D	229	172	134
	Leak from Pipeline	2-F	225	173	137
		5-D	222	167	129
FBR of Pipeline	2-F	108	83	71	
	5-D	112	87	69	
Isopropyl Alcohol	Leak from unloading hose	2-F	163	126	100
		5-D	168	126	97
	FBR of unloading hose	2-F	144	110	89
		5-D	133	100	78
	Leak from	2-F	143	110	87

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	Pipeline	5-D	144	108	84	
	FBR of Pipeline	2-F	48	37	34	
Styrene	Leak from unloading hose	5-D	52	40	32	
		2-F	92	70	55	
	FBR of unloading hose	5-D	93	68	52	
		2-F	67	50	39	
	Leak from Pipeline	5-D	63	46	36	
		2-F	77	58	46	
	FBR of Pipeline	5-D	77	56	43	
		2-F	23	17	15	
		Leak from unloading hose	5-D	25	19	15
			2-F	208	157	123
Benzene	FBR of unloading hose	5-D	207	152	117	
		2-F	191	144	112	
	Leak from Pipeline	5-D	178	131	101	
		2-F	179	135	106	
	FBR of Pipeline	5-D	175	129	99	
		2-F	74	56	44	
		Leak from unloading hose	5-D	80	61	48
			2-F	208	157	123

5.3.5.2 Consequence results for the Pool fire:

Chemical handled	Leak scenarios	Weather conditions	Pool fire radiation distances (m)		
			4.0 kW/m ²	12.5 kW/m ²	37.5 kW/m ²
MS	Leak from unloading hose	2-F	81	52	---
		5-D	83	66	51
	FBR of unloading hose	2-F	111	60	---
		5-D	131	62	---
	Leak from Pipeline	2-F	83	53	---
		5-D	83	67	52
	FBR of Pipeline	2-F	41	17	9
		5-D	47	21	9
ATF	Leak from unloading hose	2-F	76	43	---
		5-D	89	48	---
	FBR of unloading hose	2-F	53	20	---
		5-D	64	22	---
	Leak from	2-F	76	43	---
		5-D	89	48	---

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	Pipeline	5-D	89	48	---
	FBR of Pipeline	2-F	53	20	---
		5-D	64	22	---
HSD	Leak from unloading hose	2-F	98	60	---
		5-D	116	66	---
	FBR of unloading hose	2-F	76	34	---
		5-D	90	34	---
	Leak from Pipeline	2-F	96	58	---
		5-D	113	63	---
	FBR of Pipeline	2-F	74	31	---
		5-D	88	31	---
Naphtha	Leak from unloading hose	2-F	82	52	---
		5-D	89	65	52
	FBR of unloading hose	2-F	60	24	---
		5-D	73	25	---
	Leak from Pipeline	2-F	83	53	---
		5-D	90	66	53
	FBR of Pipeline	2-F	41	17	9
		5-D	47	21	9
Methanol	Leak from unloading hose	2-F	164	120	87
		5-D	169	130	92
	FBR of unloading hose	2-F	155	108	74
		5-D	157	116	75
	Leak from Pipeline	2-F	165	119	85
		5-D	169	129	88
	FBR of Pipeline	2-F	275	188	124
		5-D	277	198	123
Ethanol	Leak from unloading hose	2-F	190	134	89
		5-D	195	143	99
	FBR of unloading hose	2-F	211	143	89
		5-D	214	151	99
	Leak from Pipeline	2-F	179	125	81
		5-D	182	133	90
	FBR of Pipeline	2-F	308	203	124
		5-D	310	211	139
Toluene	Leak from unloading hose	2-F	95	55	---
		5-D	109	58	---

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	FBR of unloading hose	2-F	134	70	---
		5-D	155	70	---
	Leak from Pipeline	2-F	88	49	---
		5-D	102	51	---
	FBR of Pipeline	2-F	125	60	---
		5-D	146	60	---
Acetone	Leak from unloading hose	2-F	185	129	86
		5-D	185	134	97
	FBR of unloading hose	2-F	276	181	113
		5-D	278	188	128
	Leak from Pipeline	2-F	176	121	79
		5-D	177	127	90
FBR of Pipeline	2-F	322	205	123	
	5-D	324	214	141	
Isopropyl Alcohol	Leak from unloading hose	2-F	198	138	93
		5-D	202	146	107
	FBR of unloading hose	2-F	251	167	107
		5-D	255	175	122
	Leak from Pipeline	2-F	187	129	86
		5-D	190	136	98
FBR of Pipeline	2-F	326	212	131	
	5-D	328	219	148	
Styrene	Leak from unloading hose	2-F	99	57	---
		5-D	114	60	---
	FBR of unloading hose	2-F	138	73	---
		5-D	160	74	---
	Leak from Pipeline	2-F	92	51	---
		5-D	105	53	---
FBR of Pipeline	2-F	132	64	---	
	5-D	151	64	---	
Benzene	Leak from unloading hose	2-F	91	52	---
		5-D	105	55	---
	FBR of unloading hose	2-F	131	68	---
		5-D	152	68	---
	Leak from Pipeline	2-F	84	46	---
		5-D	98	48	---
FBR of Pipeline	2-F	123	58	---	

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		5-D	144	58	---
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5.3.5.3 Consequence results for the Flash fire:

Chemical handled	Leak scenarios	Weather conditions	Flash fire (m)	
			LFL	½ LFL
MS	Leak from unloading hose	2-F	402	594
		5-D	299	406
	FBR of unloading hose	2-F	238	362
		5-D	318	426
	Leak from Pipeline	2-F	643	888
		5-D	309	421
FBR of Pipeline	2-F	142	192	
	5-D	66	107	
ATF	Leak from unloading hose	2-F	276	400
		5-D	200	276
	FBR of unloading hose	2-F	118	146
		5-D	87	138
	Leak from Pipeline	2-F	460	627
		5-D	274	389
FBR of Pipeline	2-F	281	382	
	5-D	108	193	
HSD	Leak from unloading hose	2-F	73	150
		5-D	112	189
	FBR of unloading hose	2-F	19	33
		5-D	19	44
	Leak from Pipeline	2-F	98	273
		5-D	189	328
FBR of Pipeline	2-F	99	214	
	5-D	15	60	
Naphtha	Leak from unloading hose	2-F	390	582
		5-D	293	398
	FBR of unloading hose	2-F	215	279
		5-D	161	228
	Leak from Pipeline	2-F	644	890
		5-D	306	417
FBR of Pipeline	2-F	140	190	

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		5-D	63	104
Methanol	Leak from unloading hose	2-F	49	72
		5-D	49	106
	FBR of unloading hose	2-F	38	83
		5-D	38	91
	Leak from Pipeline	2-F	44	144
		5-D	42	126
	FBR of Pipeline	2-F	69	149
		5-D	22	68
Ethanol	Leak from unloading hose	2-F	49	73
		5-D	48	108
	FBR of unloading hose	2-F	36	73
		5-D	33	81
	Leak from Pipeline	2-F	44	149
		5-D	42	137
	FBR of Pipeline	2-F	53	129
		5-D	17	56
Toluene	Leak from unloading hose	2-F	68	145
		5-D	97	169
	FBR of unloading hose	2-F	59	106
		5-D	63	108
	Leak from Pipeline	2-F	128	298
		5-D	97	232
	FBR of Pipeline	2-F	125	201
		5-D	38	157
Acetone	Leak from unloading hose	2-F	138	267
		5-D	174	258
	FBR of unloading hose	2-F	121	181
		5-D	147	209
	Leak from Pipeline	2-F	304	494
		5-D	205	320
	FBR of Pipeline	2-F	304	414
		5-D	192	333
Isopropyl Alcohol	Leak from unloading hose	2-F	66	137
		5-D	95	171
	FBR of unloading hose	2-F	61	112
		5-D	69	121

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	Leak from Pipeline	2-F	111	283
		5-D	116	259
	FBR of Pipeline	2-F	110	190
		5-D	36	147
Styrene	Leak from unloading hose	2-F	44	50
		5-D	38	46
	FBR of unloading hose	2-F	28	32
		5-D	21	27
	Leak from Pipeline	2-F	37	43
		5-D	38	44
	FBR of Pipeline	2-F	11	21
		5-D	21	24
Benzene	Leak from unloading hose	2-F	163	291
		5-D	177	255
	FBR of unloading hose	2-F	123	183
		5-D	133	189
	Leak from Pipeline	2-F	347	504
		5-D	212	337
	FBR of Pipeline	2-F	297	398
		5-D	212	357

5.3.5.4 Consequence results for the Explosion:

Chemical handled	Leak scenarios	Weather conditions	Explosion distances (m)		
			0.03 bar	0.1 bar	0.3 bar
MS	Leak from unloading hose	2-F	1421	646	600
		5-D	1078	531	498
	FBR of unloading hose	2-F	1038	419	381
		5-D	1063	489	464
	Leak from Pipeline	2-F	2234	1143	1077
		5-D	1127	557	523
FBR of Pipeline	2-F	745	297	270	
	5-D	318	142	131	
ATF	Leak from unloading hose	2-F	1017	485	454
		5-D	747	362	339
	FBR of unloading hose	2-F	651	231	206
		5-D	386	179	167
	Leak from	2-F	1823	853	795

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	Pipeline	5-D	1087	517	483
	FBR of Pipeline	2-F	1437	576	524
		5-D	529	255	239
HSD	Leak from unloading hose	2-F	268	165	158
		5-D	342	211	203
	FBR of unloading hose	2-F	79	39	37
		5-D	84	48	46
	Leak from Pipeline	2-F	484	303	292
		5-D	720	397	378
	FBR of Pipeline	2-F	490	255	244
		5-D	172	81	76
Naphtha	Leak from unloading hose	2-F	1373	628	583
		5-D	1049	518	486
	FBR of unloading hose	2-F	849	326	294
		5-D	721	317	293
	Leak from Pipeline	2-F	2239	1144	1078
		5-D	1101	544	510
	FBR of Pipeline	2-F	715	283	257
		5-D	310	140	130
Methanol	Leak from unloading hose	2-F	181	91	86
		5-D	236	126	119
	FBR of unloading hose	2-F	153	94	90
		5-D	145	92	89
	Leak from Pipeline	2-F	277	158	151
		5-D	300	155	146
	FBR of Pipeline	2-F	376	185	173
		5-D	180	91	86
Ethanol	Leak from unloading hose	2-F	151	85	81
		5-D	197	118	114
	FBR of unloading hose	2-F	127	81	78
		5-D	14	91	88
	Leak from Pipeline	2-F	274	166	159
		5-D	326	168	158
	FBR of Pipeline	2-F	306	156	147
		5-D	144	68	63
Toluene	Leak from unloading hose	2-F	264	164	158
		5-D	308	188	181

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	FBR of unloading hose	2-F	228	124	118
		5-D	203	120	115
	Leak from Pipeline	2-F	560	342	329
		5-D	502	282	269
	FBR of Pipeline	2-F	680	282	259
		5-D	277	174	168
Acetone	Leak from unloading hose	2-F	581	314	298
		5-D	580	314	298
	FBR of unloading hose	2-F	521	230	212
		5-D	504	259	244
	Leak from Pipeline	2-F	1260	631	593
		5-D	802	405	381
FBR of Pipeline	2-F	1493	556	499	
	5-D	815	416	392	
Isopropyl Alcohol	Leak from unloading hose	2-F	243	152	146
		5-D	331	201	193
	FBR of unloading hose	2-F	219	131	125
		5-D	226	140	135
	Leak from Pipeline	2-F	488	312	301
		5-D	513	301	288
FBR of Pipeline	2-F	582	253	235	
	5-D	263	156	149	
Styrene	Leak from unloading hose	2-F	77	55	54
		5-D	75	46	45
	FBR of unloading hose	2-F	40	32	31
		5-D	32	22	21
	Leak from Pipeline	2-F	51	34	33
		5-D	146	60	55
FBR of Pipeline	2-F	56	27	25	
	5-D	67	37	35	
Benzene	Leak from unloading hose	2-F	650	343	325
		5-D	610	320	302
	FBR of unloading hose	2-F	521	222	204
		5-D	457	233	220
	Leak from Pipeline	2-F	1463	679	631
		5-D	842	429	404
FBR of Pipeline	2-F	1450	547	493	

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		5-D	880	445	418
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5.3.6 Consequence analysis of handling of Crude oil at OSTT Jetty**5.3.6.1 Consequence results for the Jet fire:**

Chemical handled	Leak scenarios	Weather conditions	Jet fire radiation distances (m)		
			4.0 kW/m ²	12.5 kW/m ²	37.5 kW/m ²
Crude Oil	Leak from unloading hose	2-F	267	199	157
		5-D	239	173	133
	FBR of unloading hose	2-F	472	351	272
		5-D	409	301	233
	Leak from Pipeline	2-F	601	449	353
		5-D	499	366	282
	FBR of Pipeline	2-F	482	359	278
		5-D	414	306	238

5.3.6.2 Consequence results for the Pool fire:

Chemical handled	Leak scenarios	Weather conditions	Pool fire radiation distances (m)		
			4.0 kW/m ²	12.5 kW/m ²	37.5 kW/m ²
Crude Oil	Leak from unloading hose	2-F	160	112	80
		5-D	114	90	73
	FBR of unloading hose	2-F	577	366	230
		5-D	564	368	248
	Leak from Pipeline	2-F	429	287	194
		5-D	413	287	210
	FBR of Pipeline	2-F	1043	661	418
		5-D	1040	673	451

5.3.6.3 Consequence results for the Flash fire:

Chemical handled	Leak scenarios	Weather conditions	Flash fire (m)	
			LFL	½ LFL
Crude Oil	Leak from unloading hose	2-F	513	726
		5-D	297	404

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FBR of unloading hose	2-F	262	416
	5-D	311	409
Leak from Pipeline	2-F	983	1534
	5-D	741	1012
FBR of Pipeline	2-F	764	995
	5-D	507	698

5.3.6.4 Consequence results for the Explosion:

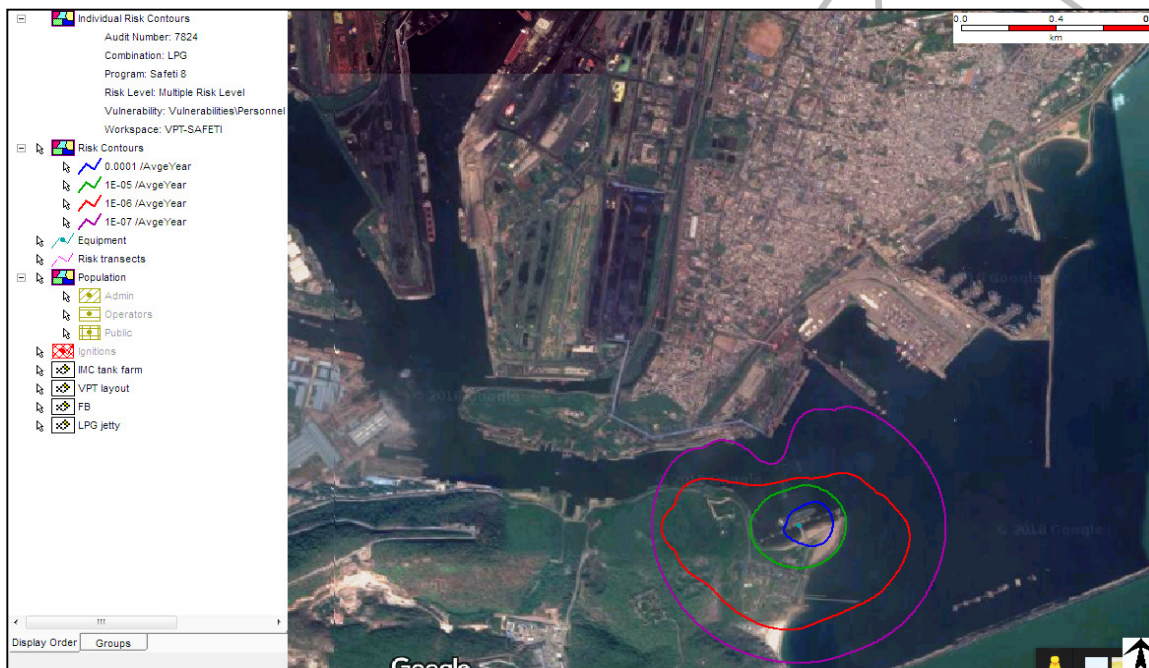
Chemical handled	Leak scenarios	Weather conditions	Explosion distances (m)		
			0.03 bar	0.1 bar	0.3 bar
Crude Oil	Leak from unloading hose	2-F	1741	853	800
		5-D	1078	531	498
	FBR of unloading hose	2-F	1343	583	537
		5-D	1012	457	430
	Leak from Pipeline	2-F	3418	1631	1523
		5-D	2793	1332	1244
	FBR of Pipeline	2-F	3183	1392	1284
		5-D	1992	839	781

5.3.7 Consequence analysis of handling of Ammonia at Fertilizer Berth:**5.3.7.1 Consequence analysis for the toxic impact Toxic impact distances (m)**

Chemical handled	Leak scenarios	Weather conditions	Toxic impact distances (m)
			IDLH (ppm)
Ammonia	Leak from unloading arm	2-F	4392
		5-D	2415
	FBR of unloading arm	2-F	3321
		5-D	2322
	Leak from Pipeline	2-F	9691
		5-D	2341
	FBR of Pipeline	2-F	8149
		5-D	2611

5.4 Risk Estimation:

5.4.1 Individual Risk results of the LPG (Propane & Butane) handling at LPG jetty



5.4.2 Individual Risk results of the MS handling at OR jetty

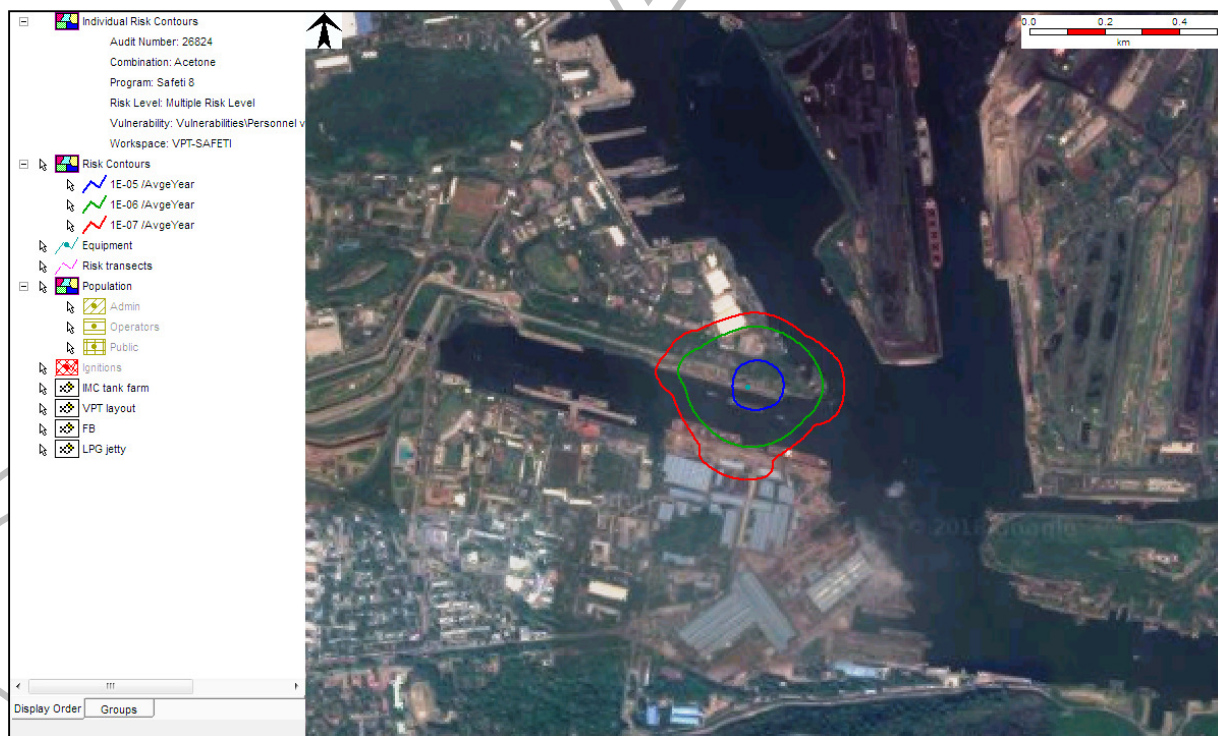


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5.4.3 Individual Risk results of the ATF handling at OR jetty



5.4.4 Individual Risk results of the Acetone handling at OR jetty



5.4.5 Individual Risk results of the Benzene handling at OR jetty



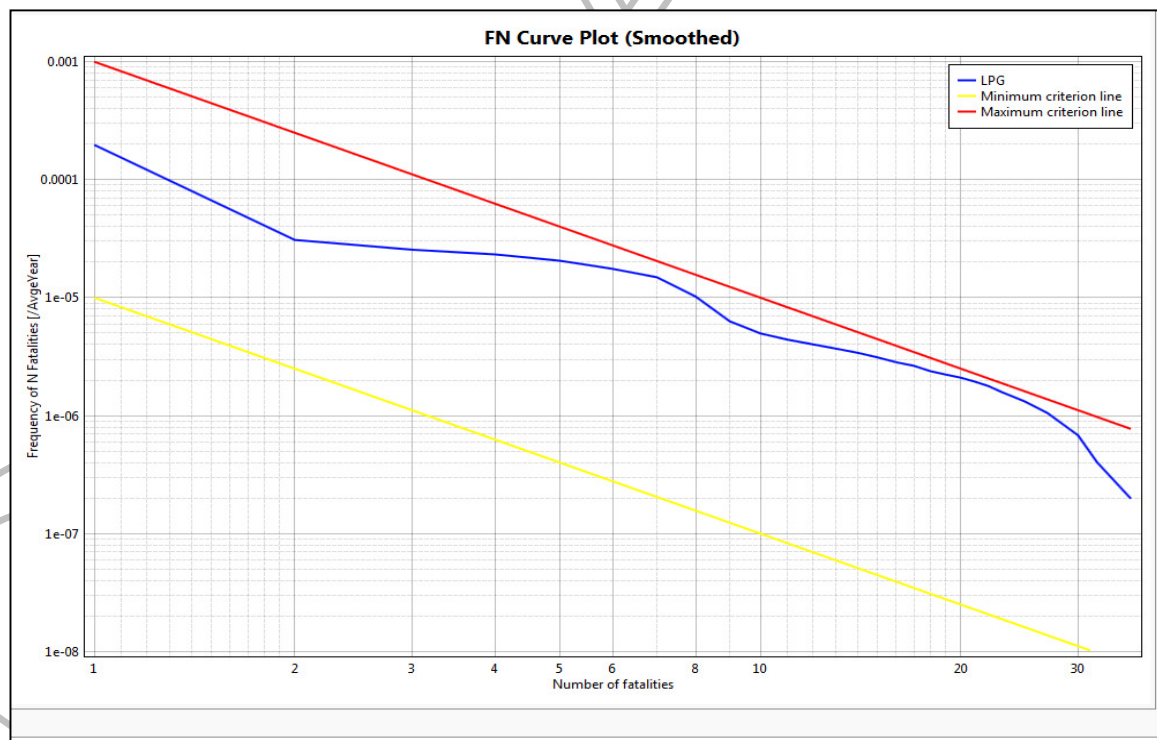
5.4.6 Individual Risk results of the Toluene handling at OR jetty



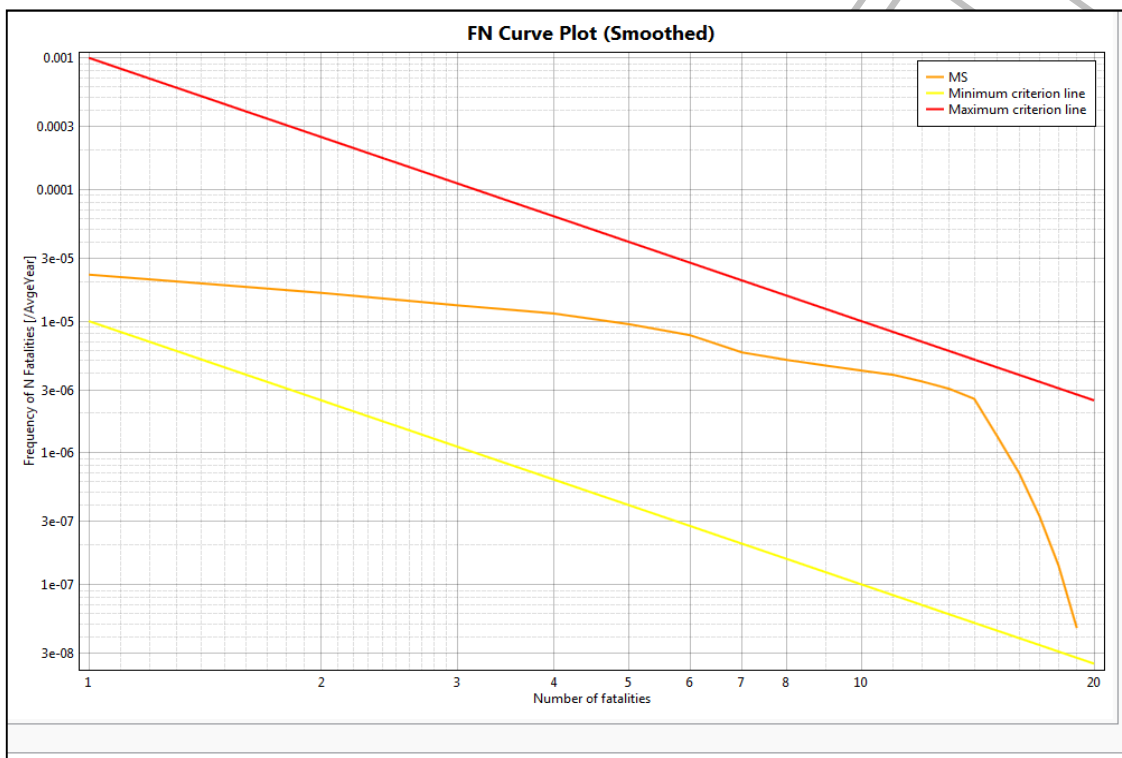
5.4.7 Individual Risk results of the Ammonia handling at Fertiliser berth



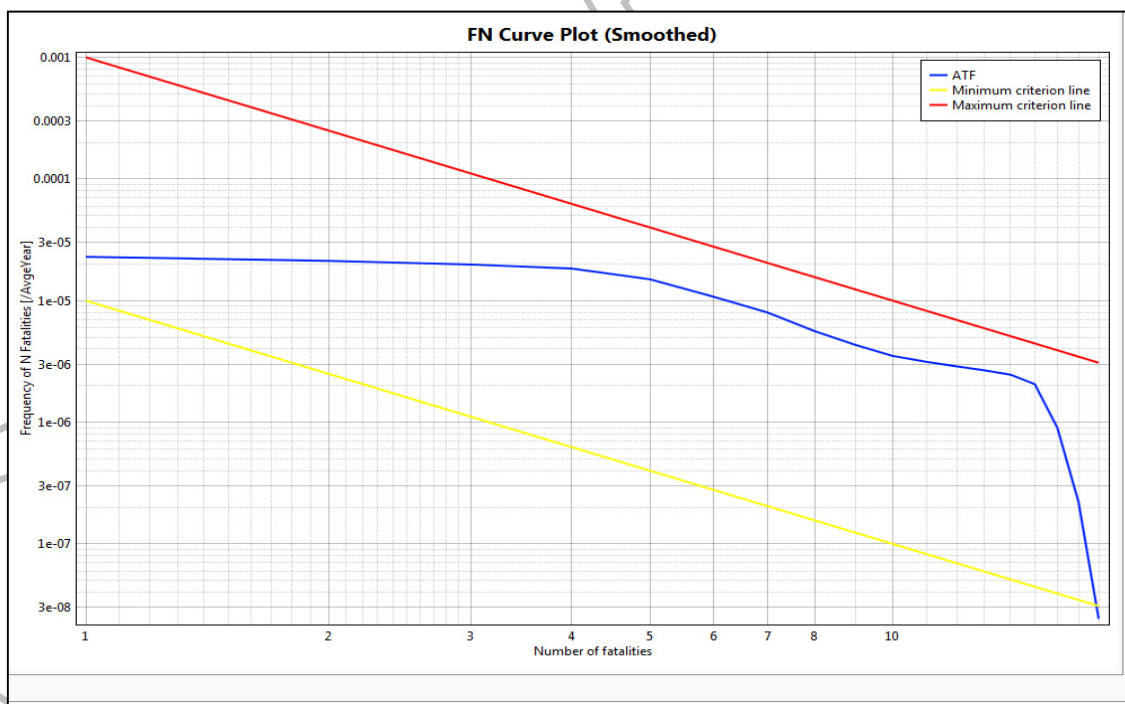
5.4.8 Societal Risk (F-N curve) results of the LPG (Propane & Butane) handling at LPG jetty



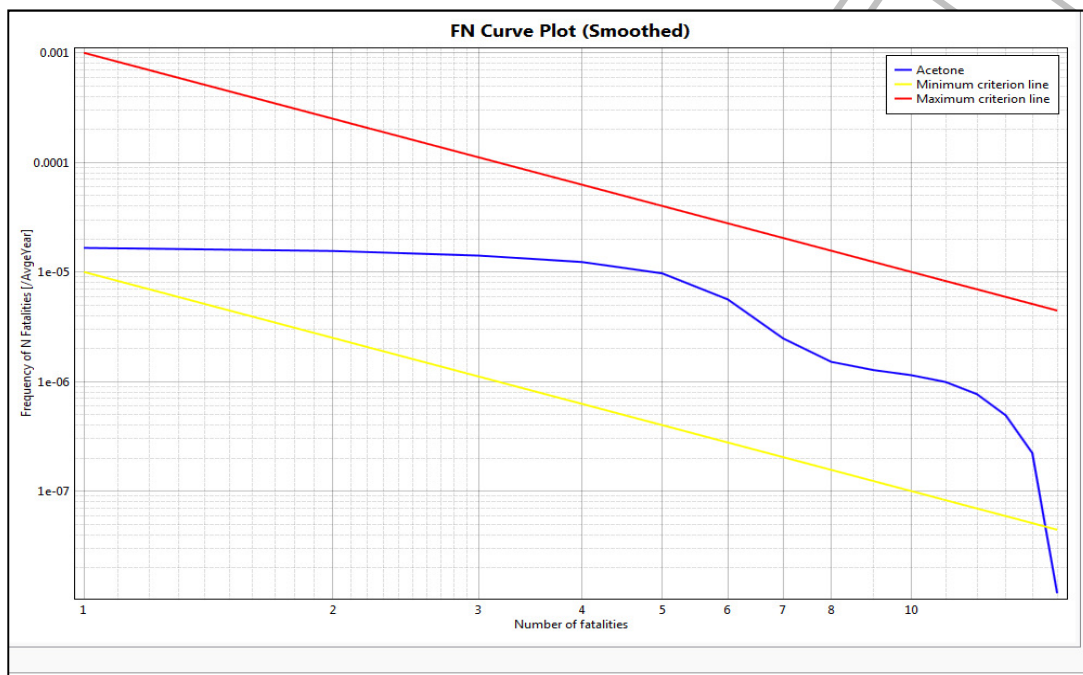
5.4.9 Societal Risk (F-N curve) results of the MS handling at OR jetty



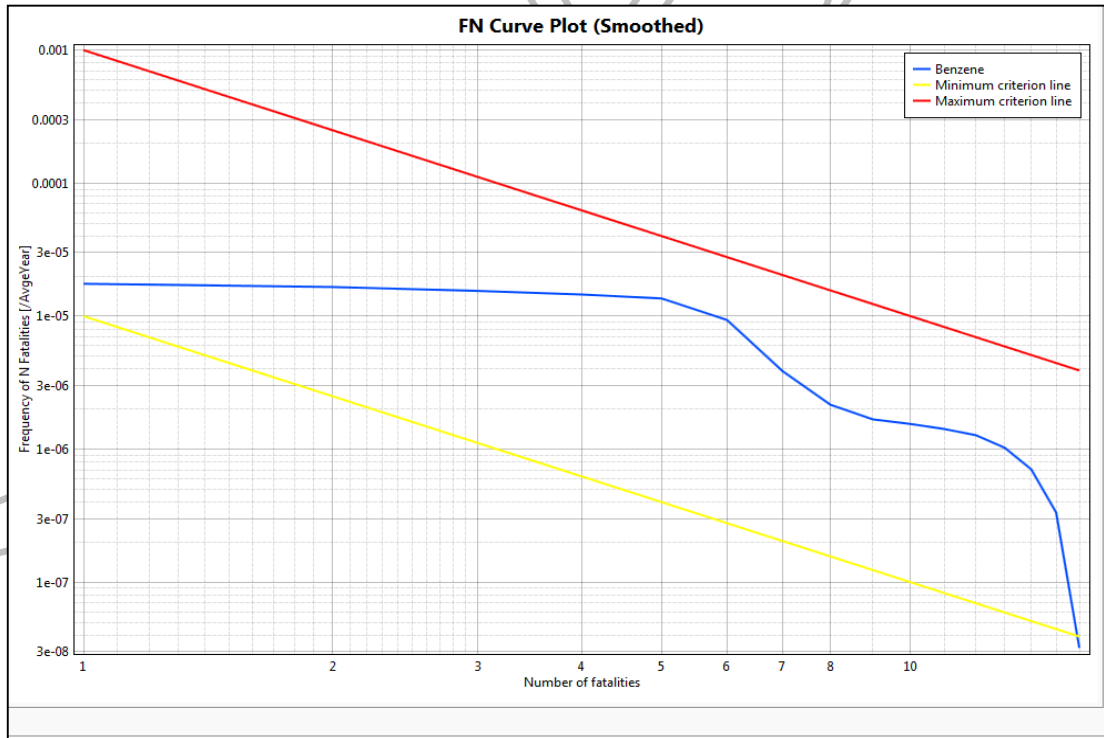
5.4.10 Societal Risk (F-N curve) results of the ATF handling at OR jetty



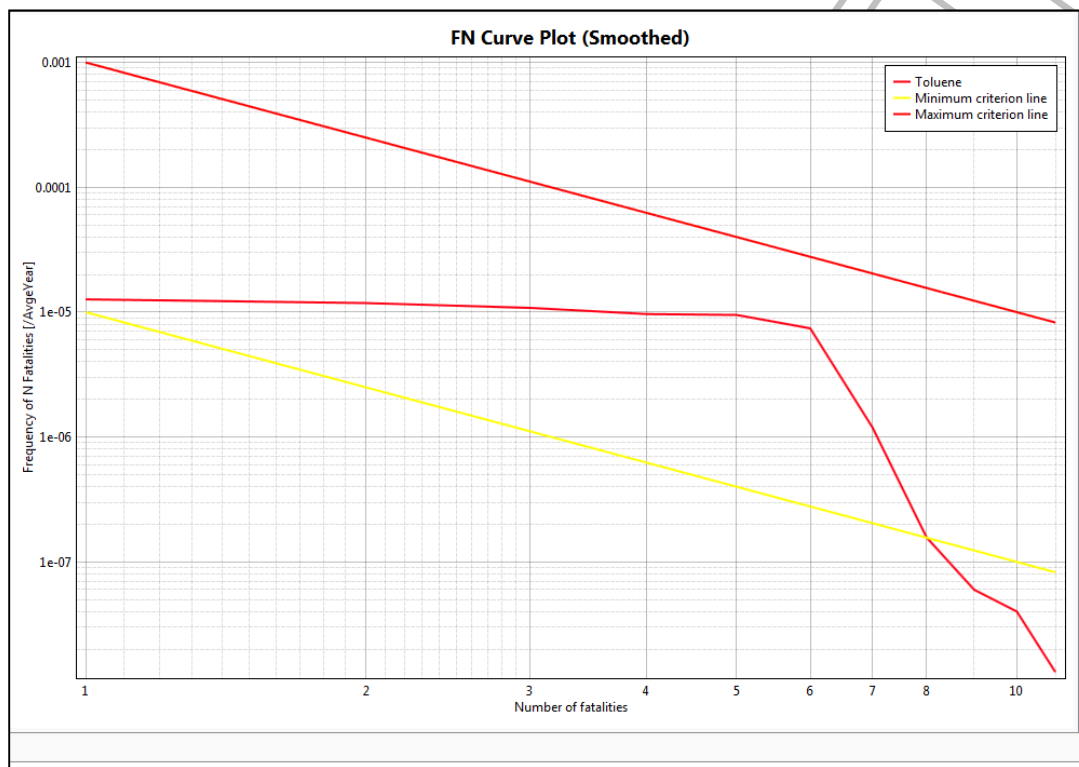
5.4.11 Societal Risk (F-N curve) results of the Acetone handling at OR jetty



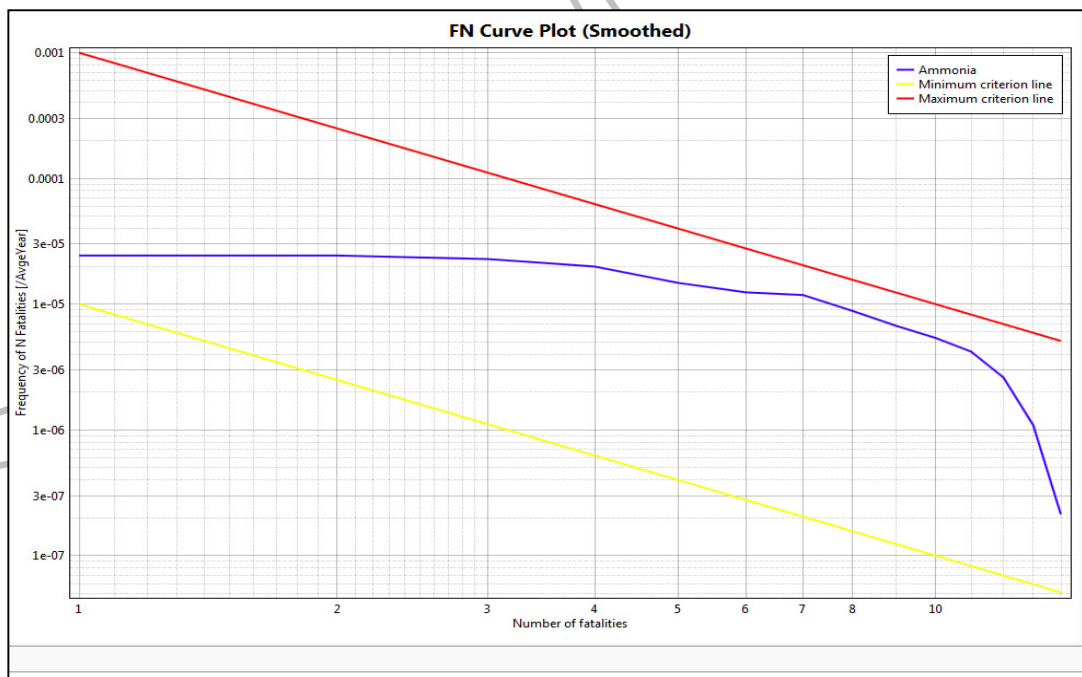
5.4.12 Societal Risk (F-N curve) results of the Benzene handling at OR jetty



5.4.13 Societal Risk (F-N curve) results of the Toluene handling at OR jetty



5.4.14 Societal Risk (F-N curve) results of the Ammonia handling at Fertiliser berth



5.5 Recommendations:

These recommendations are based on our findings through observations, study, analysis results and the best practises in the industry.

1. Before any transfer operation is commenced, it is imperative that the intended procedures are thoroughly discussed and a meeting held between the relevant and responsible personnel from the tanker and the terminal (berth operator). The purpose of the meeting is primarily to make both parties fully conversant with the characteristics of the tanker and shore handling systems, the envisaged operational and safety procedures and requirements and the parameters to be adhered to during the transfer.
2. Communications: To ensure that effective communication is established between ship and terminal personnel all through the cargo handling operations.
3. Loading arm/flexible hose: The master of a ship and the berth operator, within their respective areas of responsibility, should ensure that:
 - a) Detailed procedures and adequate means are available for the operation, supervision, disconnection of loading arms in the event of an emergency, to protect the personnel safety, environment and equipment;
 - b) Loading arm/flexible hose is not used for cargoes and operating parameters other than those for which it is suitable;
 - c) Availability of adequate means for draining the inner and outer arms before disconnection;
 - d) The operating envelope of the loading arm is suitable for the ship – to be checked/confirmed before each transfer operation;
 - e) Each loading arm has been periodically maintained and has a valid certificate for its fitness for use; and
 - f) Adequate electrical insulation of flanges are maintained.
4. Maintenance:
 - a) All fire-fighting and safety equipment are to be maintained in ready to fully operational at all times and be checked and tested on a routine basis. The prescribed pressure in the fixed fire hydrant line should be maintained and monitored at all time both at port and respective terminals. The fire detection and warning systems should be checked and tested regularly and defects detected must be rectified before start of operation.
 - b) The Gas detectors and flame detectors should be periodically calibrated as per the set value.
 - c) Pipelines should be periodically inspected and maintained.
5. Training:
 - a) All relevant personnel should be trained to use the required fire-fighting systems for carrying out fire-fighting operation effectively;
 - b) Both ship and shore personnel should be aware of each other's fire-fighting equipment and capabilities;

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6. Refrigerated Liquefied Gas (Butane & Propane): The master of a ship, the port authority and respective berth operator, within their respective areas of responsibility, should ensure that the unloading of liquefied gas at low temperatures is only carried out strictly following the SOP and also the following aspects are duly taken care of:
 - a) All automatic controls, gas detectors and other associated instruments are in working order; and
 - b) Suitable/adequate protective equipment and clothing is available and used as appropriate.
7. VPT should make sure that the illumination is adequate during night-time operations.
8. Adequate number of firefighting personnel should be available at all times.
9. Poor housekeeping was observed during the visit at OR-I & OR-II jetties. Combustible materials were found lying near pipeline at the jetty. Pit near pipeline was found dumped with garbage. Hoses kept at the jetty after usage found not blinded. Dry vegetation found all around pipeline trench. Spill observed from the FO pipeline valve (though no operations was ongoing) at the Jetty. VPT must ensure that all the users take necessary actions and precautions for good housekeeping in a responsible manner.
10. It was observed at OR-I& OR-II jetty that two-wheeler was entering operation area near vessel (Jag Pranam) since the area was not properly barricaded. VPT should make sure that the area is properly barricaded.
11. Leakage was observed on the main fire hydrant line at OR jetty. Water curtain line found in non-operational and corroded. Tower monitors structure found corroded. VPT must ensure that the firefighting system is maintained effectively and operational round the clock.
12. General:
 - a) VPT should conduct drill and exercises jointly with the all facilities in a regular manner.
 - b) Data of the incidents (minor and major) should be appropriately collated and recorded.
13. Pump House:
 - a) Good housekeeping to be maintained at the Fire water pump house.
 - b) Fire water system shall be kept pressurized for a minimum residual pressure of 7 kg/cm² even at hydraulically remotest point in the installation.
 - c) Periodic maintenance of the Pumps to be carried out suitably.

5.6 Recommendations for IMC Tank farm:

These recommendations are based on our findings through observations, study, analysis results and the best practises in the industry. It is also based on the assumption that Risk analysis for the IMC have been carried out by the respective facility on their own and necessary safeguards have been taken.

1. Before any transfer operation is commenced, it is imperative that the intended procedures are thoroughly discussed and a meeting held between the responsible personnel from the vessel and the terminal (berth operator). The purpose of the meeting is primarily to make both sides fully conversant with the characteristics of the vessel and shore handling systems, the envisaged operational and safety procedures and requirements and the parameters to be adhered to during the transfer.
2. Communications: To ensure that effective communication is established between ship and terminal personnel all through the cargo handling operations.
3. Maintenance:
 - a) All fire-fighting and safety equipment are to be maintained to remain fully operational at all times and be checked and tested on a routine basis. The prescribed pressure in the fixed fire hydrant line should be maintained and monitored both at port and respective terminals. The fire detection and warning systems should be checked and tested regularly.
 - b) Pipelines should be periodically inspected and maintained for material corrosion and system integrity.
4. Training: All relevant personnel should be trained to use the required fire-fighting systems for carrying out fire-fighting operation effectively. Also drill to be conducted periodically.
5. Adequate number of firefighting personnel should be available at all times.
6. The firewater network shall be kept pressurized at minimum 7.0 kg/cm² g at all times by use of suitable jockey pumps.
7. Good housekeeping to be maintained in terminal area. The tank farm must be kept clean and free from vegetation.
8. It was observed during the visit that two storage tanks were slightly tilted in one of the enclosure. Settlement of tanks takes place over a period of time and a depression is formed on tank pad along the circumference. The same should be effectively made up with proper slope to avoid rain water accumulation and subsequent corrosion of the bottom plate. Where large settlement is anticipated, supporting arrangement for the connected piping shall be suitably provided to take care of the settlement.
9. Approval of ERDMP of the tank farm to be obtained from PNGRB at the earliest.

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10. General:

- a) VPT should conduct drill and exercises jointly with the IMC.
- b) Data of the incidents (minor and major) should be appropriately collated and recorded.

6.0 OIL SPILL RISK ASSESSMENT DUE TO COLLISION AND GROUNDING

Evaluating oil spill risks requires consideration of two factors, namely the probability of a spill occurring, and the consequences.

The potential oil spill scenarios from the VPT marine facilities and associated activities are summarized in the next sections. In practice, due to preventive actions such as training, operating procedures and engineered solutions, potential spills are likely to be smaller. Larger oil spills being extremely unlikely.

The events and scenarios presented here are indicative only. Though accounting every eventuality is not practicable, however the above scenarios represent a broad cross section of possible oil spill incidents. The credible release quantities given are only an indication and an actual oil spill may vary significantly.

6.1 Risk Assessment Methodology

This Risk Assessment exercise is primarily for the concern of environmental pollution caused by accidental spillage of Oil/HNS at and around the VPT. The factors which may influence the risk will include the followings:

- Frequency of ship movement;
- Exposure time of the port due to transit of ship;
- Physical and mechanical condition of the ship and its equipment;
- Performance of ship's crew, including pilot;
- Traffic density;
- Hydrographic and meteorological conditions;
- Type and quantity of oil carried by the ships.

The present Risk Assessment exercise has been carried out in stages as follows:

- Gathering of relevant information and Data
- Hazard Identification
- Frequency Estimation
- Consequence Estimation
- Risk Estimation

Note: The details of the exercise can be found in the Risk assessment report.

6.1.1 Hazard Identification

Using the data obtained from the interviews, familiarization trips, document studies, questionnaire returns, HAZID meetings and workshops with VPT representatives and their associates, a preliminary list of significant hazardous scenarios with regards to oil spill accidents have been identified as follows:

Scenario 1: Collision with small craft - Tanker / Container/ Bulk Carrier in harbor approach

Scenario 2: Collision between two vessels in channel (Regulated traffic)

Scenario 3: Tanker /Container/ Bulk Carrier tug assisted berthing – Contact/Allision with jetty

Scenario 4: Tanker- Contact Allision with SPM or tug

Scenario 5: Grounding- Tanker/Container/ Bulk Carrier transiting in navigational channel

Scenario 6: Grounding- during pilotage of deep draft vessel

Scenario 7: Collision with dredger within navigational channel

Scenario 8: Collision – passing vessel in outer harbour (unregulated traffic)

Scenario 9: Collision - Dragging anchor

Scenario 10: Contact/Allision - during operations in turning circle (large vessels)

Scenario 11: Collision/Allision with channel marking buoys

Scenario 12: Fire on vessel at the Berth

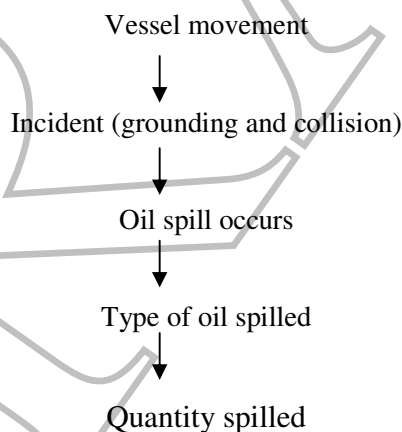
In summary there are two categories of accidents have been identified as a cause of major oil/HNS spill incident – as follows:

- Collisions
- Groundings

The collision accidents are dependent on maritime traffic situation (channel layout, traffic intensity, level of VTS management), weather conditions (wind, currents, and visibility), vessel characteristics (vessel type, vessel age, maneuverability, available bridge equipment), human factors (experience and capability of the captain and his crew, working conditions).

Grounding often occurs where there is inadequate water depth as compared to vessel draft, and do not always result in releases. This is due to the fact that the riverbeds of the most frequently traveled waterways are mostly soft mud or silts. However, there is always the potential for significant damage from rocks or debris, as well as physical distortion.

An event sequence analysis as described below may be used for estimating the frequency of spillage due to collision and grounding:



6.1.2 Historical analysis, databases, statistics

Whilst our risk analysis primarily considers spillage from oil tankers, however, there also exist possibilities of oil spillage from other ship types calling VPT. Table 6.1 shows fuel oil capacity of different type of vessels.

*Risk Assessment Report***Table 6.1:** Fuel oil capacity of Vessels [Ref. No. 14]

ID	Ship Type	Deadweight (M. Tons)	No. of bunker tanks >100 m ³ in volume	Fuel oil capacity at 98% Filling (M. Tons)
T1	Tanker (Panamax)**	48000	2	1070
T2	Tanker (Aframax)**	82000	5	2312
T3	Tanker (Suezmax)**	121000	6	4528
T4	Tanker (Suezmax)	151000	6	4074
T5	Tanker (VLCC)	300000	7	8759
T6	Tanker (VLCC)**	306000	8	7896
T7	Tanker (Panamax)	40000	3	1892
T8	Tanker (Panamax)	37000	3	2211
T9	Tanker (Aframax)	85000	5	2849
T10	Tanker (Suezmax)	136000	5	4659
C1	Containership (Post Panamax)	55000	16	7801
C2	Containership (Panamax)	36000	12	5253
C3	Containership (Panamax)	29000	8	2838
C4	Containership (Feedership)	11000	4	933
C5	Containership (Feedership)	25000	12	4043
C6	Containership (Feedership)	15000	8	2293
O1	LNG Carrier	72000	9	7020
O2	Livestock Carrier	23000	13	3229
O3	Ro-Ro Vessel	28000	9	8314
B1	Bulk carrier (Capesize)	161000	4	4728
B2	Bulk carrier (Handysize)	28000	5	1633
B3	Bulk carrier (Handysize)	25000	3	1379
B4	Bulk carrier (Panamax)	45000	8	2437
B5	Bulk carrier (Handysize)	31000	3	338

** Indicates vessels with double-hull in way of all bunker tanks

6.1.3 Information provided by ITOPF indicates (as shown in Table 6.2):

- A significant number of accidental tankers spill less than 7 tonnes (50 barrels) occur during loading and discharging operations (35%);
- For spills between 7 and 700 tonnes (50-5000 barrels), loading and discharging operations still remain a significant cause (29%), in addition to collision (25%) and grounding (20%);

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- However, for spills greater than 700 tonnes (5000 barrels) the major causes are collision (29%) and grounding (35%).

Table 6.2: Incidence of spills by cause (1974-2010) [Ref. no. 19]

	<7 Tonnes	7-700 Tonnes	>700 Tonnes	TOTAL
OPERATIONS				
Loading/Discharging	3157	385	37	3579
Bunkering	562	33	1	596
Other Operations	1250	61	15	1326
ACCIDENTS				
Collisions	180	337	132	649
Groundings	237	269	160	666
Hull Failures	198	57	55	310
Equipment Failures	202	39	4	245
Fires & Explosions	84	33	34	151
Other/Unknown	1975	121	22	2118
TOTAL	7845	1335	460	9640

6.1.4 Consequence Assessment

Assessment of consequence has been done considering the effect of potential accidents on -

- Life (e.g. personal injury, fatality, etc),
- Property damage (e.g. damage to ship),
- Environment (Oil pollution, Air pollution, soil contamination etc),
- Port Business (reputation, financial loss, etc).

Table 6.3: Consequence Categorization

Scale	People	Property	Environment	Port Business
C0	No injury	No damage	Negligible environmental impact	Negligible
C1	Minor (Single slight injury)	Minor damage	Minor Tier 1 oil spill, Minimal environmental harm	Minor
C2	Slight (multiple minor or single major injury)	Local damage	Moderate Tier 2 (limited outside assistance) oil spill or environmental amenity impaired, Moderate environmental impact	Moderate Bad local publicity or short term loss of dues, revenue, etc.
C3	Serious	Major	Serious	Serious

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	(multiple major injuries or single fatality)	damage	Tier 2 (regional assistance) oil spill, localized flooding or multiple amenities impaired, Long term or serious environmental damage	Bad widespread publicity, temporary port closure or prolonged restriction of navigation
C4	Major (More than one fatality)	Total loss	Major Tier 3 (national assistance) oil spill, widespread flooding or extensive damage to amenities, Major environmental harm. e.g. major pollution incident causing significant damage or potential to health or the environment	Major Port closes, navigation seriously disrupted for more than 1-2 days. Long term loss of trade

6.1.5 Frequency Assessment

The probability of collision and groundings depends on the factors including the followings:

- maritime traffic situation (channel layout, traffic intensity, level of VTS management);
- weather conditions (wind, currents, visibility);
- vessel characteristics (vessel type, vessel age, maneuverability, available bridge equipment);
- human factors (experience and capability of the captain and his crew, working conditions).

Frequencies are derived for 'most credible' and 'worst credible' hazard events, using the following frequency criteria:

Table 6.4: Frequency Matrix

Category	Descriptive term	Definition
F1	Frequent	An event occurring once a week to once an operating year
F2	Likely	An event occurring once a year to once every 10 operating years
F3	Remote	An event occurring once every 10 operating years to once in 100 operating years
F4	Unlikely	An event occurring less than once in 100 operating years
F5	Rare	Considered to occur less than once in 1000 operating years

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6.1.6 Risk Assessment

6.1.6.1 Risk Assessment Matrix

For each identified hazard, risk quantification is done based on a scale of 1 (low risk) to 10 (high risk) as described in the Table 6.5 as below:

Table 6.5: Risk Assessment Matrix

Consequence	C4	5	6	7	8	10
	C3	4	5	6	7	9
	C2	3	3	4	6	8
	C1	1	2	2	3	6
	C0	0	0	0	0	0
Frequency		F5	F4	F3	F2	F1

Where: -

- 0 & 1 - Negligible Risk
- 2 & 3 - Low Risk
- 4, & 5 – Assessed to be in ALARP region
- 6 – Heightened Risk
- 7, 8 & 9 - Significant Risk
- 10- High Risk

Based on the values of frequency and consequence as assessed, Risk Ranking have been done in Table 6.6 for each of the four consequence entities as described in Table 6.3 both for the ‘most likely’ and the ‘worst credible’ scenarios as mentioned in **Appendix A** - Hazard Assessment Worksheet.

6.1.6.2 Risk Summary

The risk assessment matrix demonstrates that all of VPT’s oil spill risks based on identified scenarios are of low to medium status. The matrix identifies areas that require continuous improvement to reduce their occurrence and areas where risk reduction measures are required.

Table 6.6: Risk ranking for VPT port for Grounding, Collision & Oil pollution

Scenario No.	Rank No.	Category	Hazard Detail	Assessed Risk							
				Most Credible				Worst Credible			
				People	Property	Environment	Business	People	Property	Environment	Business
3	1	Contact/ Allision	Tanker/ Container/ BC tug assisted berthing – Contact/ Allision with jetty	6	8	0	6	2	6	2	4
12	2	Fire	Fire on vessel at berth	6	3	0	3	6	6	3	6

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8	3	Collision	Collision - passing vessel in Outer harbour (unregulated traffic)	3	6	0	3	6	5	3	5
2	4	Collision	Collision between two vessels in channel (Regulated)	4	4	2	4	6	6	3	6
4	5	Contact/Allision	Tanker-Contact/Allision with SPM or tug	3	6	0	3	2	5	2	3
1	6	Collision	Collision with small craft – Tanker/ Container/ BC in harbor approach	3	3	0	0	6	7	2	2
11	7	Contact/Allision	Contact with channel marking buoys	0	3	0	3	5	6	5	5
9	8	Collision	Collision – Anchor dragging	2	2	0	2	5	5	5	6
7	9	Collision	Collision with dredger within the navigational channel	0	2	0	2	6	6	3	6
5	10	Grounding	Grounding – Tanker/ Container/ BC transiting in channel	0	4	0	0	2	5	5	5
10	11	Contact/Allision	Contact – During operations in turning circle (Large vessels)	0	3	0	3	3	5	3	5
6	12	Grounding	Grounding – During pilotage of deep draft vessel	0	2	0	0	3	5	3	5

6.2 VULNERABILITY ANALYSIS

All coastal flora and fauna are vulnerable to Oil / Chemical disaster and Natural disaster. The vulnerability analysis provides information about resources and communities that could be harmed. Vulnerable areas and entities in and around VPT have been identified using reliable information sources.

Table 6.9 provides vulnerability level of VPT surroundings. Consequences of accidents (Fire/explosion/toxic dispersion) at VPT on the surrounding flora and fauna have been assessed.

Oil Spill Trajectory Modelling is given in **Appendix C**. HNS spill impact is given in **Appendix D**.

6.2.1 Sensitive areas around VPT

(Source: <https://en.wikipedia.org/wiki/Visakhapatnam>)

6.2.1.1 Shore Line

Beaches along the coastline of the Bay of Bengal include Ramakrishna Mission Beach, Rushikonda Beach and Mangamaripeta Beach. Others are Yarada, Bheemili, Lawson's Bay, Tenneti, Sagar Nagar and Gangavaram beaches.

Tyda, Kambalakonda Wildlife Sanctuary under Andhra Pradesh Forest Department are wildlife conservation sites near the city.

6.2.1.2 Human Use resources

Important human use features are given in Table 6.7. The fish landing centres are in Visakhapatnam. A recreational beach is present near Visakhapatnam Port.

Table 6.7: Classification of Human use Resources

Commercial	Management areas	Cultural	Recreational
Plantation	Protected Coastline	Temple	Beaches
Industries	Light House	Fishing	-

6.2.1.3 Biological Resources

Scattered patches of mangroves are present along the coast.

Table 6.8: Biological Resources

Birds	Fish	Habitats & Plants
Birds breeding/Flocking area	Fisheries	Mangroves (Directly exposed to sea)
		Mangroves (Not directly exposed to sea)

6.2.1.4 Environmental Sensitivity

Table 6.9: Assessing vulnerability data for VPT coastal area

		Very low (0)	Low (1)	Moderate (5)	Unknown or high (20)	Extreme (50)
Environment	Shoreline character				X	
	Plants and animals				X	
	Protected sites				X	
Human	Economic			X		
	Cultural			X		
	Social, amenity and recreation			X		

6.2.2 Overall vulnerability ratings of VPT coastal area = 75 (HIGH) (Using Table 6.10 & Table 6.11)

Table 6.10: Conversion of consequence score into qualitative vulnerability rating

Sum of combined scores	Vulnerability rating
0	Very low
1-3	Low
4-18	Moderate
19-79	High
80+	Extreme

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Table 6.11: Categories to determine vulnerability level

Resource category		Consequence level description				
		Very low (0)	Low (1)	Moderate (5)	Unknown or High (20)	Extreme (50)
Environment	Shoreline character	Negligible sensitivity	Low sensitivity (e.g. exposed rocky headlands, eroding wave cut platforms)	Moderate sensitivity (e.g. fine grained sand beaches, exposed compacted tidal flats, mudstone, coarse grained beaches)	High sensitivity (e.g. mixed sand and gravel beaches, gravel beaches, shelter rocky coasts)	Extremely high sensitivity (e.g. sheltered tidal flats, salt marshes, mangroves)
	Plants and animals	None or very few vulnerable species	Minor short-term impacts	Vulnerable species are generally of local value only	Limited but medium term effects	Vulnerable species are of local and regional importance
	Protected sites	No protected sites present	Scenic or wildlife management reserve	Scenic/nature reserve, wildlife refuge	Marine park, marine reserve, wildlife/marine mammal sanctuary	International protected sites
Human	Economic	No resources or activities of economic significance	Low economic significance for the region and nation	Some economic significance of the region, none nationally	High regional economic significance, some national significance	High national economic significance
	Cultural	No cultural importance	Some importance for local community, low regional significance	Importance to local and regional community but low national significance	Importance to local and regional community, some national significance	High national cultural significance
	Social, amenity and recreation	No community significance	Low community significance for the region and nation	Some community significance for the region, none nationally	High regional community significance, some national significance	High national community significance

6.3 Recommendations

1. The VTS system being vital for monitoring vessel traffic in the area should be fully functional round the clock.
2. Appropriate training for the concerned personnel of VPT should be imparted regularly.
3. Weather limit for safe operation (the existing procedure) to be complied and updated periodically based on actual experience gained.
4. Weather forecast to be followed regularly and the port operation to be planned accordingly.
5. Tug masters should undergo induction and refresher training periodically.

7.0 CONCLUSION

1. As per the agreed scope of work, we have completed the following tasks:
 - a. Risk Assessment, and
 - b. Disaster Management Plan.
2. The RA and DMP have been developed based on the Information/Data received from VPT authority, review of pertinent literature includes relevant guidelines, and our experience and knowledge gained through various authentic sources.
3. The successful implementation of the Risk Control measures and DMP depend on the active and effective coordination between VPT, berth operators and the support organizations.
4. It is concluded that the best practices of ship handling operations will be followed and all the requirements towards applicable rules and regulations will be complied with.
5. We conclude that the existing control measures will be maintained in effective manner. The additional measures as required to reduce risk which have been listed under the recommendations will be implemented at the earliest.
6. Risk Assessment for handling of MS, HSD, Ammonia, Naphtha, LPG and other chemicals have been carried out with regards to Fire, Explosion and toxic dispersion and the analysis results can be seen in chapter 5.

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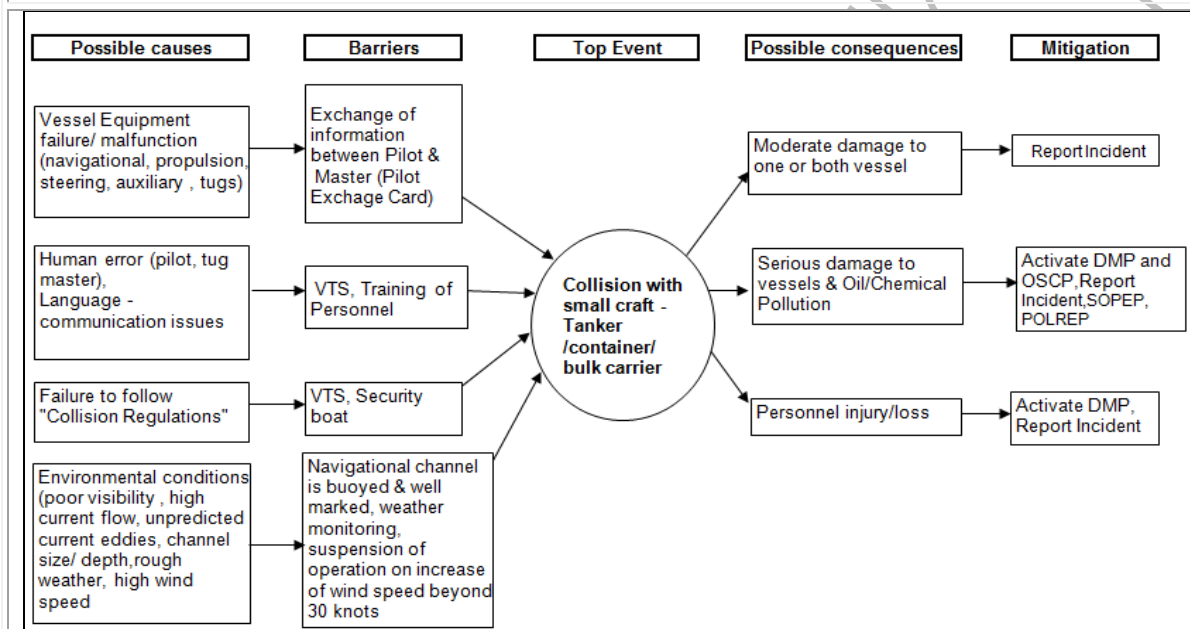
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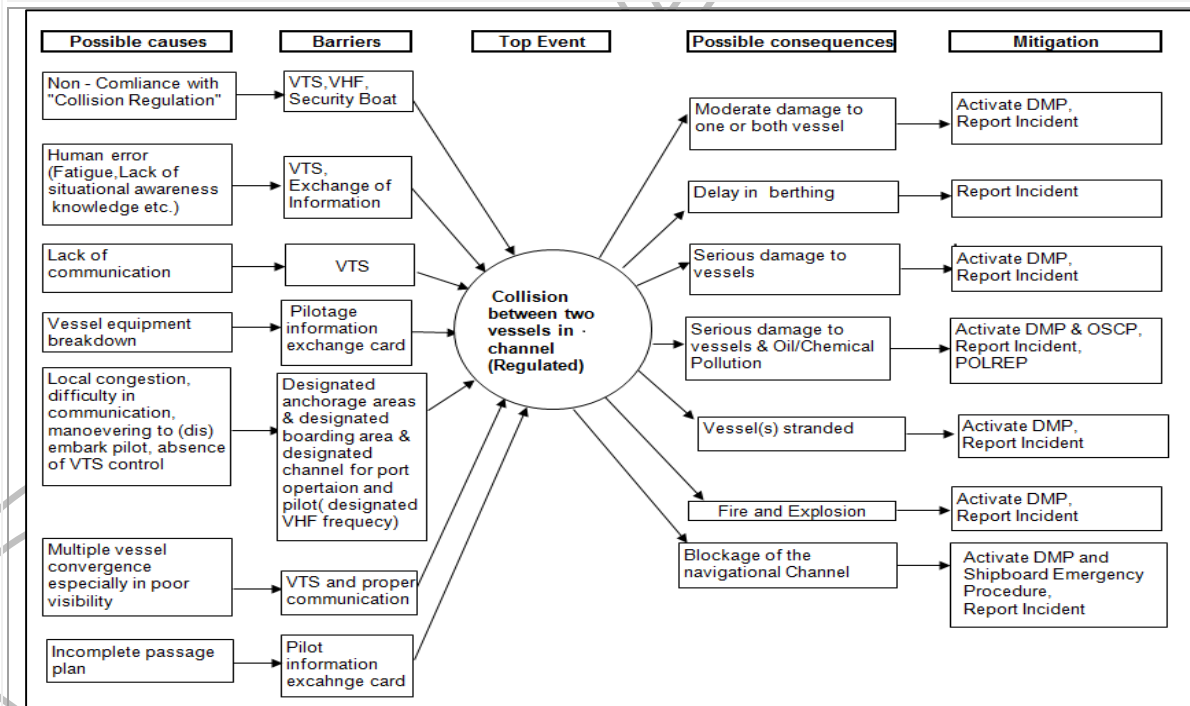
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APPENDIX A: BOW – TIE DIAGRAMS USED FOR HAZARD ANALYSIS

Scenario 1: Collision with Small Craft- Tanker/Container/Bulk Carrier

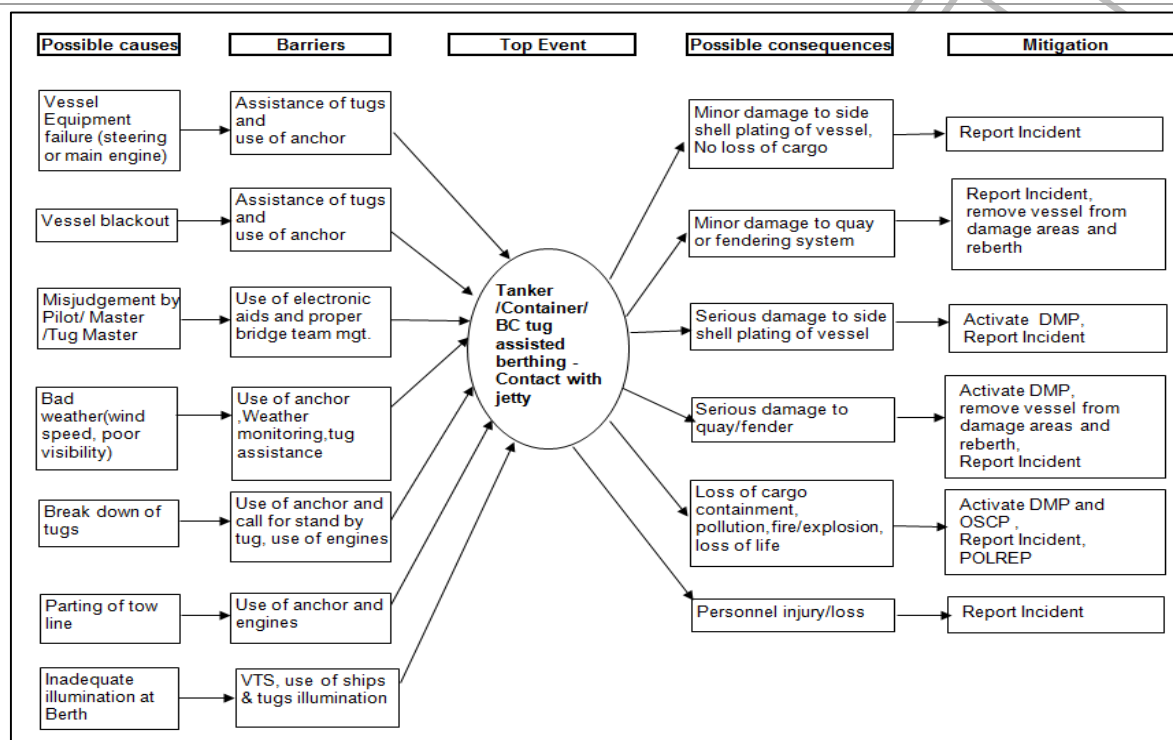


Scenario 2: Collision between two vessels in Channel (Regulated)

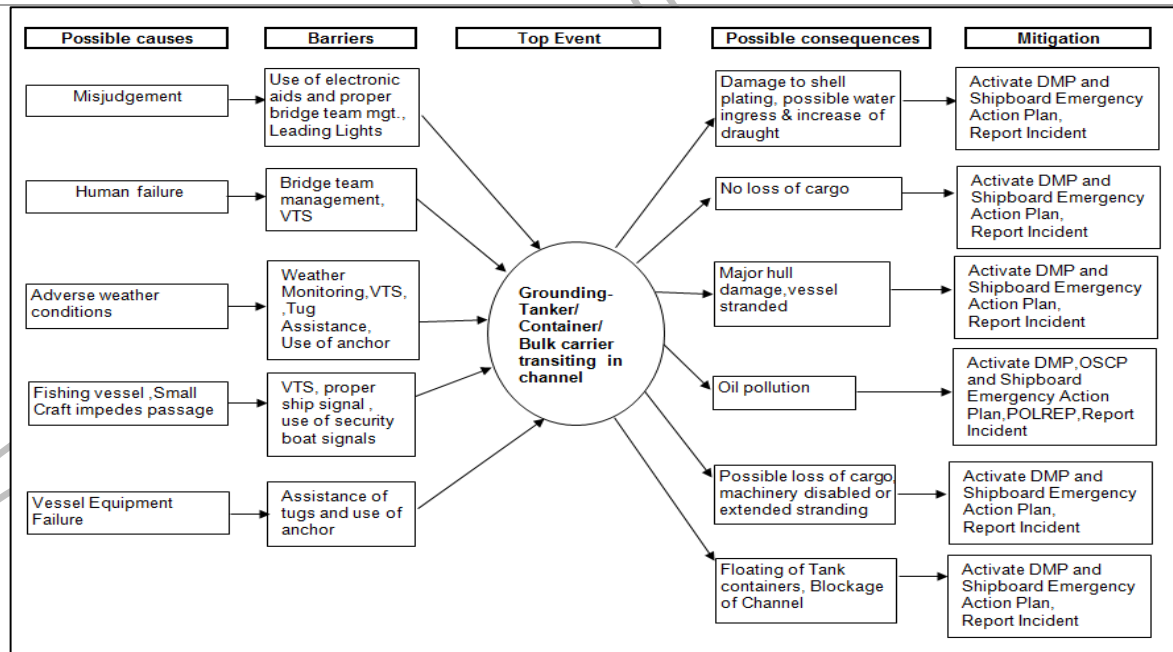


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Scenario 3: Tanker /Container/BC tug assisted berthing- Contact with Jetty

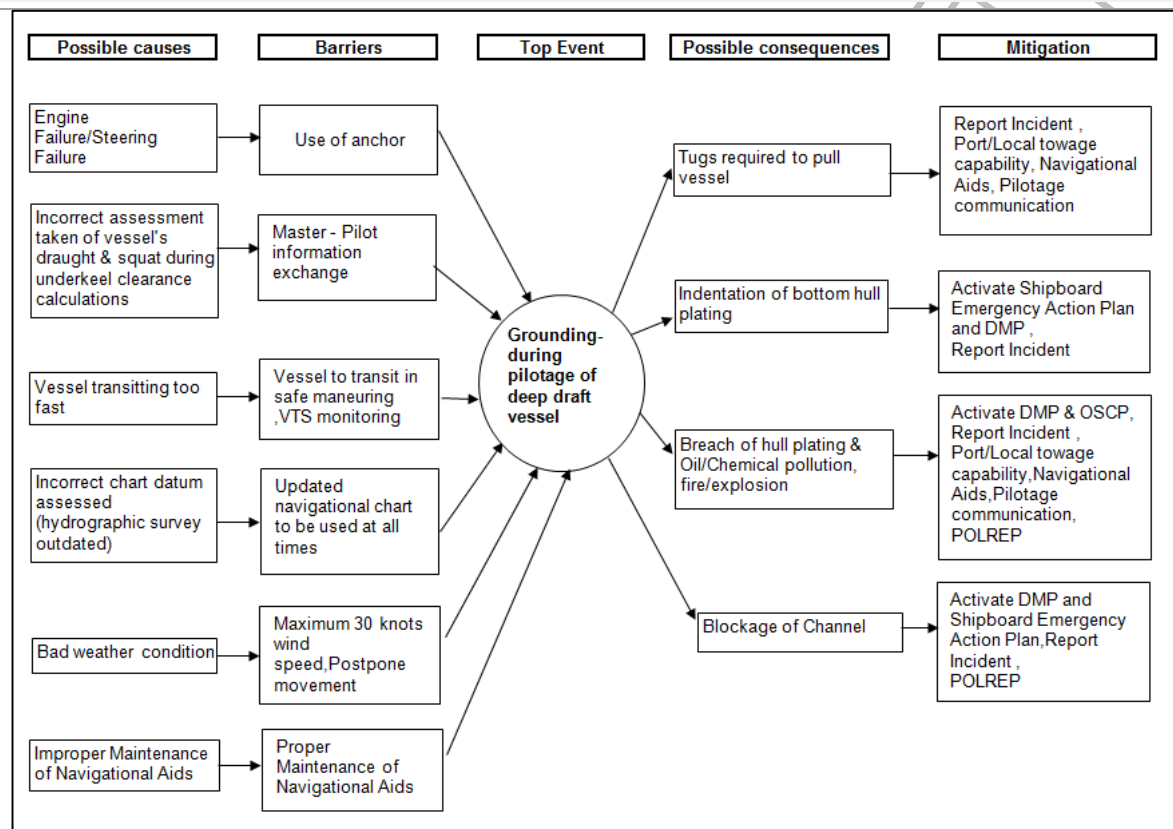


Scenario 4: Grounding- Tanker/Container/Bulk Carrier transiting in Channel

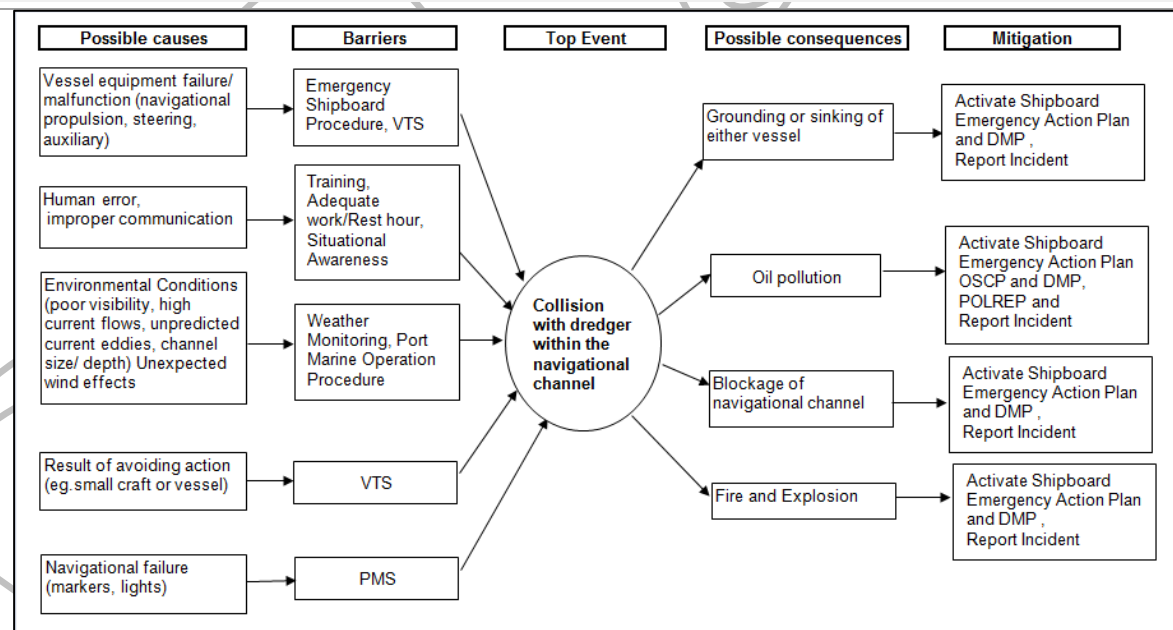


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Scenario 5: Grounding – During pilotage of deep draft vessel

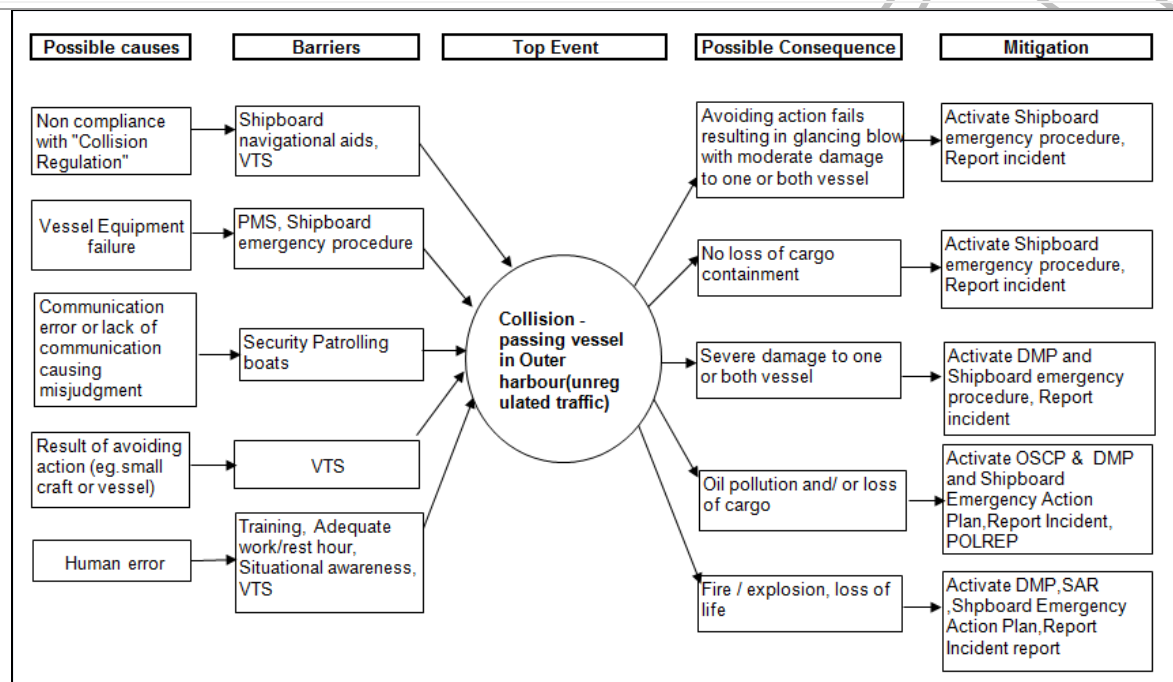


Scenario 6: Collision with dredger within the Navigational channel

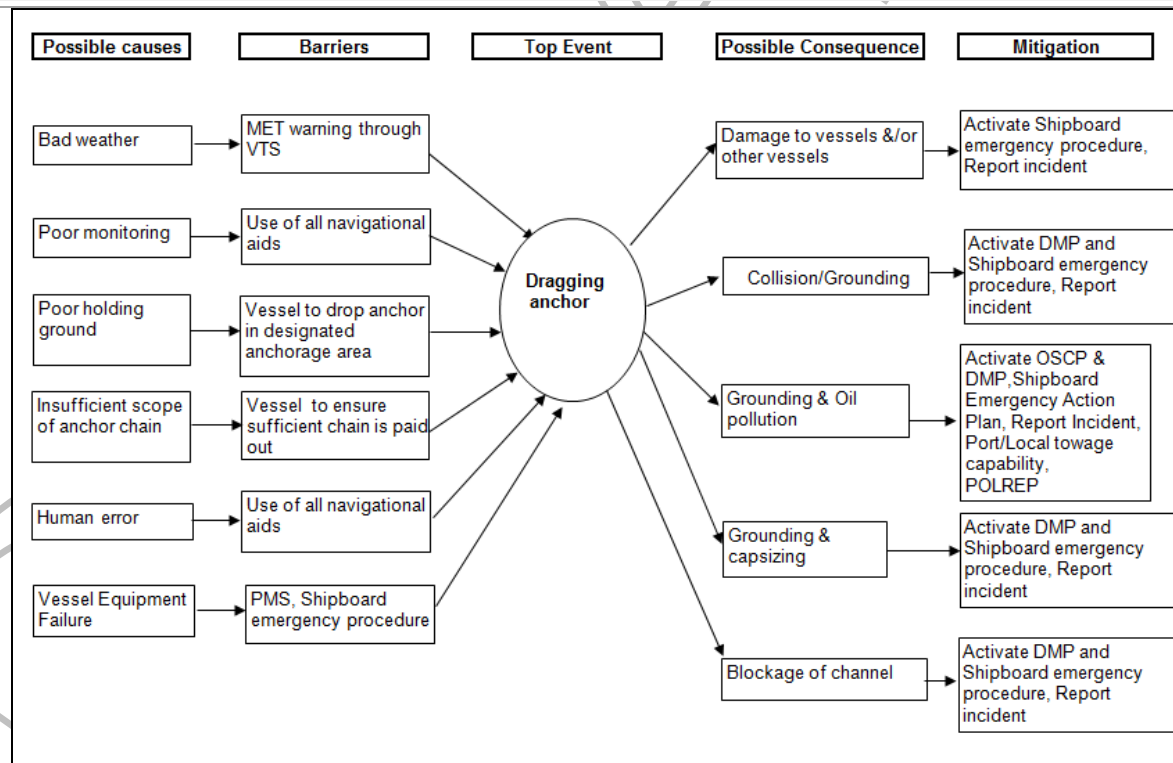


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Scenario 7: Collision- Passing vessel in Outer harbor (unregulated traffic)

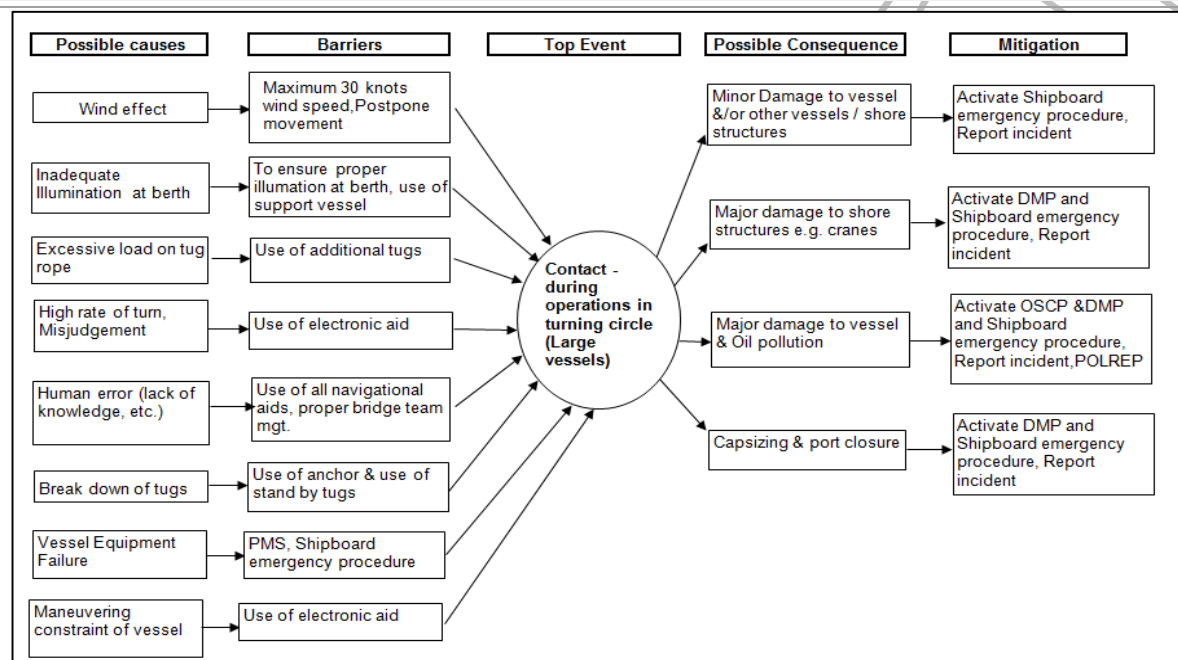


Scenario 8: Dragging anchor

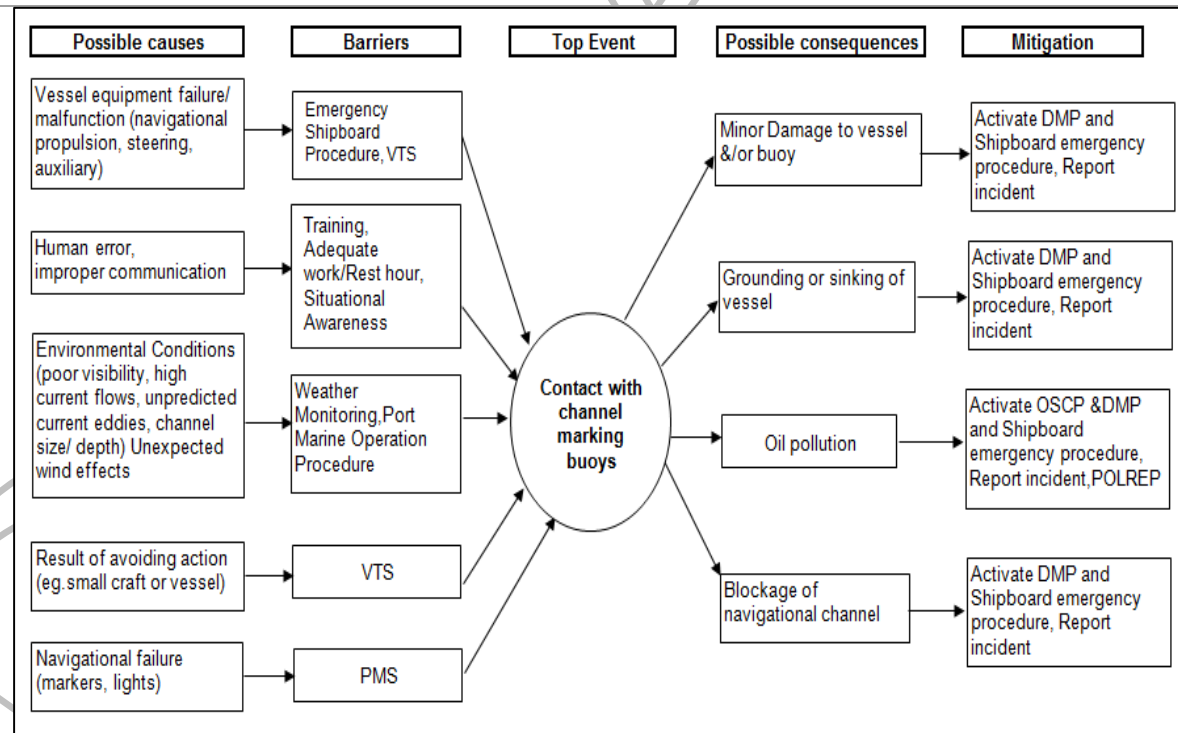


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Scenario 9: Contact – during operations in turning circle (Large vessels)

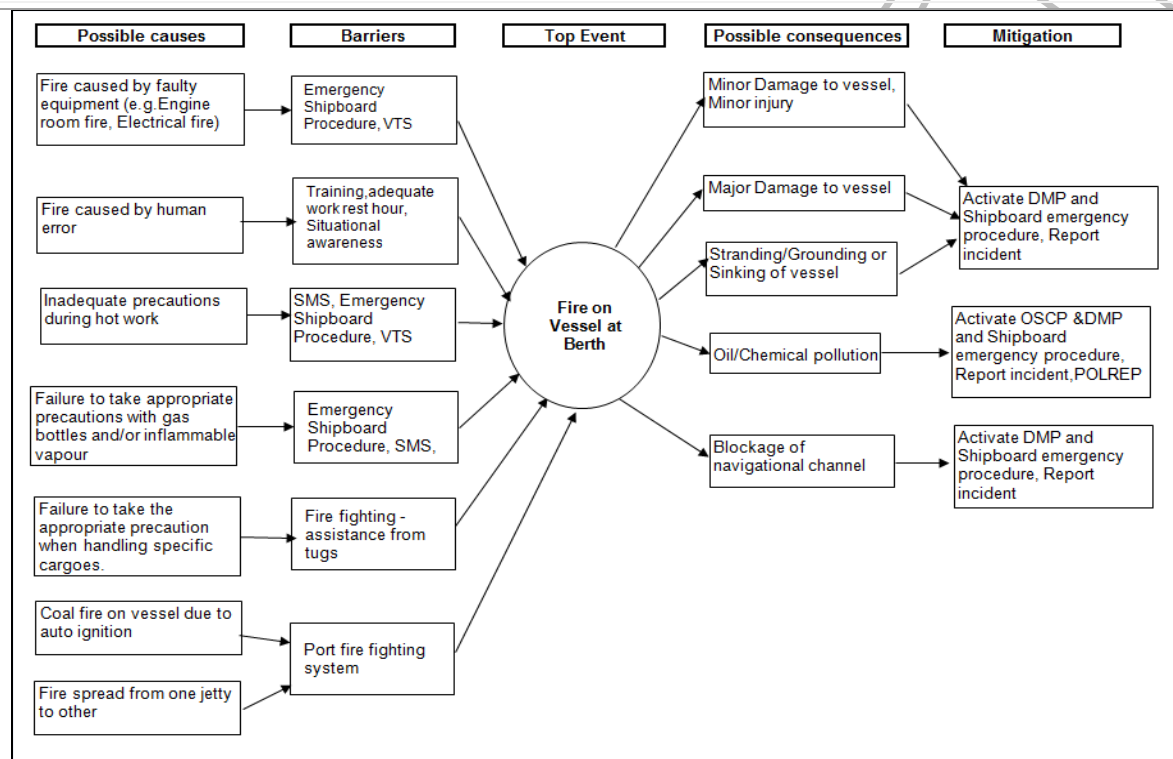


Scenario 10: Contact with channel marking buoys

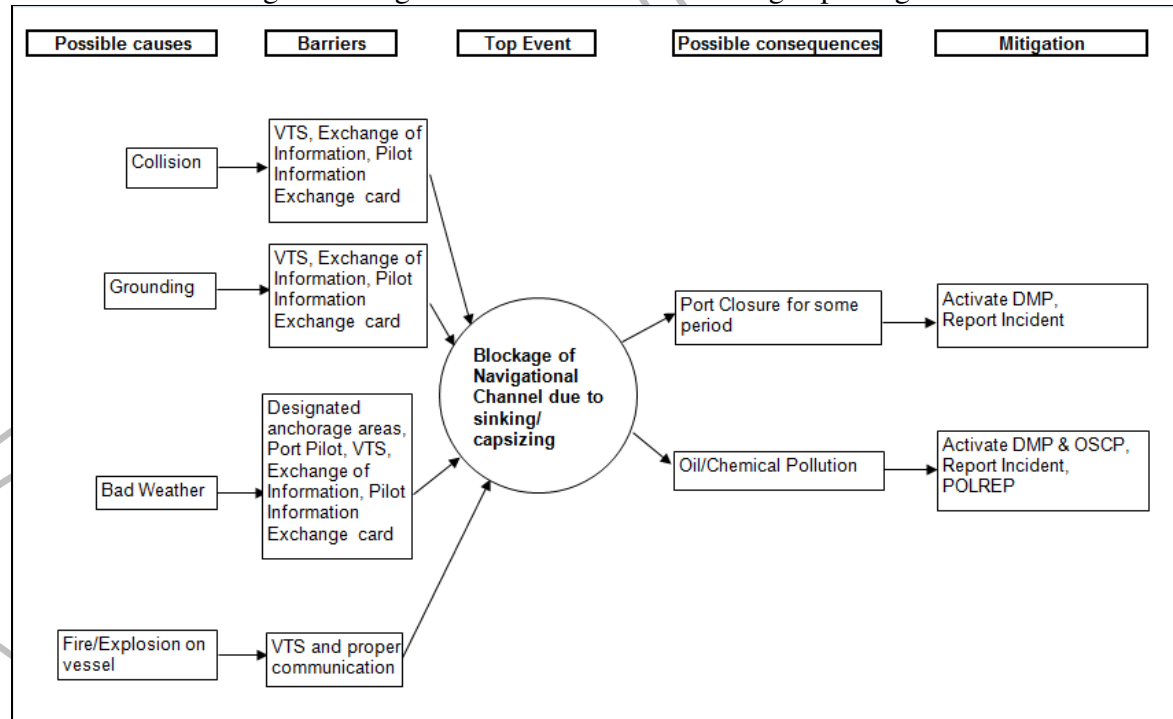


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Scenario 11: Fire on vessel at Berth



Scenario 12: Blockage of Navigational channel due to sinking/capsizing



APPENDIX B: HAZARD ANALYSIS WORKSHEET

Scenario No.	Area	Category	Hazard Detail	Possible Causes	Hazard Reduction Barriers	MCS	WCS	Rating					Mitigation					
								Most Credible						Worst Credible				
								Consequence						Consequence				
								People	Property	Environment	Business	Frequency		People	Property	Environment	Business	Frequency
1	Outer Harbour	Collision	Collision with small craft – Tanker/ Container/ BC in harbor approach	Vessel equipment failure/malfunction (navigational, propulsion, steering etc), Human error (pilot, master, tug), Language communication issues, Failure to follow COLREG, Environmental conditions (poor visibility, high current flow, channel size/ depth, rough weather, high wind speed), Fishing nets, Fishing Boat Anchored	Exchange of information between Pilot & Master (Pilot exchange card), VTS, Training of personnel, Security boat, Navigational channel is buoyed & well marked, weather monitoring, suspension of operation on increase of wind speed beyond 30 knots	Avoiding action fails resulting in glancing blow with moderate damage to one or both vessel, Delay to berthing	Penetration to Oil tanker/ Container/ BC, Oil pollution, serious damage to small craft, possible total loss and life of personnel	1	1	0	0	2	3	4	1	1	3	Incident report, Activate port DMP, SOPEP, POLREP, Activate port OSCP

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Scenario No.	Area	Category	Hazard Detail	Possible Causes	Hazard Reduction Barriers	MCS	WCS	Rating										Mitigation					
								Most Credible					Worst Credible										
								Consequence					Consequence										
								People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency						
2	Navigational Channel	Collision	Collision between two vessels in channel (Regulated traffic)	Non compliance with COLREG, Human error, Lack of communication, Ship's equipment breakdown, Local congestion, difficulty in communication, maneuvering to (dis)embark pilot, absence of VTS control, Multiple vessel convergence especially in poor visibility, Incomplete passage plan	VTS, VHF, proper communication, Security boat, arrival report, Pilot information exchange card, Designated anchorage area & designated boarding area & designated channel for port operation & pilot (designated VHF frequency), Night time restriction	Moderate damage to one or both vessel, Delay to berthing, Minor Oil Spill	Serious damage to vessels and oil pollution, Vessel(s) stranded, Fire & Explosion, Blockage of navigational channel															Incident report, Activation of port DMP, SOPEP, POLREP, Activation of port OSCP	
								2	2	1	2	3	4	4	2	4	4						

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Scenario No.	Area	Category	Hazard Detail	Possible Causes	Hazard Reduction Barriers	MCS	WCS	Rating										Mitigation
								Most Credible					Worst Credible					
								Consequence					Consequence					
								People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
3	Inner Harbour	Contact/Allision	Tanker/ Container/ BC tug assisted berthing – Contact/ Allision with jetty	Vessel equipment failure (steering or main engine), Vessel blackout, Misjudgment by pilot/master/tug master, Bad weather (wind speed), Break down of tugs, Parting of tow line, Inadequate illumination at berth	Assistance of tugs and use of anchor, Use of electronic aids and proper bridge team management, VTS, Pilot information card, Use of anchor and engines, Weather monitoring, Use of ship's and tugs illumination for night berthing	Minor damage to side shell plating of vessel, No loss of cargo containment, Minor damage to quay or fendering system	Serious damage to side shell plating of vessel, Serious damage to quay/fender , Loss of cargo containment, Oil pollution, Personnel injury/loss	1	2	0	1	1	1	3	1	2	3	Incident report, Remove vessel from damage areas and reberth, Activate port DMP, SOPEP, POLREP, Activate port OSCP

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Scenario No.	Area	Category	Hazard Detail	Possible Causes	Hazard Reduction Barriers	MCS	WCS	Rating										Mitigation
								Most Credible					Worst Credible					
								Consequence					Consequence					
								People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
4	SPM	Contact/Allision	Tanker-Contact /Allision with SPM or tug	Vessel equipment failure (steering or main engine), Vessel blackout, Misjudgment by pilot/master/tug master, Bad weather (wind speed), Break down of tugs, Parting of tow line, Inadequate illumination at SPM	Assistance of tugs and use of anchor, Use of electronic aids and proper bridge team management, VTS, Pilot information card, Use of anchor and engines, Weather monitoring, Use of ship's and tugs illumination for night berthing	Minor damage to side shell plating of vessel, No loss of cargo containment, Minor damage SPM	Serious damage to side shell plating of vessel, Serious damage to SPM, Loss of cargo containment, Oil pollution, Personnel injury/loss	1	2	0	1	2	1	3	1	2	4	Incident report, Activate port DMP, SOPEP, POLREP, Activate port OSCP

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Scenario No.	Area	Category	Hazard Detail	Possible Causes	Hazard Reduction Barriers	MCS	WCS	Rating										Mitigation	
								Most Credible					Worst Credible						
								Consequence					Consequence						
								People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
5	Navigational Channel	Grounding	Grounding – Tanker/ Container/ BC transiting in navigational channel	Human error, Adverse weather conditions, Fishing vessel/small craft impedes passage, vessel equipment failure, Steering failure	Use of electronic aids and proper bridge team management, Weather monitoring VTS, Use of Anchor, Tug assistance, Proper ship signal, Use of security boat signal	Damage to shell plating - possible water ingress & increase of draught, No loss of cargo containment	Major hull damage, Vessel stranded, Oil pollution, Possible loss of cargo, machinery disabled or extended stranding, floating of tank containers, blockage of channel	0	2	0	0	3	1	3	3	3	3	4	Incident report, Shipboard emergency procedure, Activate port DMP, POLREP, Activate port OSCP

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Scenario No.	Area	Category	Hazard Detail	Possible Causes	Hazard Reduction Barriers	MCS	WCS	Rating										Mitigation
								Most Credible					Worst Credible					
								Consequence					Consequence					
								People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
6	Navigational Channel	Grounding	Grounding – During pilotage of deep draft vessel	Engine Failure/Steering Failure, Incorrect assessment taken of vessel's draught & squat during under-keel clearance calculations, Vessel transiting too fast, Incorrect chart datum assessed (hydrographic survey outdated), Bad weather condition, Improper Maintenance of Navigational Aids	Use of Anchor, Pilot info exchange card, Vessel to transit in safe maneuvering, VTS monitoring Updated navigational chart to be used, Max 30 knots wind speed operational limit, Postpone movement, Maintenance of Navigational Aids	Tugs required to pull vessel clear, Indentation of bottom hull plating	Breach of hull plating & oil/chemical pollution, fire & explosion, blockage of navigational channel	0	1	0	0	3	2	3	2	3	4	Incident report, Port/Local towage capability, Navigational aids, Shipboard emergency procedure, Pilotage, Activate port DMP, POLREP, Activate port OSCP

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Scenario No.	Area	Category	Hazard Detail	Possible Causes	Hazard Reduction Barriers	MCS	WCS	Rating										Mitigation				
								Most Credible					Worst Credible									
								Consequence					Consequence									
								People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency					
8	Outer Harbour	Collision	Collision - passing vessel in Outer harbour (unregulated traffic)	Non-compliance with COLREGS, vessel equipment failure, communication error or lack of communication causing misjudgment, result of avoiding action (eg. Small craft or vessel), Human error.	Shipboard navigational aids, VTS, PMS, shipboard emergency procedure, security patrolling boats, training, adequate work/hour, situational awareness.	Avoiding action fails resulting in glancing blow with moderate damage to one or both vessel, No loss of cargo, No serious injury	Severe damage to one or both vessel, Oil/chemical pollution and/ or loss of cargo, Fire / explosion, loss of life															Incident report, Shipboard emergency procedure, Activation of port DMP, POLREP, Activation of port OSCP, SAR

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Scenario No.	Area	Category	Hazard Detail	Possible Causes	Hazard Reduction Barriers	MCS	WCS	Rating										Mitigation	
								Most Credible					Worst Credible						
								Consequence					Consequence						
								People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
9	Outer Harbour	Collision	Collision – Anchor dragging	Bad weather, Poor monitoring, Poor holding ground, Insufficient scope of anchor chain, Human error, Vessel Equipment Failure	Met. warning through VTS, Use of all Navigational aids, Vessel to drop anchor in designated area, Vessel to ensure that sufficient chain is paid, PMS, Shipboard emergency procedure	Minor Damage to either/b oth of the vessel	Grounding and oil pollution, Grounding and capsizing, Blockage of channel	1	1	0	1	3	3	3	3	3	4	4	Incident report, Shipboard emergency procedure, Port/Local towage capability, Activation of port DMP, POLREP, Activation of port OSCP

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Scenario No.	Area	Category	Hazard Detail	Possible Causes	Hazard Reduction Barriers	MCS	WCS	Rating										Mitigation
								Most Credible					Worst Credible					
								Consequence					Consequence					
								People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
10	Inner Harbour	Contact/Allision	Contact/allision – During operations in turning circle (Large vessels)	Wind effect, Illumination inadequate at berth, Excessive load on tug rope, High rate of turn, Misjudgment, Human error (fatigue, lack of knowledge, etc.), Break down of tugs, Vessel Equipment Failure, Maneuvering constraint of vessel	Maximum 30 knots wind speed operational limit, Postpone movement, To ensure proper illumination at berth, Use of support vessel illumination, Use of additional tugs, Use of electronic aids and proper bridge team management, PMS	Minor Damage to vessel &/or other vessel/ Shore structures	Major damage to shore structures e.g. cranes, Major damage to vessel & Oil pollution, fall of containers, listing & temporary port closure	0	1	0	1	2	2	3	2	3	4	Incident report, Shipboard emergency procedure, Activation of port DMP, POLREP, Activation of port OSCP

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Scenario No.	Area	Category	Hazard Detail	Possible Causes	Hazard Reduction Barriers	MCS	WCS	Rating										Mitigation				
								Most Credible					Worst Credible									
								Consequence					Consequence									
								People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency					
11	Navigational Channel	Contact/Allision	Collision/allision with channel marking buoys	Vessel equipment failure/malfunction (navigational propulsion, steering, auxiliary), human error, improper communication, environmental conditions (poor visibility, high current flows, unpredicted current eddies, channel size/depth), results of avoiding action (eg. small craft or vessel), navigational failure (markers, lights)	Emergency shipboard procedure, VTS, training, adequate work/rest hour, situational awareness, weather monitoring, port marine operation procedure, PMS	Minor Damage to vessel/buoy & fouling of ship propellers/steering	Grounding of vessel, Oil pollution, Blockage of navigational channel															Incident report, Shipboard emergency procedure, Port DMP activation, POLREP and Port OSCP

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Scenario No.	Area	Category	Hazard Detail	Possible Causes	Hazard Reduction Barriers	MCS	WCS	Rating					Mitigation					
								Most Credible						Worst Credible				
								Consequence						Consequence				
								People	Property	Environment	Business	Frequency		People	Property	Environment	Business	Frequency
1 2	Berth	Fire	Fire on vessel at berth	Fire caused by faulty equipment, fire caused by human error, inadequate precautions during hot work, failure to take appropriate precautions with gas bottles and/or inflammable vapour, failure to take the appropriate precaution when handling specific cargoes, Coal fire on vessel due to auto ignition, Fire spread from one jetty to other	Emergency shipboard procedure, VTS, training, adequate work/rest hour, situational awareness, Emergency Shipboard Procedure SMS, PMS, fire fighting assistance from tugs, Port fire fighting system.	Minor damage to vessel, Injury to personnel	Major damage to vessel, Multiple injury and/or fatality to personnel, Loss of cargo, Loss of vessel control	2	1	0	1	2	4	4	2	4	4	Incident report, Shipboard emergency procedure, Port DMP activation, POLREP and Port OSCP

APPENDIX C

OIL SPILL TRAJECTORY MODELING BY USING GNOME

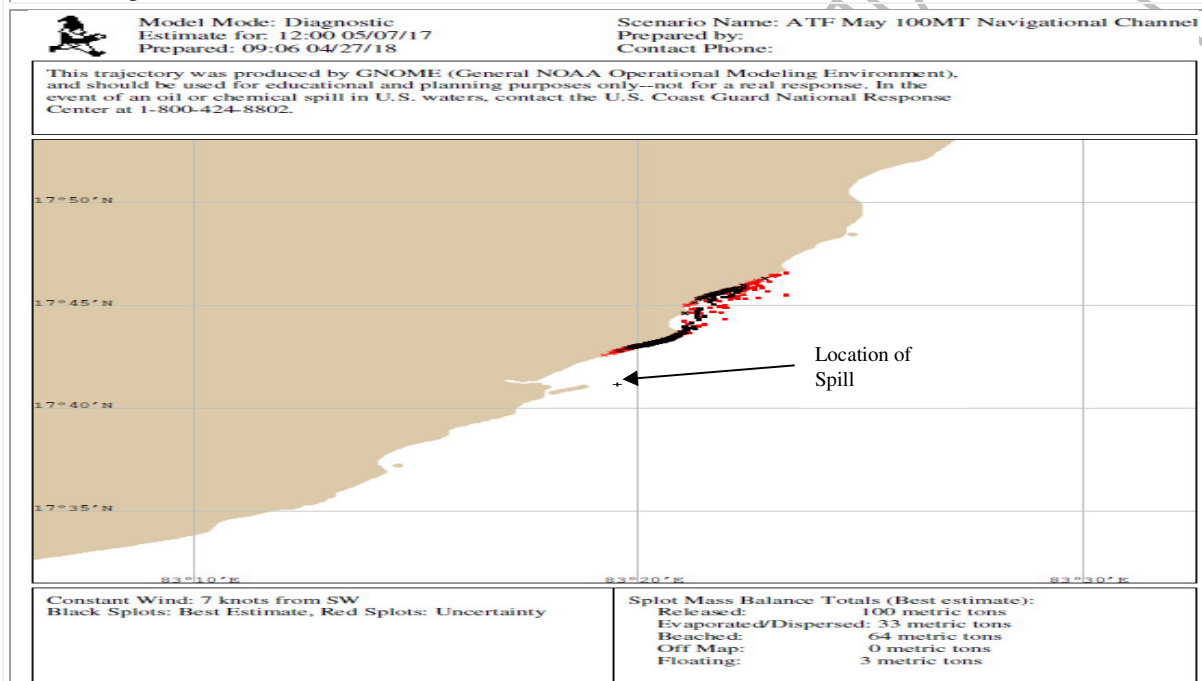
The National Oceanic and Atmospheric Administration's (NOAA's) GNOME model is used to simulate trajectory of Oil Spill. Input data for GNOME includes:

- Map file generated from GNOME Global custom map generator.
- Avg. wind speed of 7 knots – South-West for May, 6 knots – South-South-West for October and 5 knots – North-East for January as per data provided by the VPT and website (https://www.windfinder.com/windstatistics/visakhapatnam_port)
- Current file is taken from HYCOM.
- Location of Spill
 - At SPM
 - In Navigational Channel
 - Outside Port Limit
- Trajectory Modeling is carried out for spillage of ATF, Diesel and Bunker Oil of quantity 10 MT and 100 MT for 2hr, 6 hr and 12 hr.

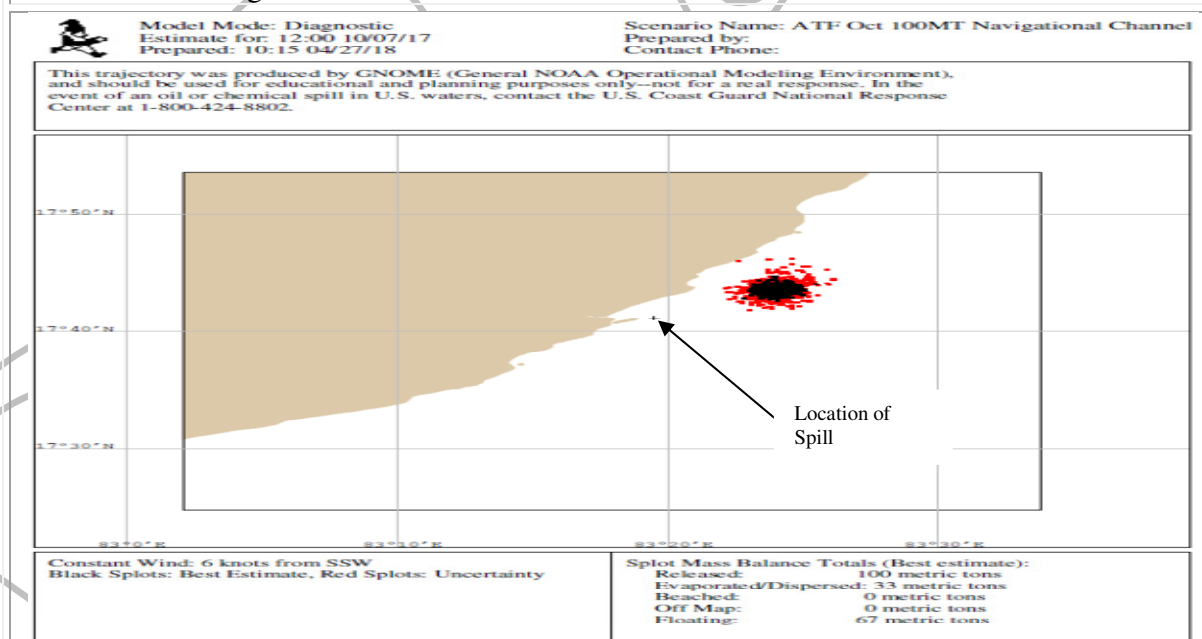
Risk Assessment Report

ATF

1.1 Trajectory of spillage of ATF of 100MT in VPT limit in the navigational channel for the month of May is as shown in below figure. After 6 hrs the position of the slick is shown in the figure.



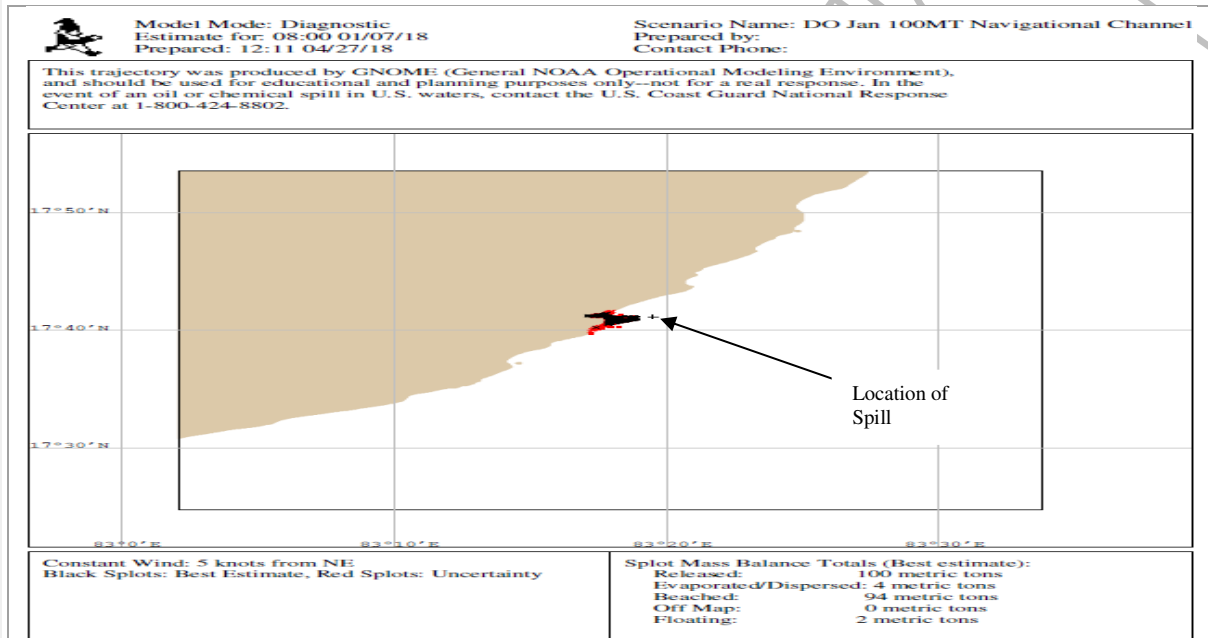
1.2 Trajectory of spillage of ATF of 100MT in VPT limit in the navigational channel for the month of October is as shown in below figure. After 6 hrs the position of the slick is shown in the figure.



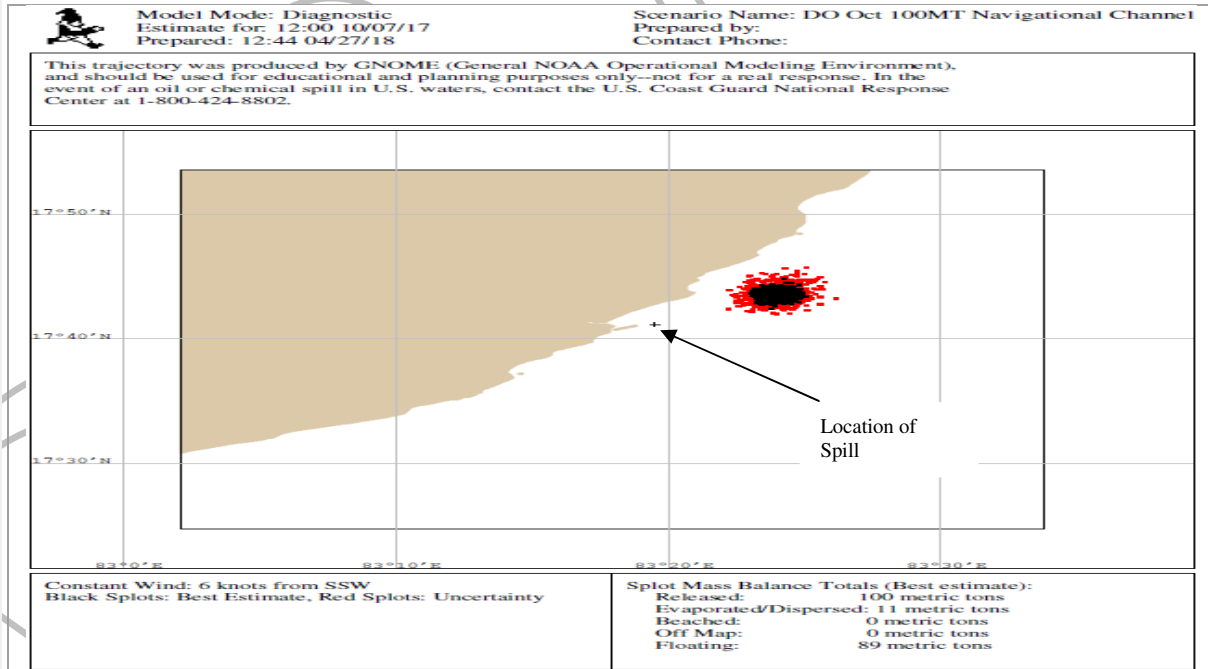
Risk Assessment Report

Diesel Oil

2.1 Trajectory of spillage of Diesel oil of 100MT in VPT limit in the navigational channel for the month of January is as shown in below figure. After 2 hrs the position of the slick is shown in the figure.



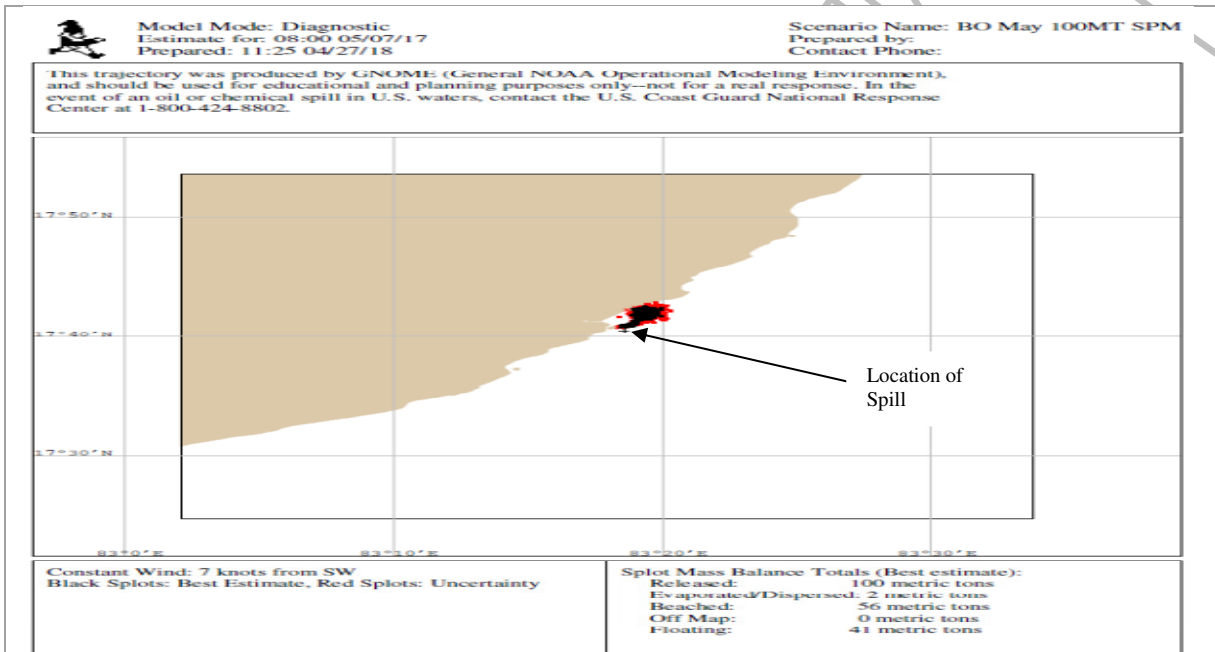
2.2 Trajectory of spillage of Diesel oil of 100MT in VPT limit in the navigational channel for the month of October is as shown in below figure. After 6 hrs the position of the slick is shown in the figure.



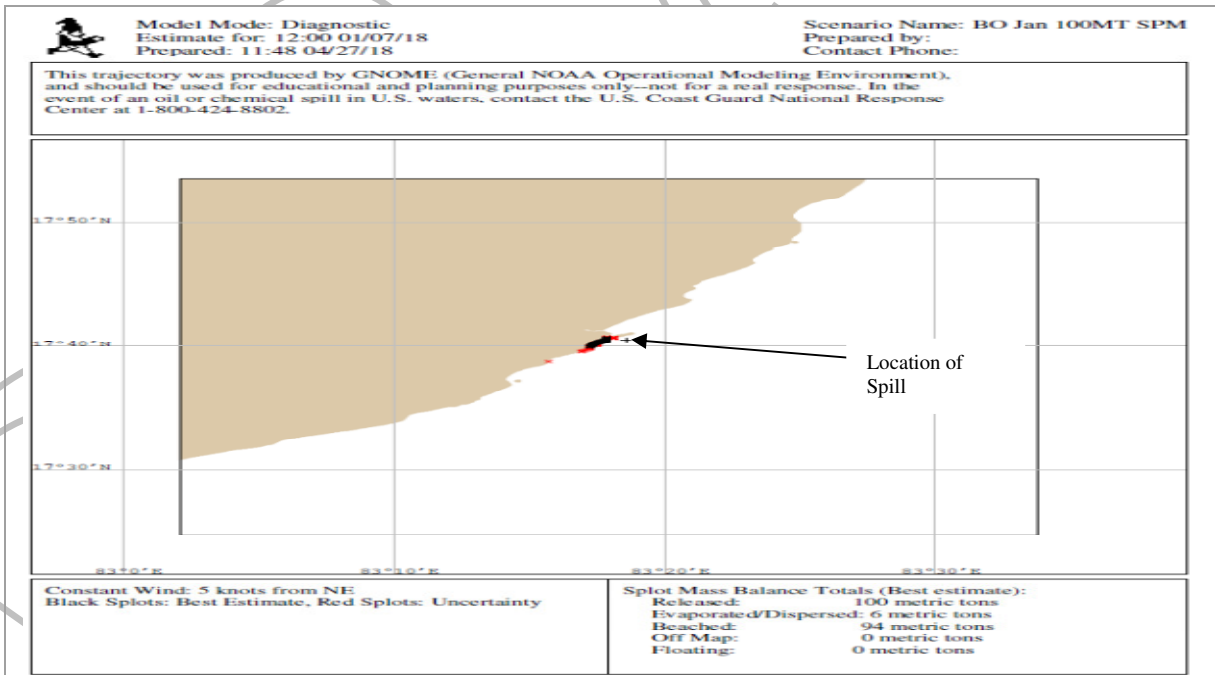
Risk Assessment Report

Bunker Oil

3.1 Trajectory of spillage of Bunker oil of 100MT in VPT limit in the navigational channel for the month of May is as shown in below figure. After 2 hrs the position of the slick is shown in the figure.

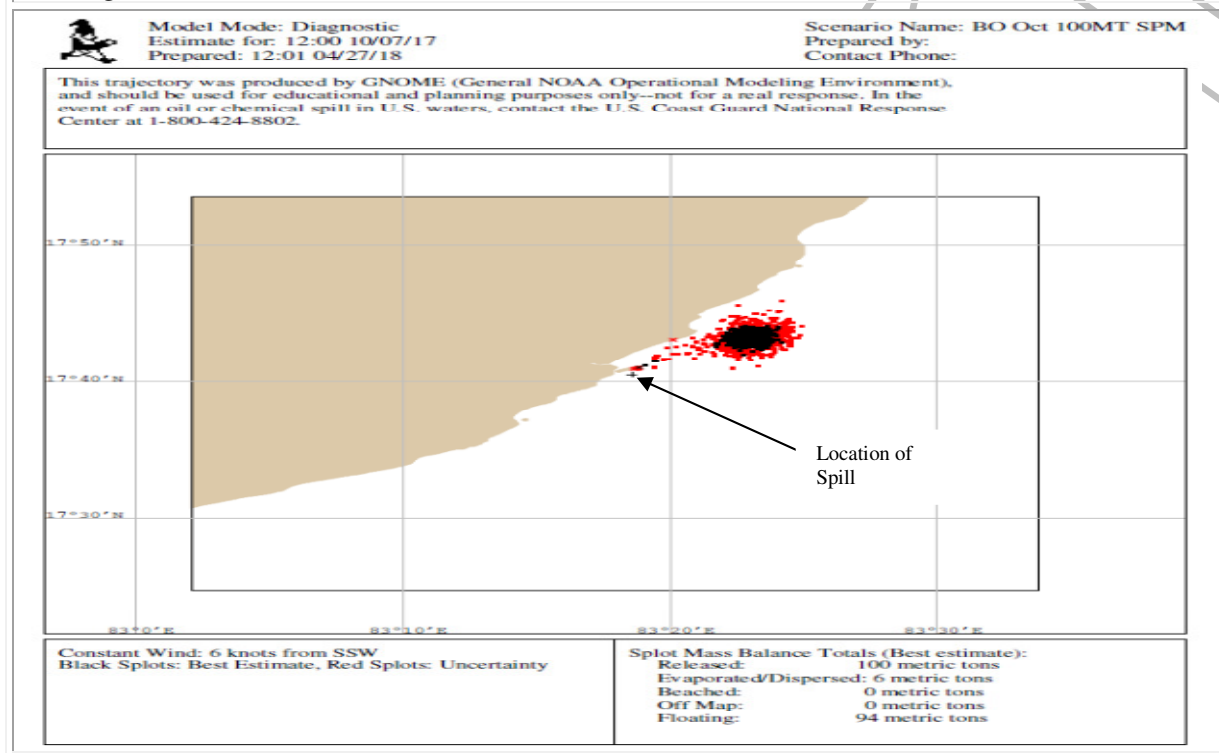


3.2 Trajectory of spillage of Bunker oil of 100MT in VPT limit at SPM for the month of January is as shown in below figure. After 6 hrs the position of the slick is shown in the figure.



Risk Assessment Report

3.3 Trajectory of spillage of Bunker oil of 100MT in VPT limit at SPM for the month of October is as shown in below figure. After 6 hrs the position of the slick is shown in the figure.



10 MT Spill

Summary for 2 hr trajectory
 Release: 10MT
 Location : At SPM

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
Diesel	0.4	5.5	4.2	0.4	0.1	9.5	0.4	9.5	0.1
Bunker Oil	0.2	5.6	4.1	0.2	0.1	9.7	0.2	9.7	0.1

Summary for 6 hr trajectory
 Release: 10MT
 Location : At SPM

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
Diesel	1.1	8.5	0.4	1.1	0	8.9	1.1	8.9	0
Bunker Oil	0.6	8.9	0.5	0.6	0	9.4	0.6	9.4	0

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Summary for 12 hr trajectory
Release: 10MT
Location : At SPM

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
Diesel	2.1	7.8	0.1	2.1	0	7.9	2.1	7.9	0
Bunker Oil	1.1	8.9	0.1	1.1	0	8.9	1.1	8.9	0

100 MT Spill

Summary for 2 hr trajectory
Release: 100MT
Location : At SPM

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
Diesel	4	55	42	4	1	95	4	95	1
Bunker Oil	2	56	41	2	1	97	2	97	1

Summary for 6 hr trajectory
Release: 100MT
Location : At SPM

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
Diesel	11	85	4	11	0	89	11	89	0
Bunker Oil	6	89	5	6	0	94	6	94	0

Summary for 12 hr trajectory
Release: 100MT
Location : At SPM

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
Diesel	21	78	1	21	0	79	21	79	0
Bunker Oil	11	89	1	11	0	89	11	89	0

10 MT Spill

Summary for 2 hr trajectory
Release: 10MT
Location : Outside Port limit

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
ATF	1.3	0	8.7	1.3	0	8.7	1.3	0	8.7
Diesel	0.4	0	9.6	0.4	0	9.6	0.4	0	9.6
Bunker Oil	0.2	0	9.8	0.2	0	9.8	0.2	0	9.8

Summary for 6 hr trajectory
Release: 10MT
Location : Outside Port limit

May	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
ATF	3.3	0.3	6.4	3.3	0	6.7	3.3	6.6	0.1

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Diesel	1.1	0.5	8.5	1.1	0	8.9	1.1	8.8	0.1
Bunker Oil	0.6	0.6	8.8	0.6	0	9.4	0.6	9.4	0

Summary for 12 hr trajectory
Release: 10MT
Location : Outside Port limit

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
ATF	5.2	4.1	0.8	5.2	0	4.9	5.2	4.9	0
Diesel	2.1	6.8	1.2	2.1	0	7.9	2.1	7.9	0
Bunker Oil	1.1	7.7	1.2	1.1	0	8.9	1.1	8.9	0.1

100 MT Spill

Summary for 2 hr trajectory
Release: 100MT
Location : Outside Port limit

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
ATF	13	0	87	13	0	87	13	0	87
Diesel	4	0	96	4	0	96	4	0	96
Bunker Oil	2	0	98	2	0	98	2	0	98

Summary for 6 hr trajectory
Release: 100MT
Location : Outside Port limit

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
ATF	33	3	64	33	0	67	33	66	1
Diesel	11	5	85	11	0	89	11	88	1
Bunker Oil	6	6	88	6	0	94	6	94	0

Summary for 12 hr trajectory
Release: 100MT
Location : Outside Port limit

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
Gasoline	52	41	8	52	0	49	52	49	0
Diesel	21	68	12	21	0	79	21	79	0
Bunker Oil	11	77	12	11	0	89	11	89	1

10 MT Spill

Summary for 2 hr trajectory
Release: 10MT
Location : Navigational Channel

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
ATF	1.3	0.1	8.6	1.3	0	8.7	13	85	2

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Diesel	0.4	03	9.3	0.4	0	9.6	0.4	9.4	0.2
Bunker Oil	0.2	0.2	9.6	0.2	0	9.8	0.2	9.6	0.2

Summary for 6 hr trajectory
Release: 10MT
Location : Navigational Channel

May	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
ATF	3.3	6.4	0.3	3.3	0	6.7	3.3	6.7	0
Diesel	1.1	8.7	0.3	1.1	0	8.9	1.1	8.9	0
Bunker Oil	0.6	9	0.4	0.6	0	9.4	0.6	9.3	0.1

Summary for 12 hr trajectory
Release: 10MT
Location : Navigational Channel

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
ATF	5.2	4.8	0	5.2	0	4.9	5.2	4.8	0
Diesel	2.1	7.8	0.1	2.1	0	7.9	2.1	7.9	0
Bunker Oil	1.1	8.9	0.1	1.1	0	8.9	1.1	8.9	0

100 MT Spill

Summary for 2 hr trajectory
Release: 100MT
Location : Navigational Channel

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
ATF	13	1	86	13	0	87	13	85	2
Diesel	4	3	93	4	0	96	4	94	2
Bunker Oil	2	2	96	2	0	98	2	96	2

Summary for 6 hr trajectory
Release: 100MT
Location : Navigational Channel

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
ATF	33	64	3	33	0	67	33	67	0
Diesel	11	87	3	11	0	89	11	89	0
Bunker Oil	6	90	4	6	0	94	6	93	1

Summary for 12 hr trajectory
Release: 100MT
Location : Navigational Channel

Oil type	May			October			January		
	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating	Evaporated/ Dispersed	Beached	Floating
ATF	52	48	0	52	0	49	52	48	0
Diesel	21	78	1	21	0	79	21	79	0
Bunker Oil	11	89	1	11	0	89	11	89	0

APPENDIX D

POTENTIAL IMPACTS FROM HNS SPILL

F.1 Introduction

In general terms, HNS material comprise of inorganic or organic chemical compounds, minerals, etc for use within or derived from industries like manufacturing, petrochemical, textile, pharmaceutical, food and agrichemical.

HNS material broadly comprised of the following:

- Refined products derived from oil,
- Other noxious or dangerous liquid substances,
- Liquefied gases,
- Gases,
- Solid bulk materials with chemical hazards,
- Liquids with flash points not exceeding 60°C, and
- Packaged dangerous, harmful and hazardous material.

From a response perspective, this list can be simplified to gas, liquid or solid released in bulk and/or released as packaged goods.

F.2 Fate of released HNS

Whether solid, liquid or gaseous in form, when chemicals are spilled they can behave in a number of different ways. Properties of HNS e.g. flammability, reactivity, toxicity, explosiveness, corrosiveness which can impact on safety, environment, property and socioeconomic activity once it is released into the environment. The fate also determines if it is possible to deploy counter-pollution response techniques, and which options should be chosen.

HNS can be grouped based on its post release behaviour. Grouping of HNS substances as shown in Table F.1 below has the advantage of focusing attention on those aspects of the release that relate to potential impact and problems of response, as follows:

- **Evaporators:** Comprises all volatile liquids which are less dense than sea water;
- **Floaters:** Comprises all non-volatile liquids which are less dense than sea water;
- **Sinkers:** Comprises all products which are more dense than sea water, and;
- **Dissolvers:** Comprises all products which are soluble in sea water.

*Risk Assessment Report***Table F.1: Grouping of HNS substances (handled at VPT) by its behavior**

	Group	Properties	Chemicals handled at VPT
Evaporate immediately(gases)	G Gas	Evaporate immediately	Propane, Butane
	GD gas/dissolver	Evaporate immediately, dissolve	
Evaporate rapidly	E evaporator	Float, evaporate rapidly	Toluene
	ED evaporator/ dissolver	Evaporate rapidly, dissolve	Acetone
Float	FE floater /evaporator	Float, evaporate	Xylene, Styrene
	FED floater/ evaporator /dissolver	Float, evaporate, dissolve	
	F Floater	Float	Diesel Oil, Bunker oil
	FD floater/dissolver	Float, dissolve	
Dissolve	DE dissolver/ evaporator	Dissolve rapidly, evaporate	Methanol
	D dissolver	Dissolve rapidly	IPA
Sink	SD sinker/dissolver	Sink, dissolve	
	S sinker	Sink	

F.3 Factors determining the safety, environmental and socioeconomic impact of HNS incidents

When dealing with an HNS incident one of the priority requirements is the identification of the hazards and assessment of the risk posed by HNS cargo to public and responder safety, the environment and socioeconomic assets. The risk is the product of hazards, probability and consequences or in a mathematical formula:

$$\text{Risk} = \text{Probability} \times \text{Consequences}$$

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Probability can be derived from statistics/incidents reports which show the frequency of incidents.

Consequences are depending on the vulnerability of the incident site or the vessel. It differs from location/vessel to location/ vessel as well as the means of technical equipment and response resources available.

The HNS risks during an accidental release event could be minimised by initially preparing a suitable risk assessment, and then by following the response options:

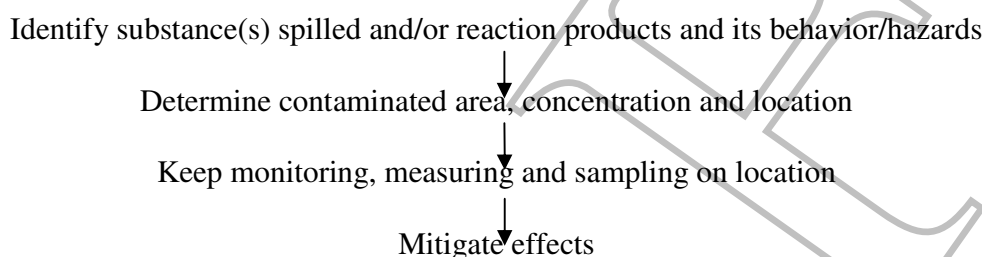


Figure F.1: Flow diagram of general approach to spills involving HNS

In risk assessment it is important to know the geographical scale or “risk area” that could be affected if a risk is not successfully responded to; for example the area around a vessel where explosion damage could extend to. It should be noted that in some cases the risk area will move either with the vessel or, in the case of a release to air or water, with the direction and extent of a toxic HNS plume. Wind, current and tide changes should be considered accordingly.

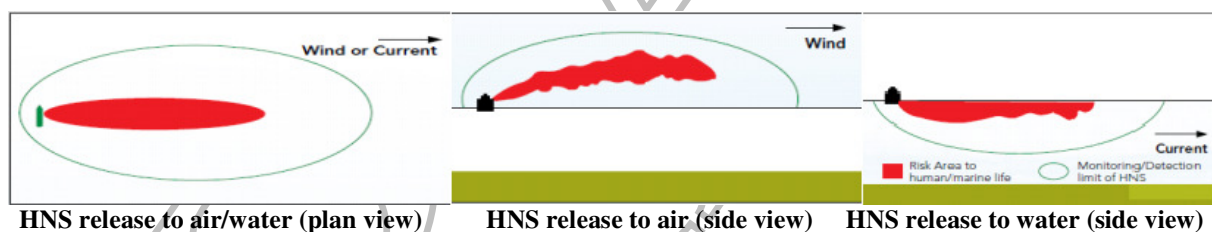


Figure F.2: HNS release to air/water, air and water

F.3.1 Safety impact

The physical fate can therefore determine the hazards posed by an HNS release. In the example of gases/evaporators with toxic (inhalation), flammable or explosive characteristics, the rate of evaporation combined with the total quantity evaporated and atmospheric dilution provides the resultant atmospheric concentration. This concentration relates to the potential toxicity of the substance, the concentration where there is an explosion hazard and/or flash point for flammability.

Similarly with those substances that act as solvers in sea water and have toxic properties (aquatic), hazards will be determined by the rate of dissolution, the total quantity dissolved and dilution by seawater with the resulting concentration determining the level of toxicity a substance has.

Response organizations should also consider the potential for ‘domino effects’ i.e. where an HNS release could initiate another incident, such as a ship fire or explosion could damage and ignite a neighboring vessel, port facility, storage depot, etc.

F.3.2 Environmental impact

In addition to the toxicity hazards to humans, HNS substances can have lethal effects on marine organisms. Incidents involving releases to marine waters have the benefit of sea and air dilution, to reduce the concentration of a substance to below a lethal dose. However, it should be remembered that lower doses can produce sub-lethal effects to marine organisms over a wider area. Sub-lethal effects may produce some form of impairment which may be detrimental to individual organisms, species, populations or marine communities over a longer term, depending upon the persistence of the released HNS in the marine environment.

Where not directly toxic some forms of HNS material can damage the marine ecosystems by causing changes in the environment. Such changes include variation in salinity and pH, together with de-oxygenation when material is broken down or used biologically in the marine environment (e.g. palm oil, fertilizers, etc). Changes in environmental conditions can induce lethal effects in marine ecosystems.

F.3.3 Socioeconomic impact

Sub-lethal effects can reduce the commercial value of marine resources, e.g. fin erosion, skeletal deformities, growths, etc. on marketed fish.

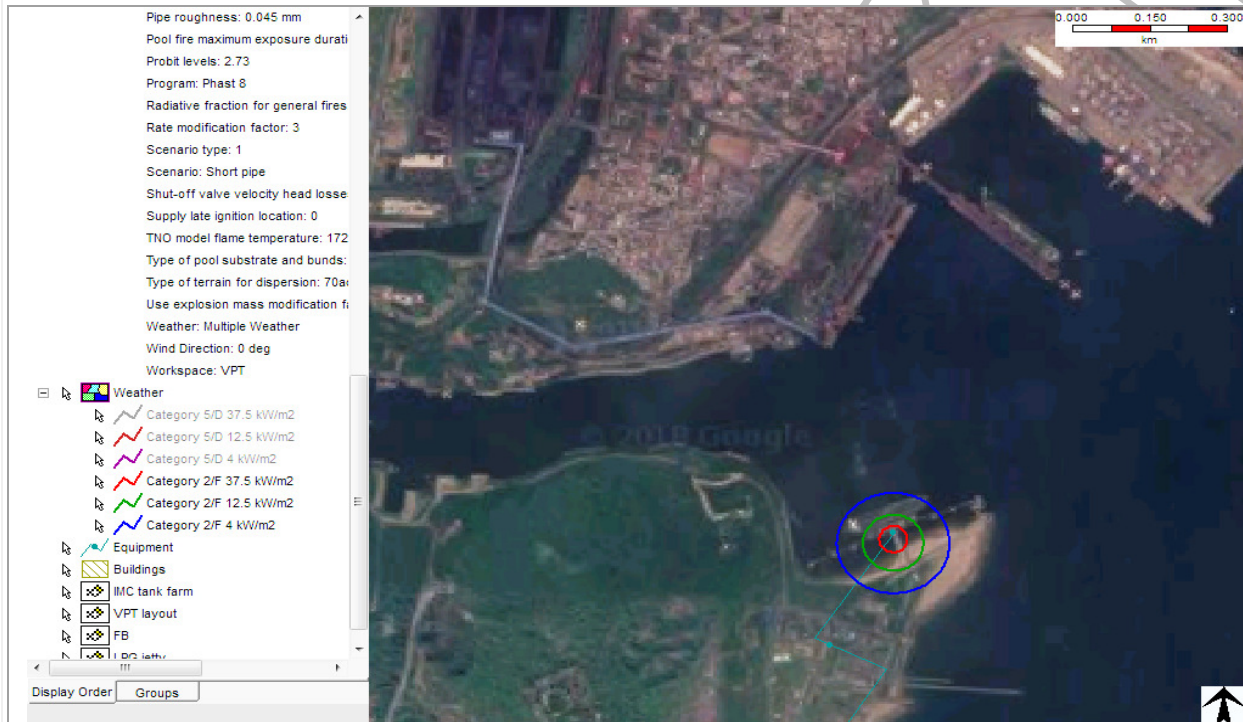
Contamination of an area may reduce its amenity value for economic drivers such as tourism, for example through the pollution of amenity beaches and bathing/recreation waters.

Toxicity, particularly with respect to contamination of commercial fish and shellfish by a bio-accumulating substance may lead to the closure of fishing and aquaculture areas.

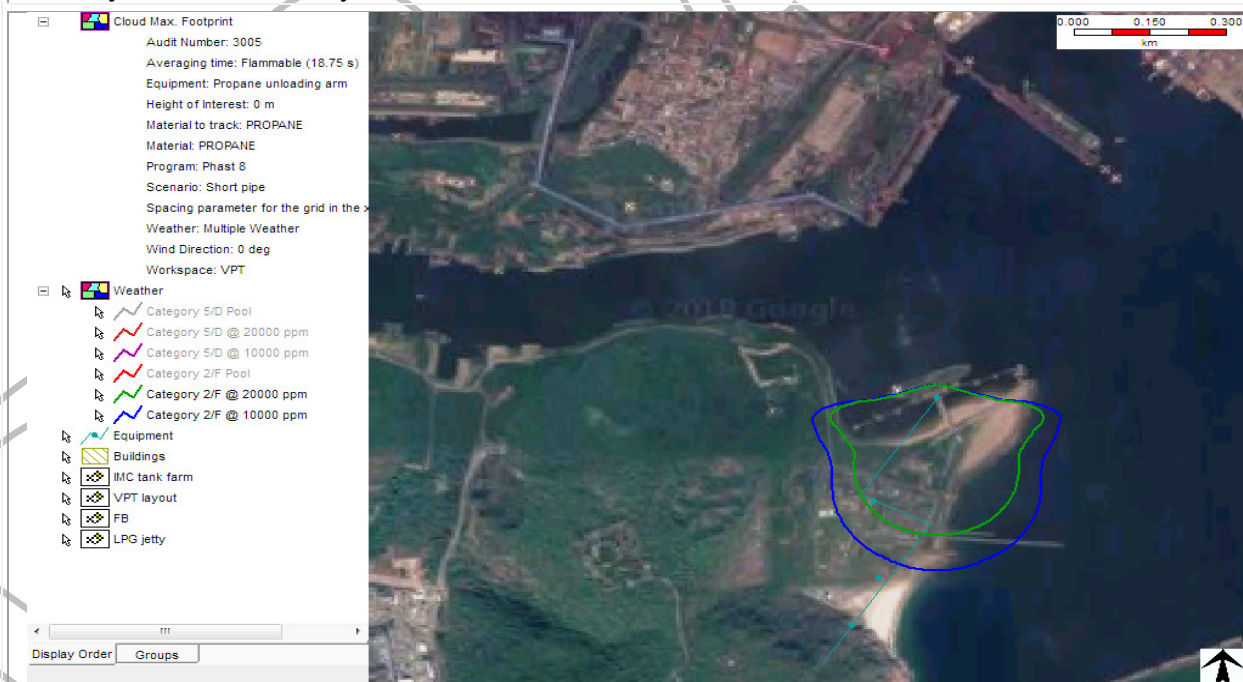
There is also the impact of ‘public perception’, whereby the impact of an incident can be magnified if public opinion considers the area is not safe to visit or consumer products (e.g. fish, shellfish, etc) from the location are polluted.

APPENDIX E: CONSEQUENCE ANALYSIS RESULTS

1. Pool fire from Full Bore Rupture of Propane unloading arm with wind speed 2 m/s and F stability class at LPG Jetty.

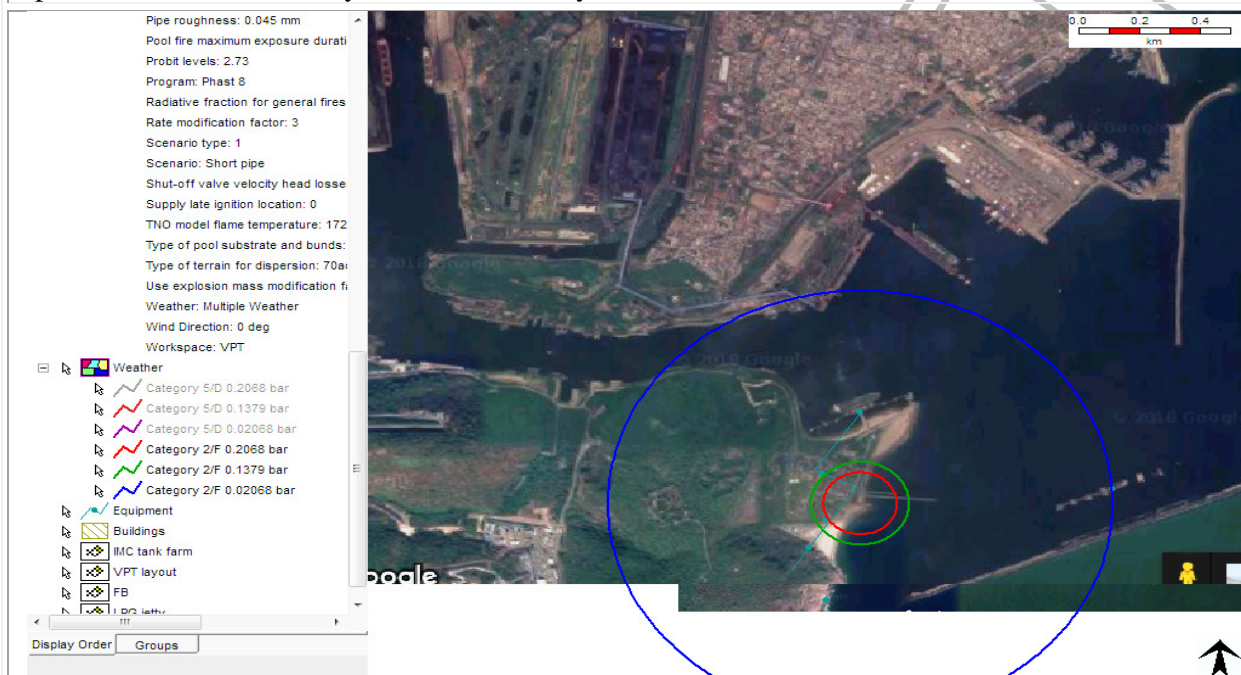


2. Flash fire from Full Bore Rupture of Propane unloading arm with wind speed 2 m/s and F stability class at LPG Jetty.

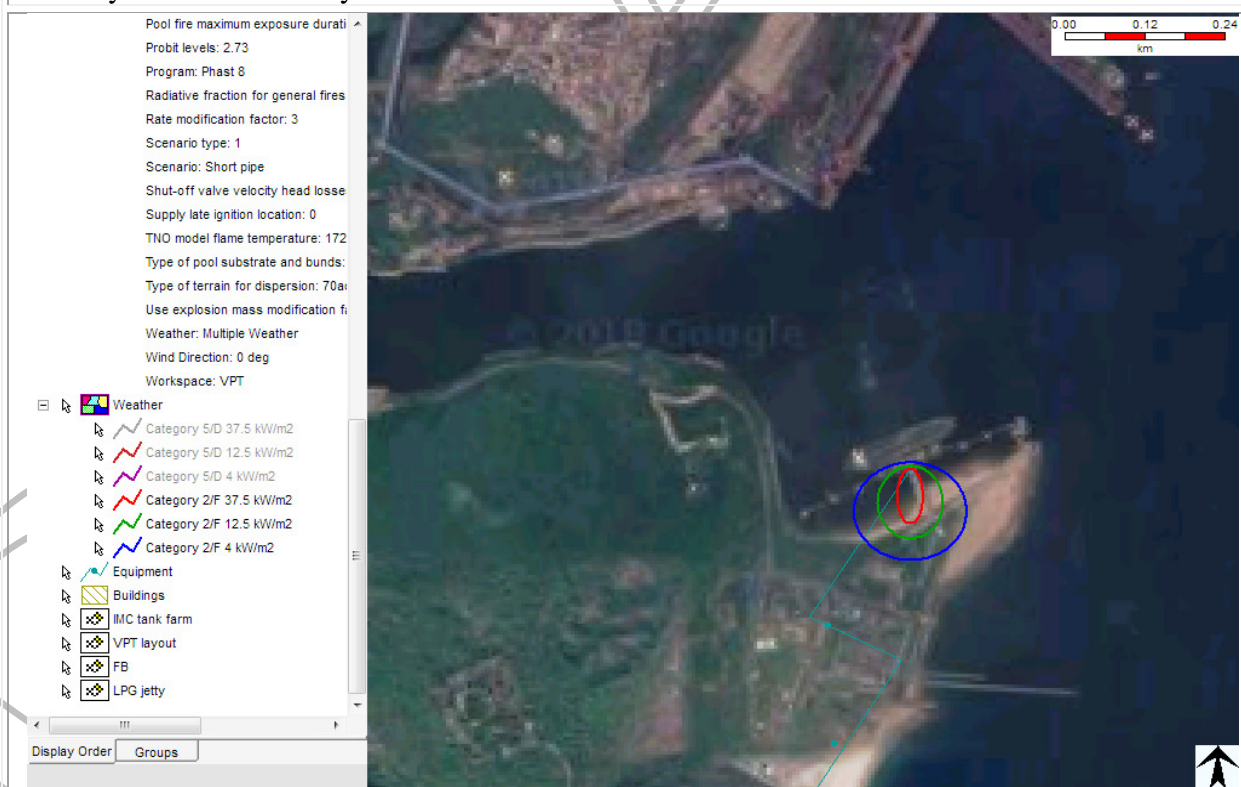


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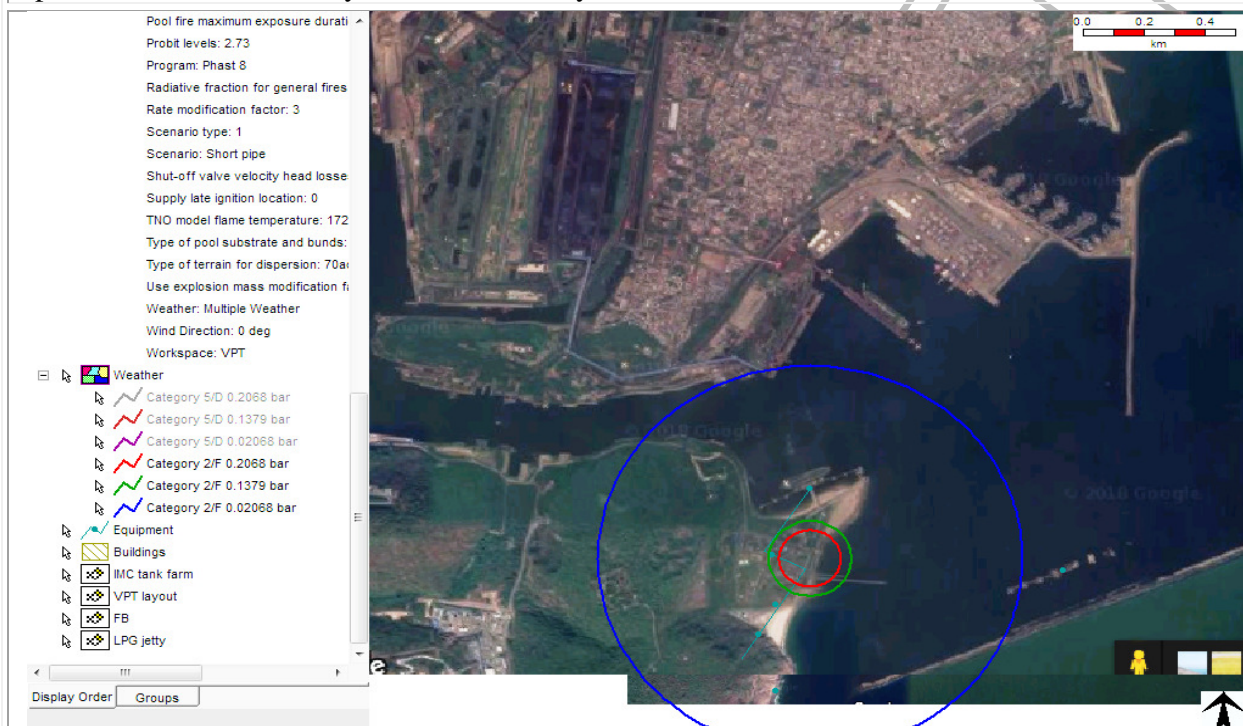
3. Vapor Cloud Explosion (VCE) from Full Bore Rupture of Propane unloading arm with wind speed 2 m/s and F stability class at LPG Jetty.



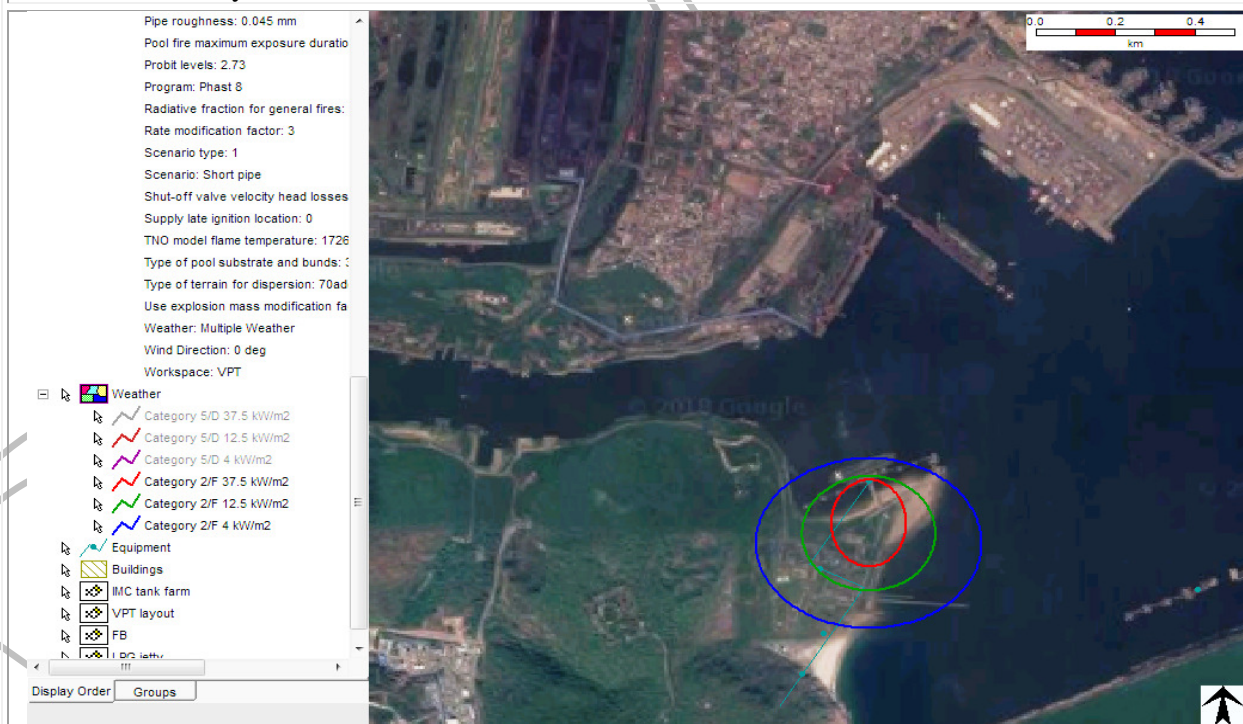
4. Jet Fire from Full Bore Rupture of Propane unloading arm with wind speed 2 m/s and F stability class at LPG Jetty.



5. Vapor Cloud Explosion (VCE) from Full Bore Rupture of Butane unloading arm with wind speed 2 m/s and F stability class at LPG Jetty.

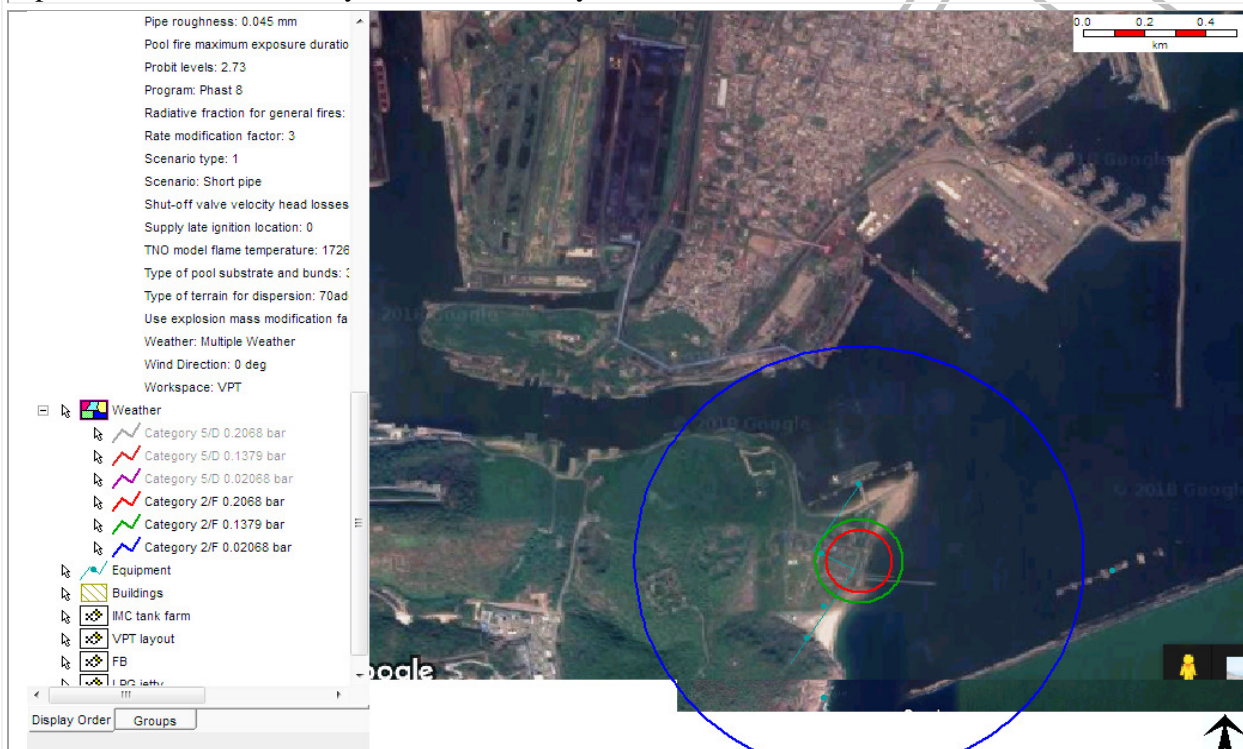


6. Jet fire from Full Bore Rupture of Naphtha hose (STS) with wind speed 2 m/s and F stability class at LPG Jetty.

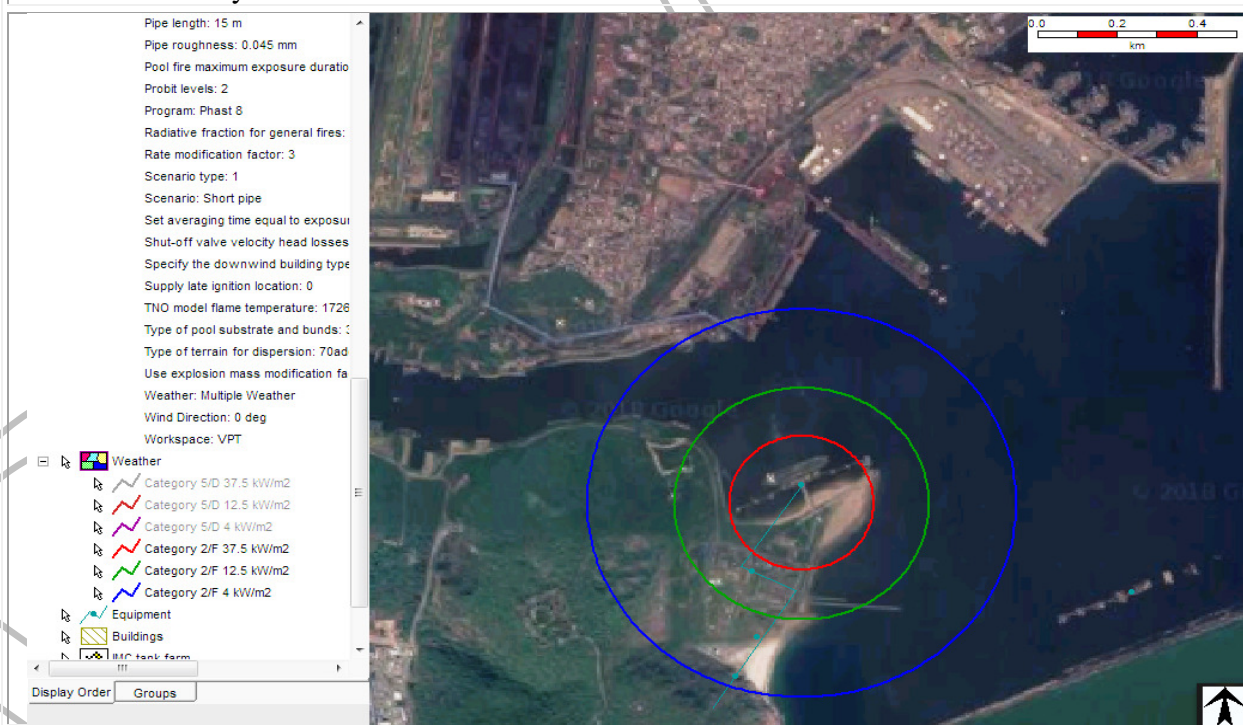


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7. Vapor Cloud Explosion (VCE) from Full Bore Rupture of Naphtha hose (STS) with wind speed 2 m/s and F stability class at LPG Jetty.

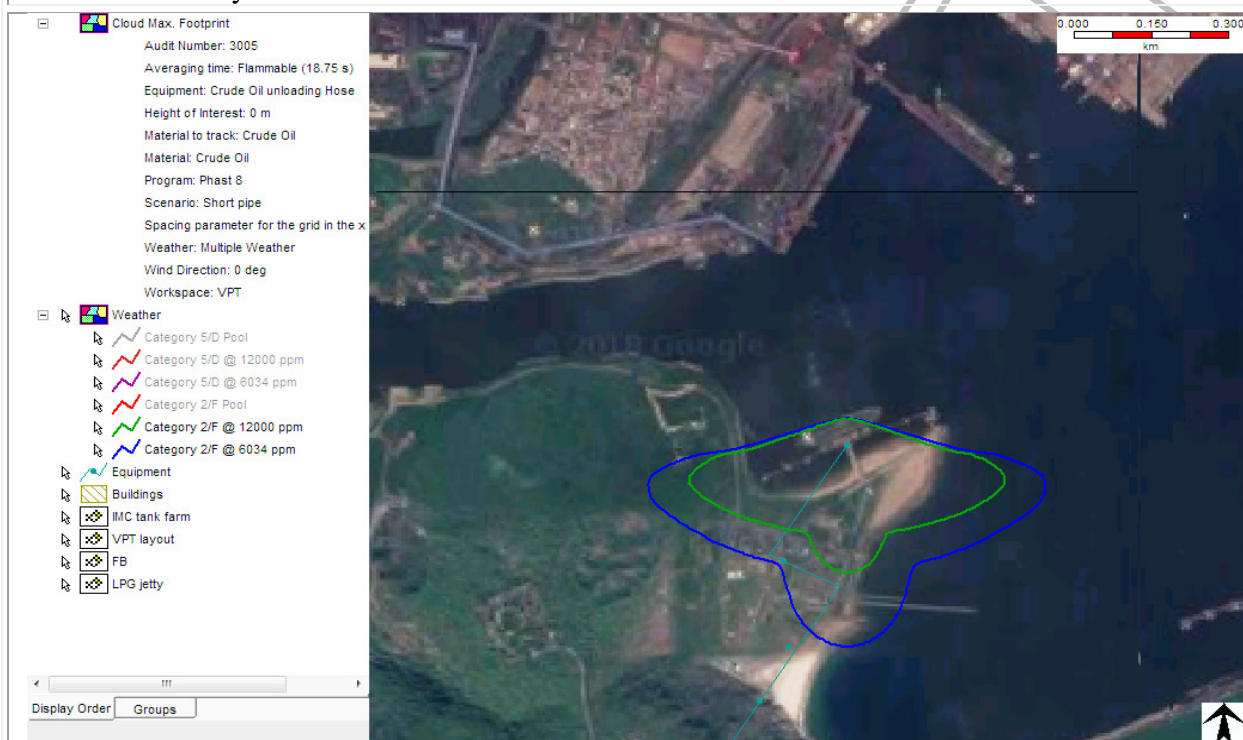


8. Pool fire from Full Bore Rupture of Crude Oil hose with wind speed 2 m/s and F stability class at LPG Jetty.

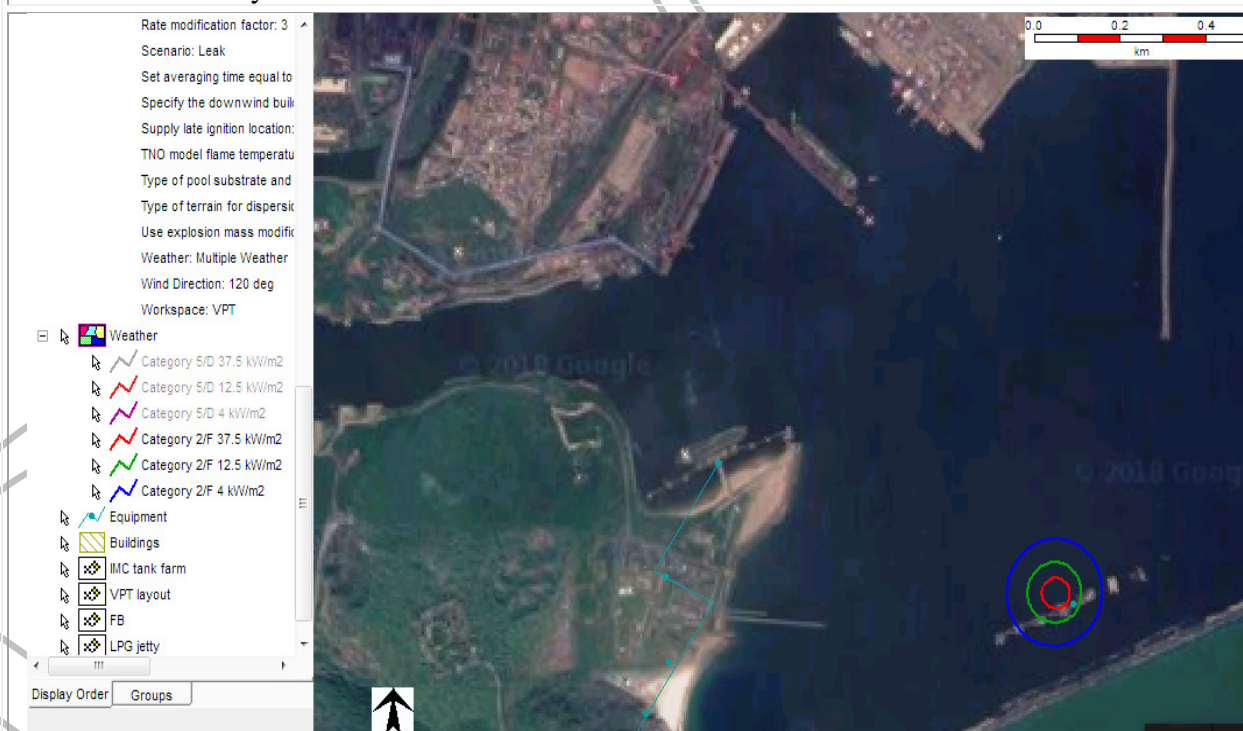


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9. Flash fire from Full Bore Rupture of Crude Oil hose with wind speed 2 m/s and F stability class at LPG Jetty.

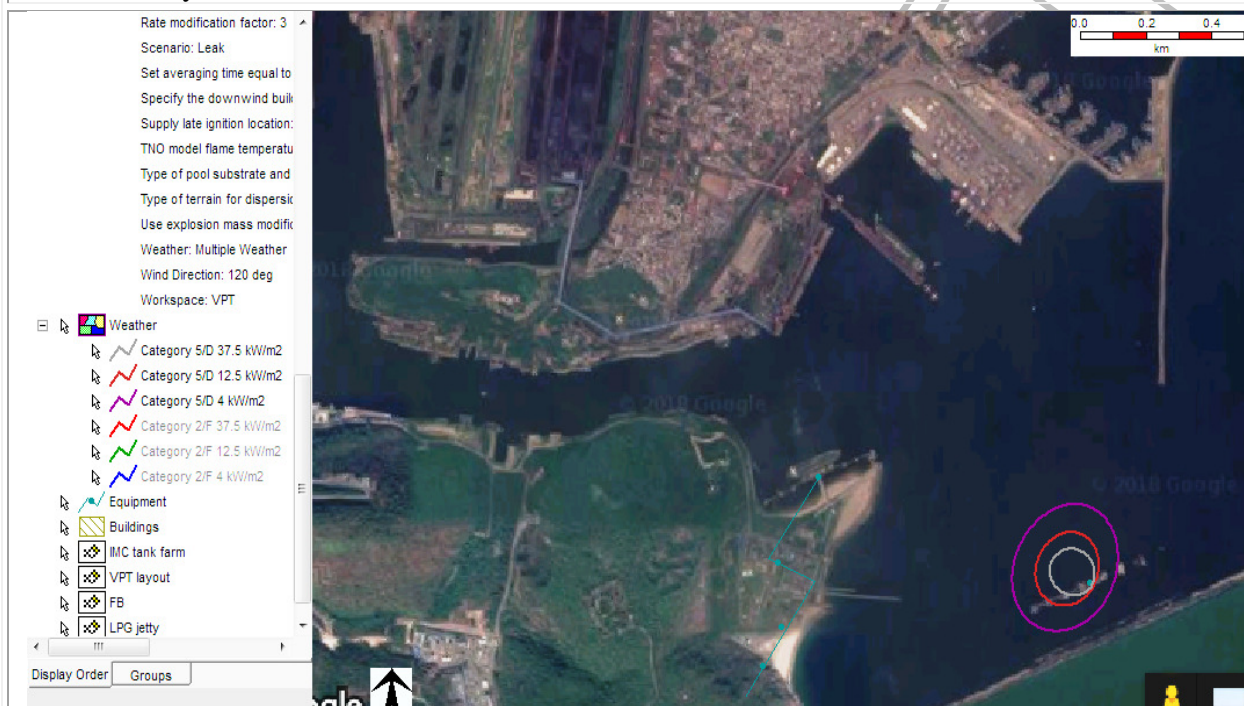


10. Pool fire from Full Bore Rupture of Crude Oil hose with wind speed 2 m/s and F stability class at OSTT Jetty.



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11. Jet fire from Full Bore Rupture of Crude Oil hose with wind speed 5 m/s and D stability class at OSTT Jetty.

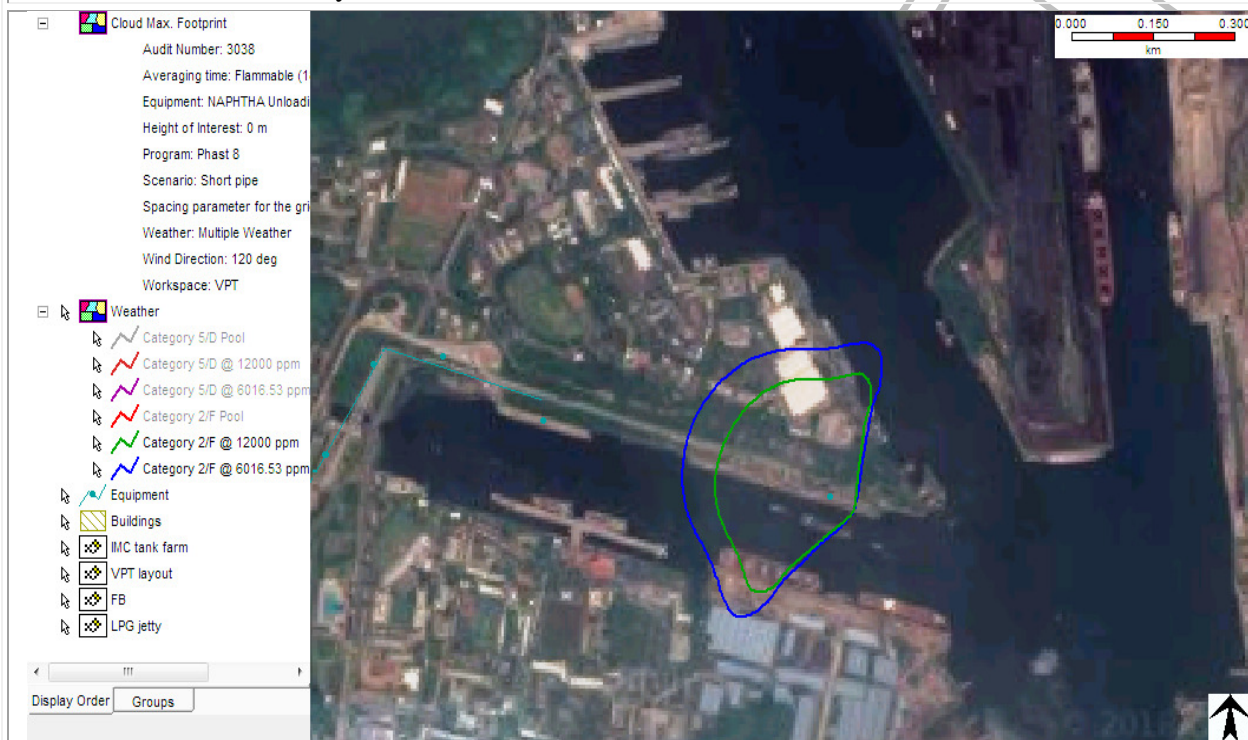


12. Vapor Cloud Explosion (VCE) from Full Bore Rupture of Crude Oil hose with wind speed 2 m/s and F stability class at OSTT Jetty.



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13. Flash fire from Full Bore Rupture of Naphtha hose with wind speed 5 m/s and D stability class at OR-I / OR-II Jetty.

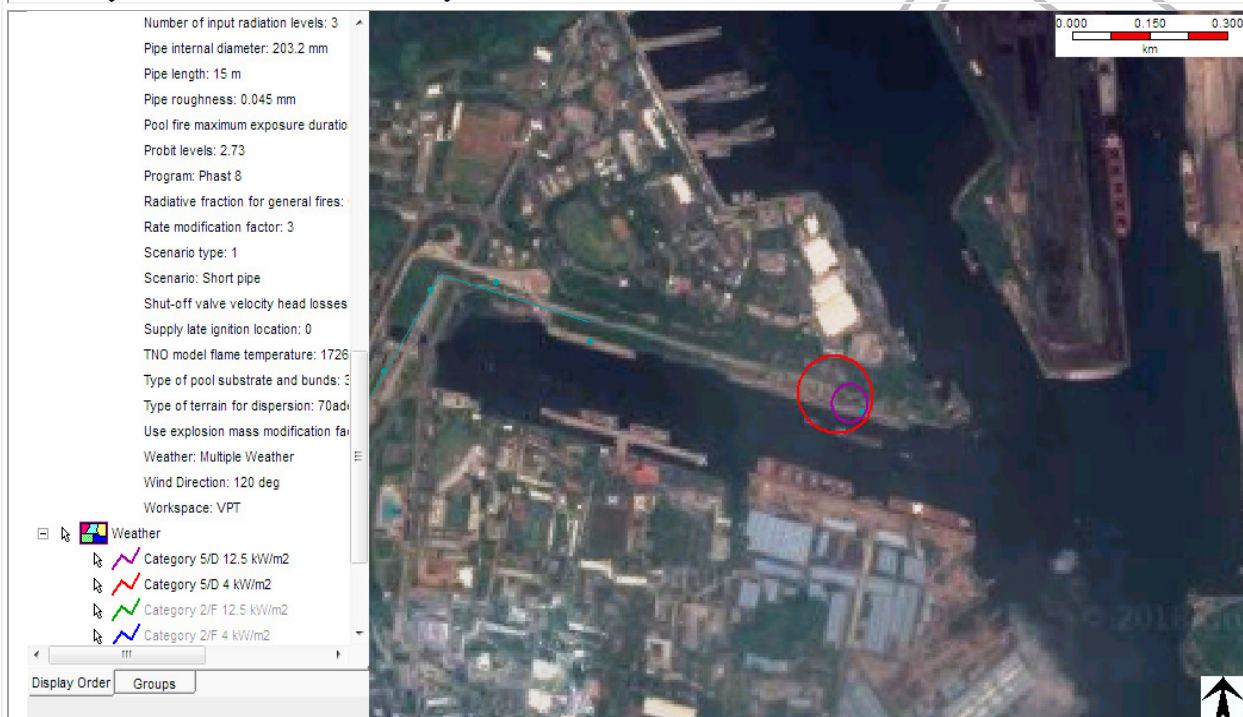


14. Vapor Cloud Explosion (VCE) from Full Bore Rupture of Naphtha hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.

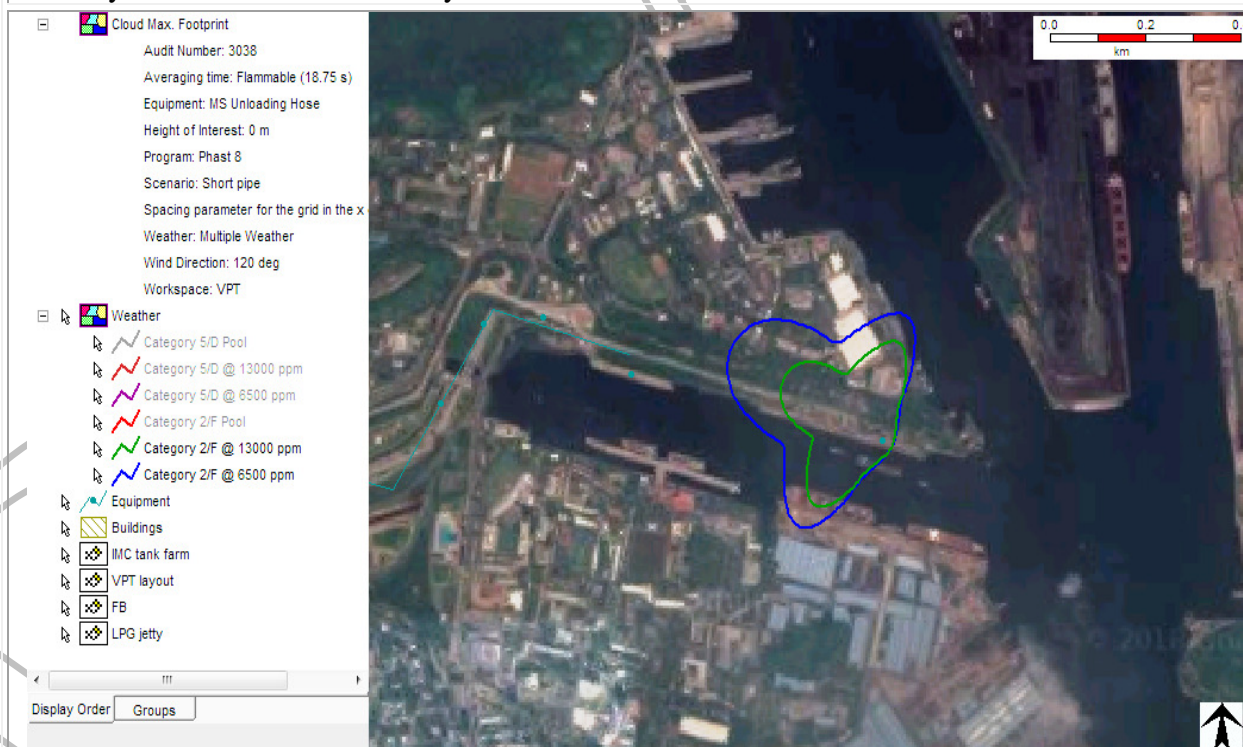


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15. Pool fire from Full Bore Rupture of Motor Spirit (MS) hose with wind speed 5 m/s and D stability class at OR-I / OR-II Jetty.

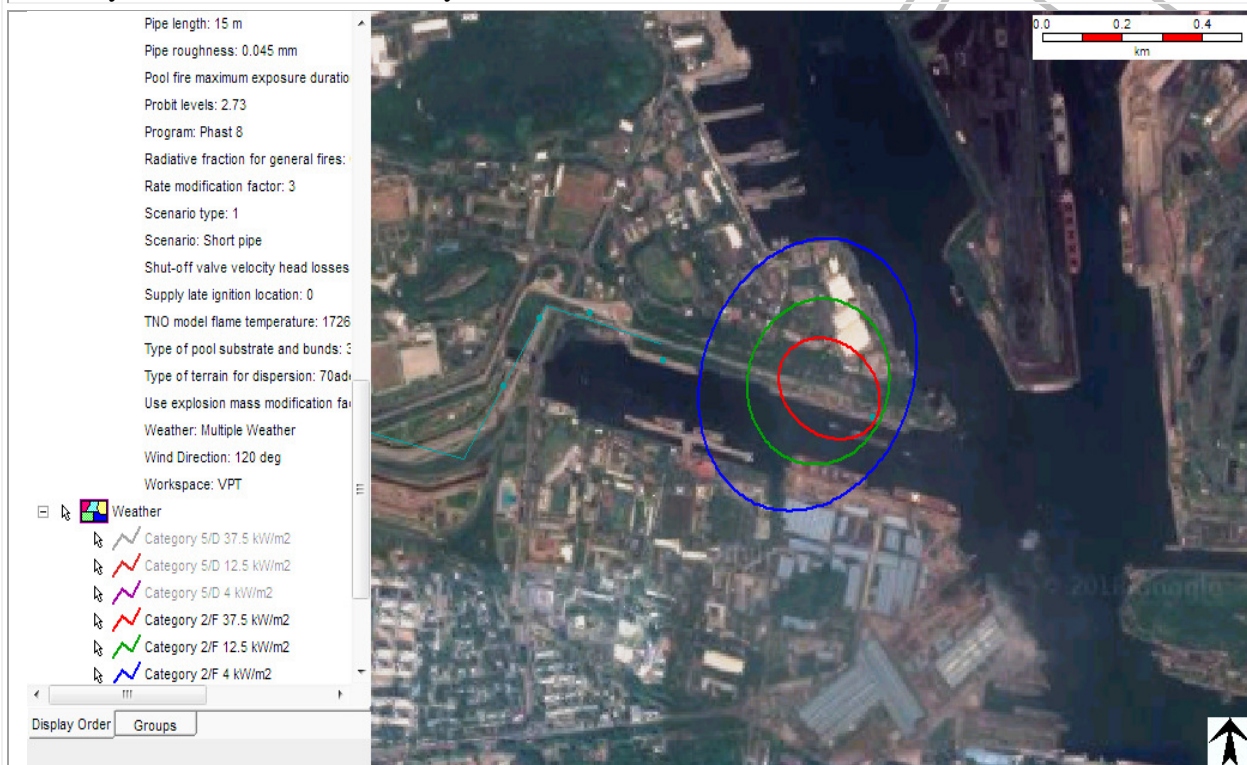


16. Flash fire from Full Bore Rupture of Motor Spirit (MS) hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.

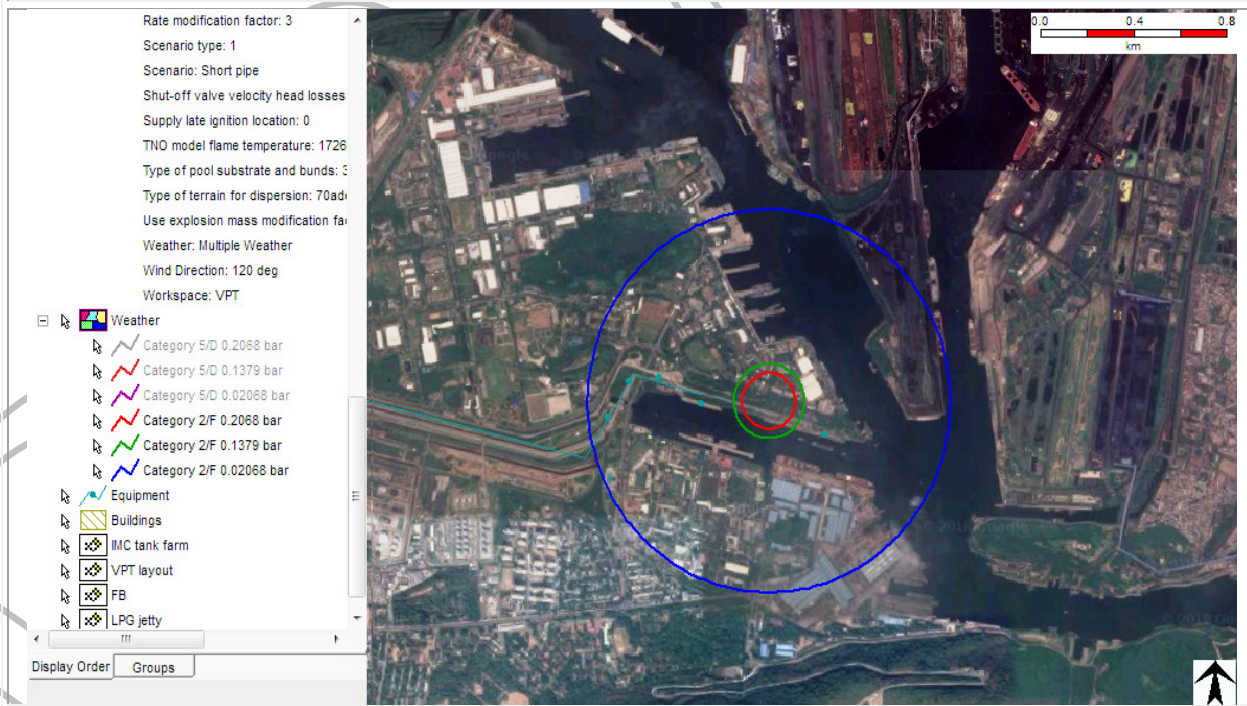


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17. Jet fire from Full Bore Rupture of Motor Spirit (MS) hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.

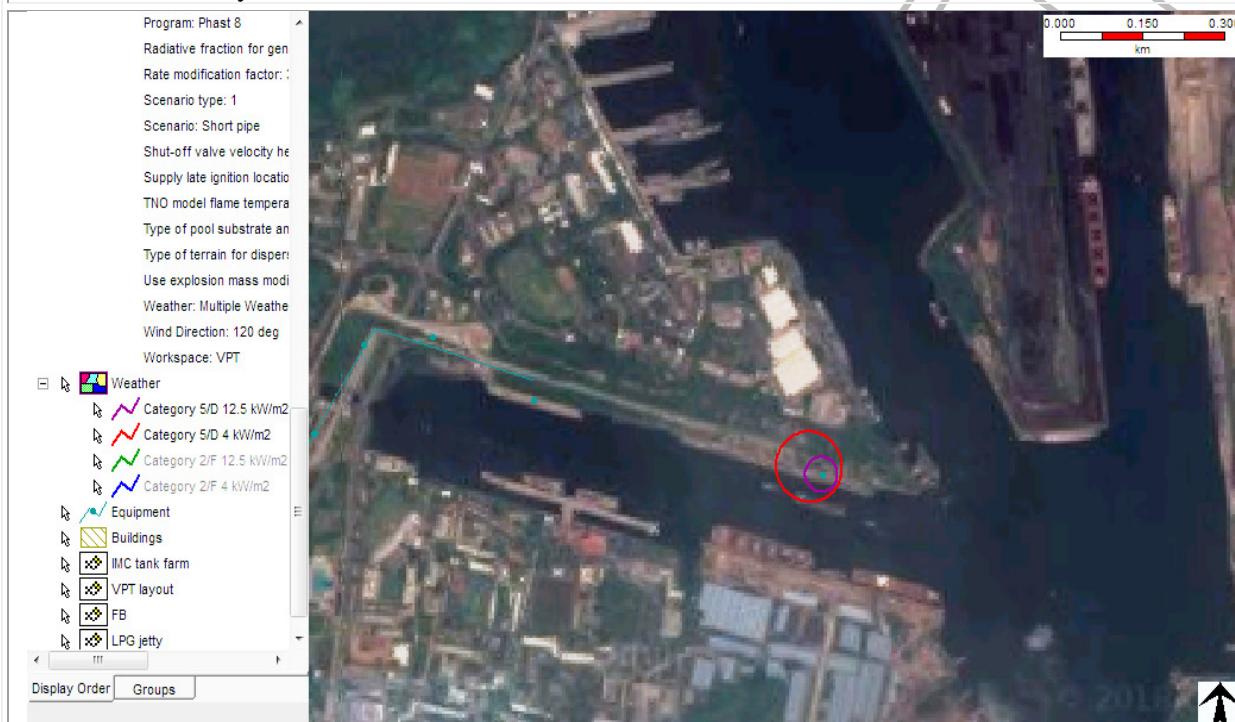


18. Vapor Cloud Explosion (VCE) from Full Bore Rupture of Motor Spirit (MS) hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.

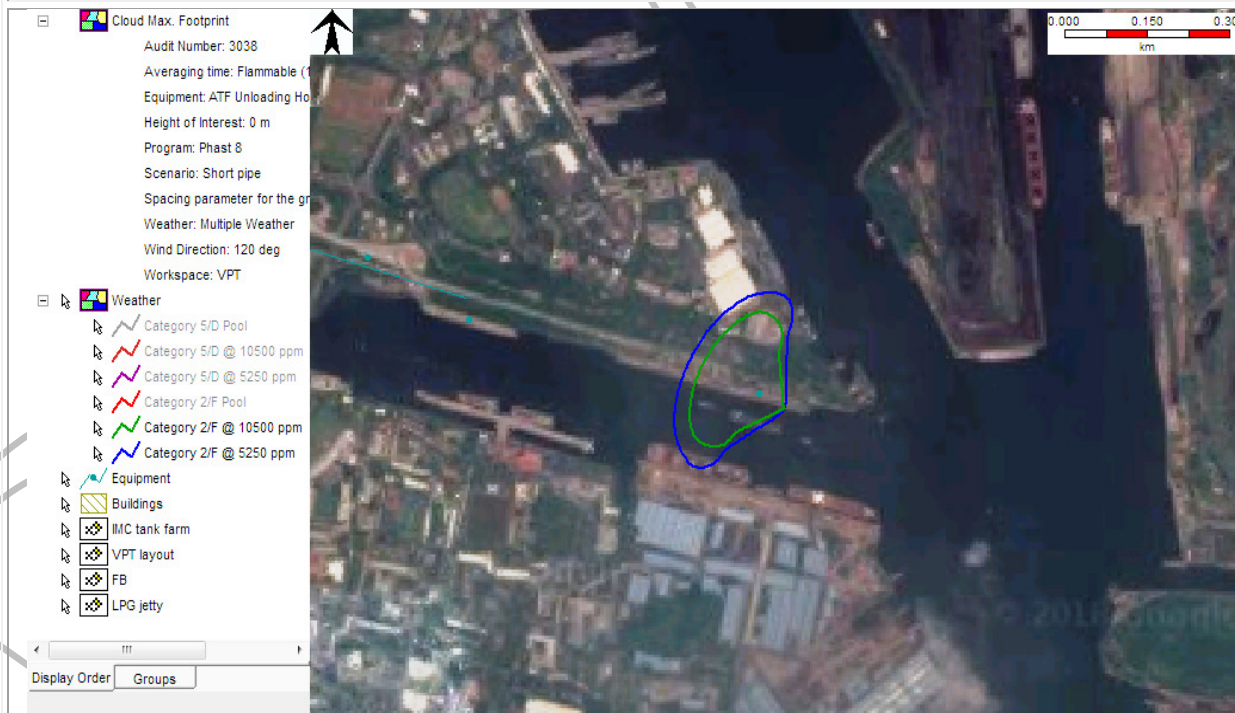


Risk Assessment Report

19. Pool fire from Full Bore Rupture of HSD hose with wind speed 5 m/s and D stability class at OR-I / OR-II Jetty.



20. Flash fire from Full Bore Rupture of ATF hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.

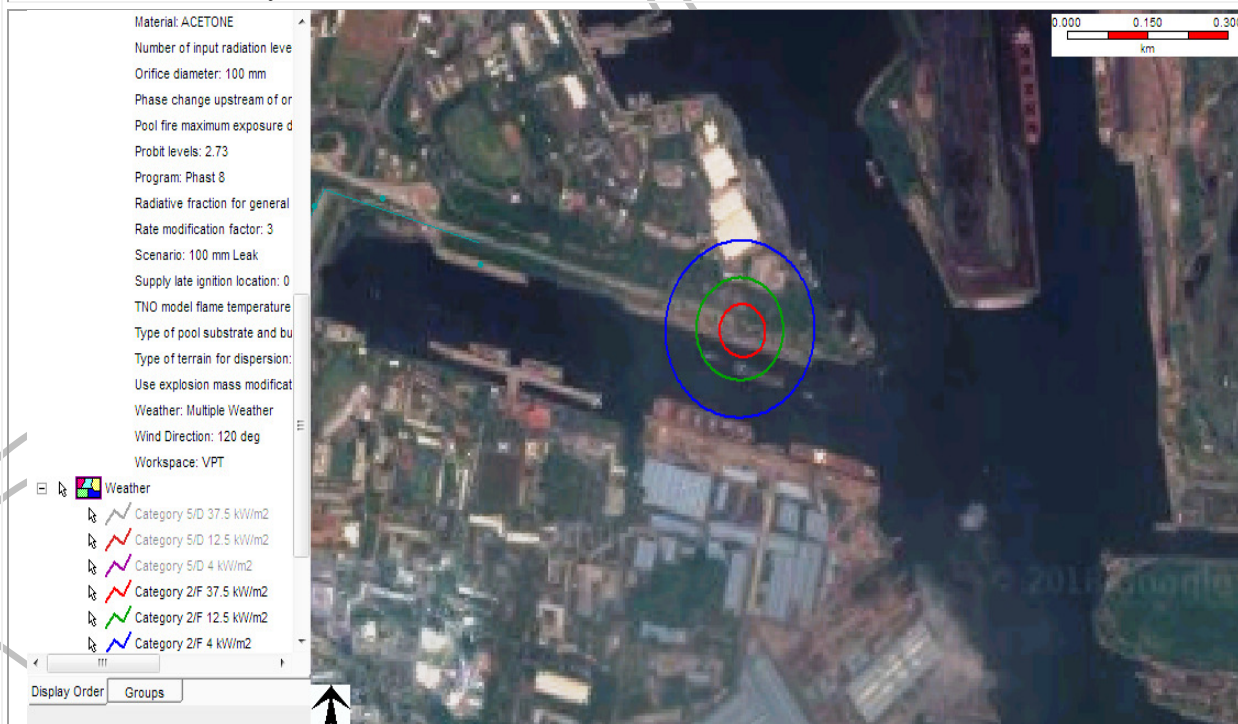


Risk Assessment Report

21. Vapor Cloud Explosion (VCE) from Full Bore Rupture of ATF hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.

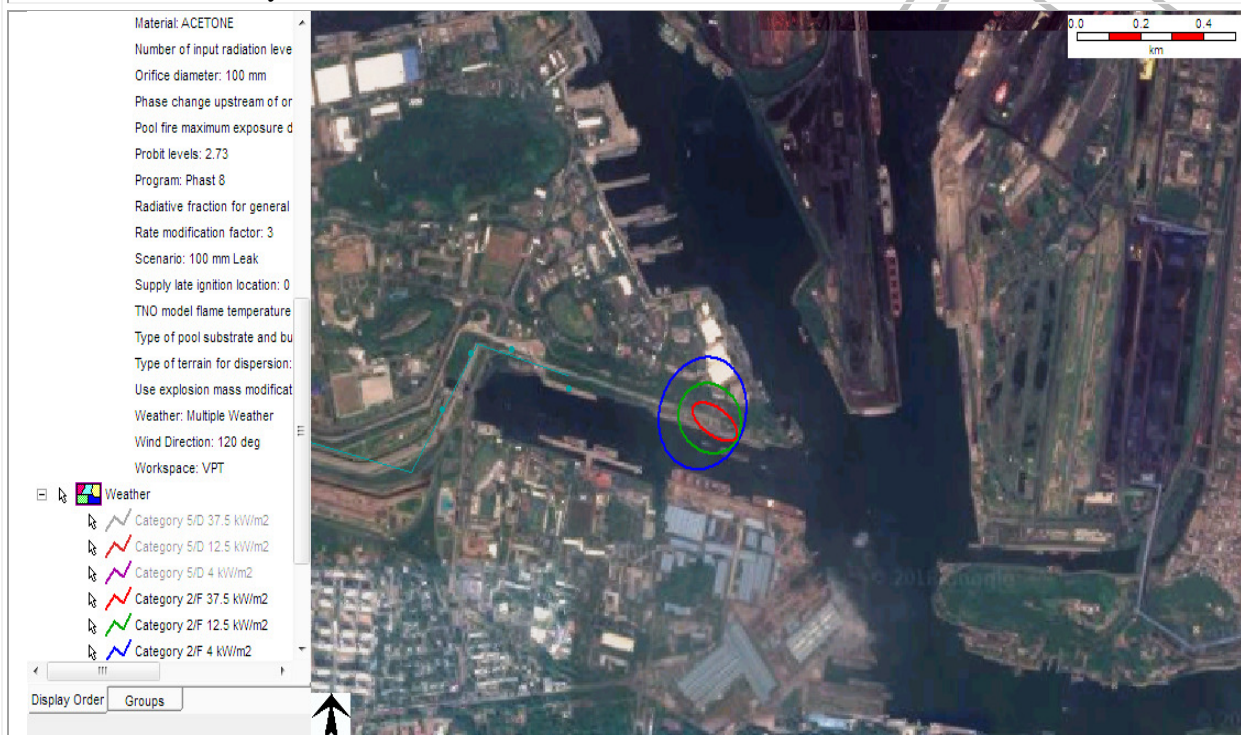


22. Pool fire from Full Bore Rupture of Acetone hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.

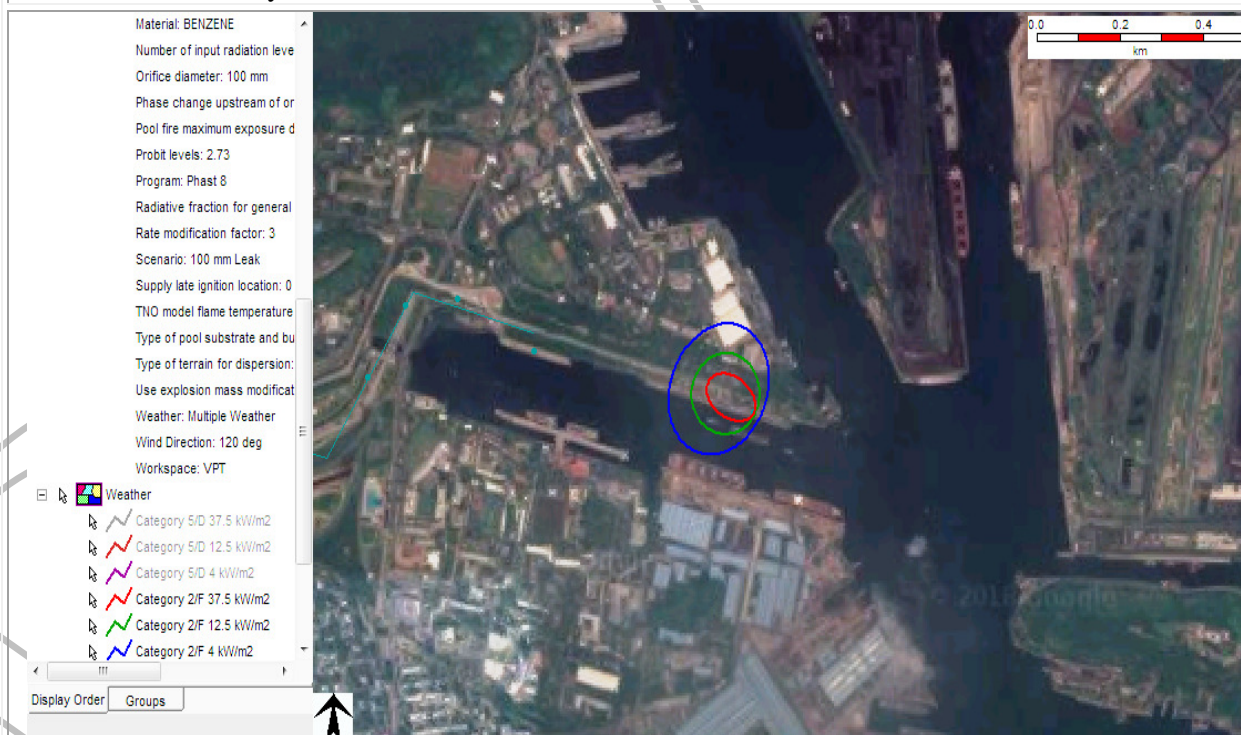


Risk Assessment Report

23. Jet fire from Full Bore Rupture of Acetone hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.

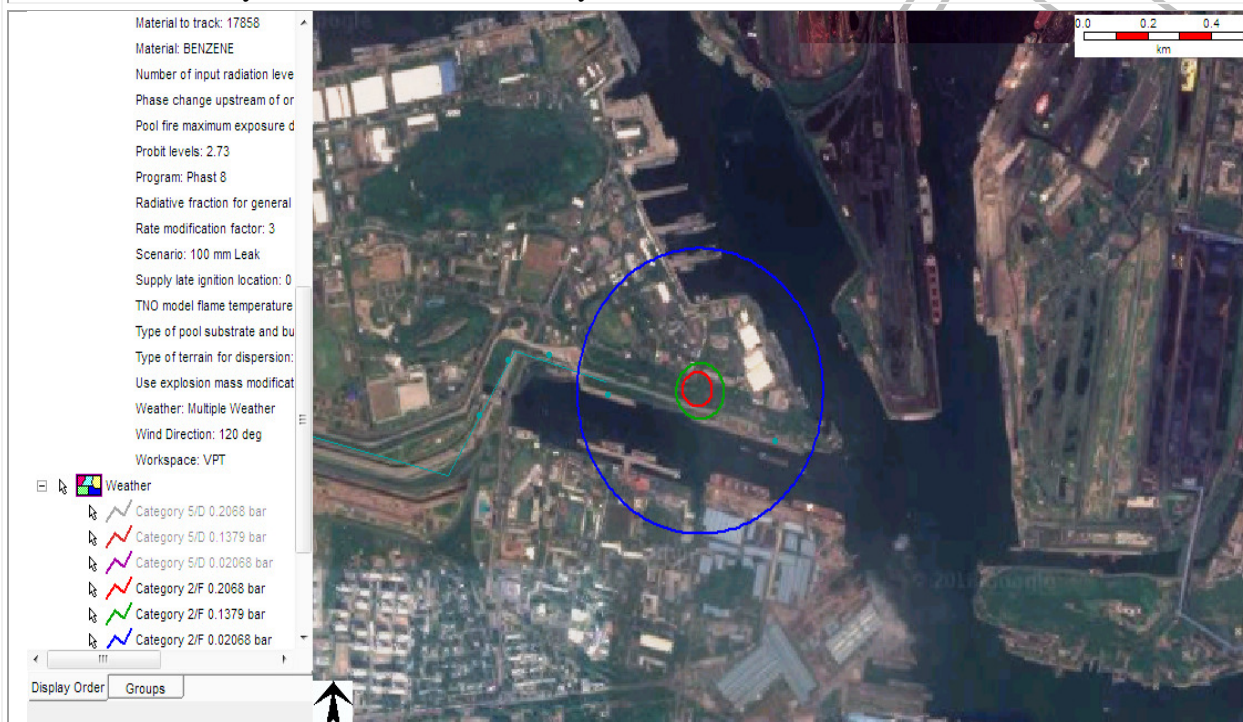


24. Jet fire from Full Bore Rupture of Benzene hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.

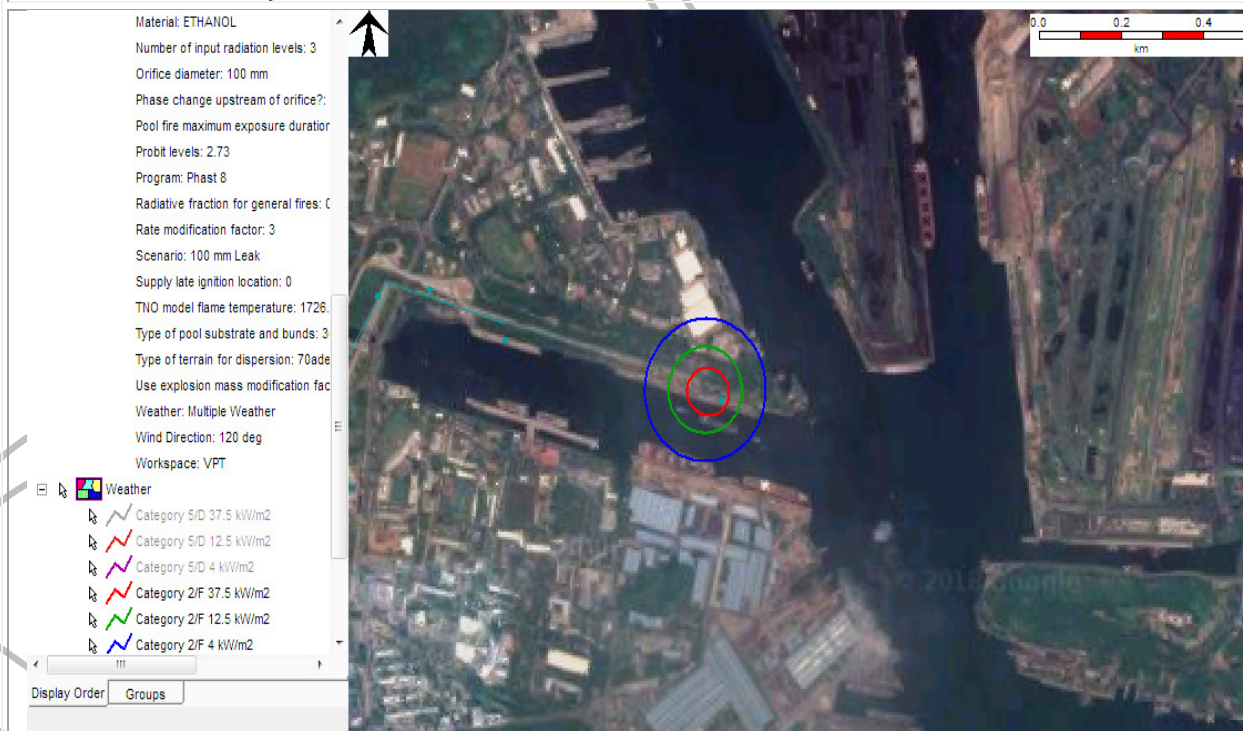


Risk Assessment Report

25. Vapor Cloud Explosion (VCE) from Full Bore Rupture of Benzene hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.

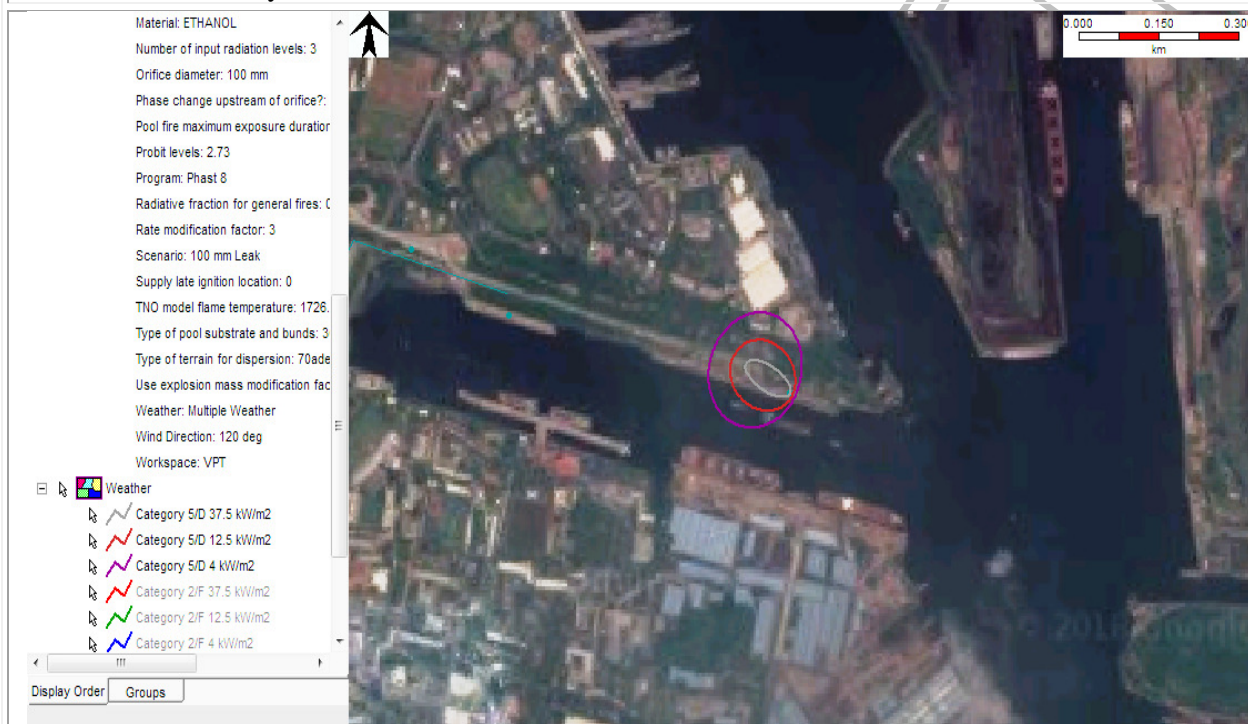


26. Pool fire from Full Bore Rupture of Ethanol hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.



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27. Jet fire from Full Bore Rupture of Ethanol hose with wind speed 5 m/s and D stability class at OR-I / OR-II Jetty.



28. Pool fire from Full Bore Rupture of Isopropyl Alcohol hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.



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29. Jet fire from Full Bore Rupture of Isopropyl Alcohol hose with wind speed 5 m/s and D stability class at OR-I / OR-II Jetty.

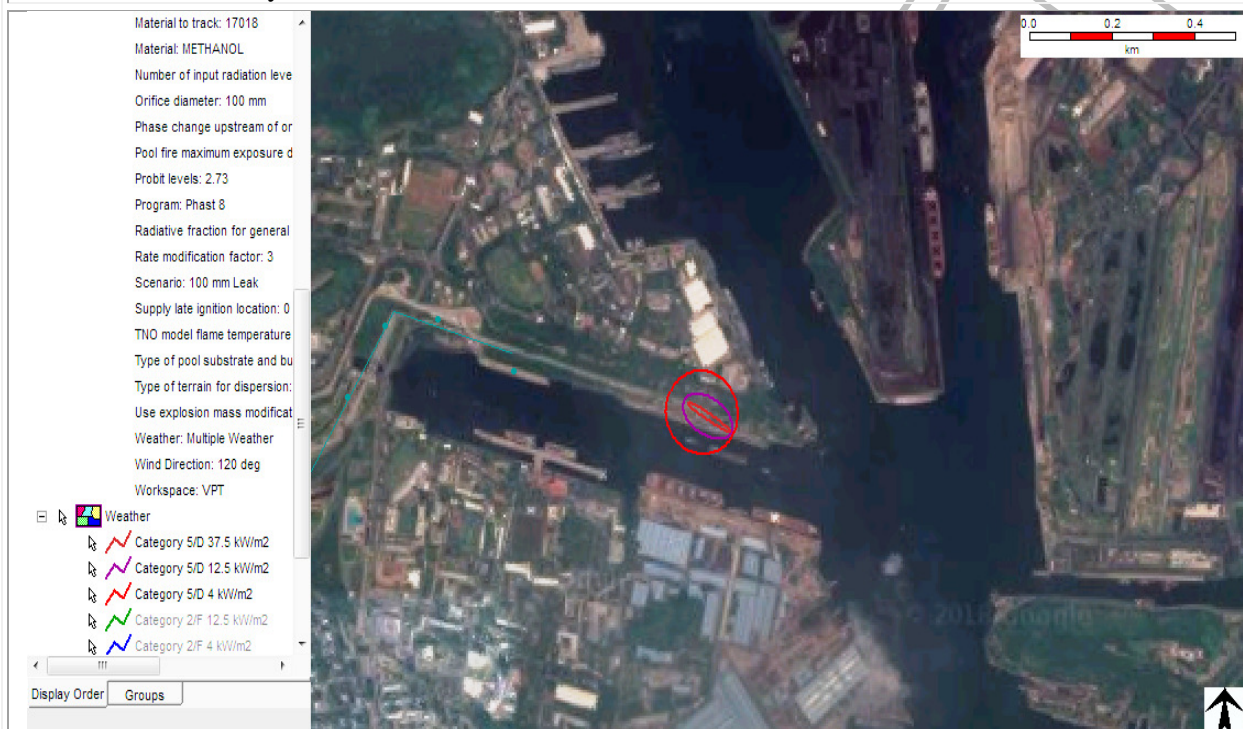


30. Pool fire from Full Bore Rupture of Methanol hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.

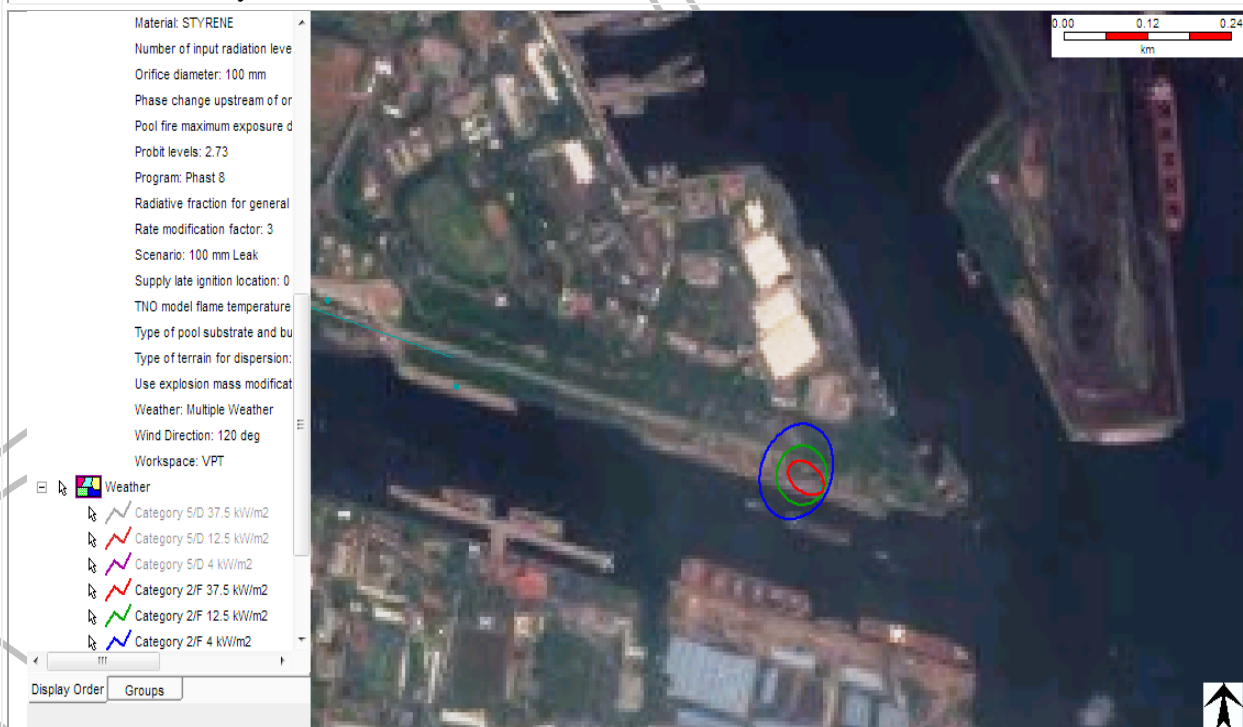


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31. Jet fire from Full Bore Rupture of Methanol hose with wind speed 5 m/s and D stability class at OR-I / OR-II Jetty.



32. Jet fire from Full Bore Rupture of Styrene hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.

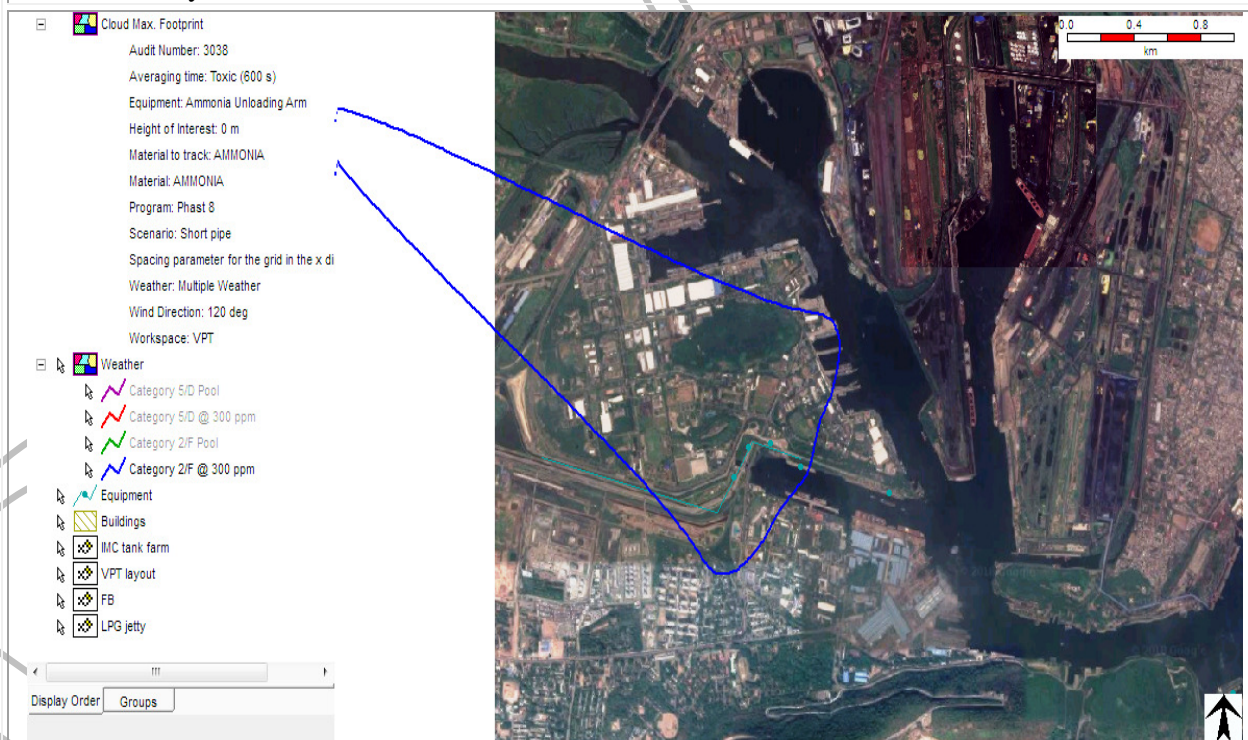


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33. Jet fire from Full Bore Rupture of Toluene hose with wind speed 2 m/s and F stability class at OR-I / OR-II Jetty.



34. Toxic Dispersion from Full Bore Rupture of Ammonia unloading arm with wind speed 2 m/s and F stability class at Fertilizer Berth.



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35. Flash fire from Full Bore Rupture of Naphtha pipeline with wind speed 2 m/s and F stability class.

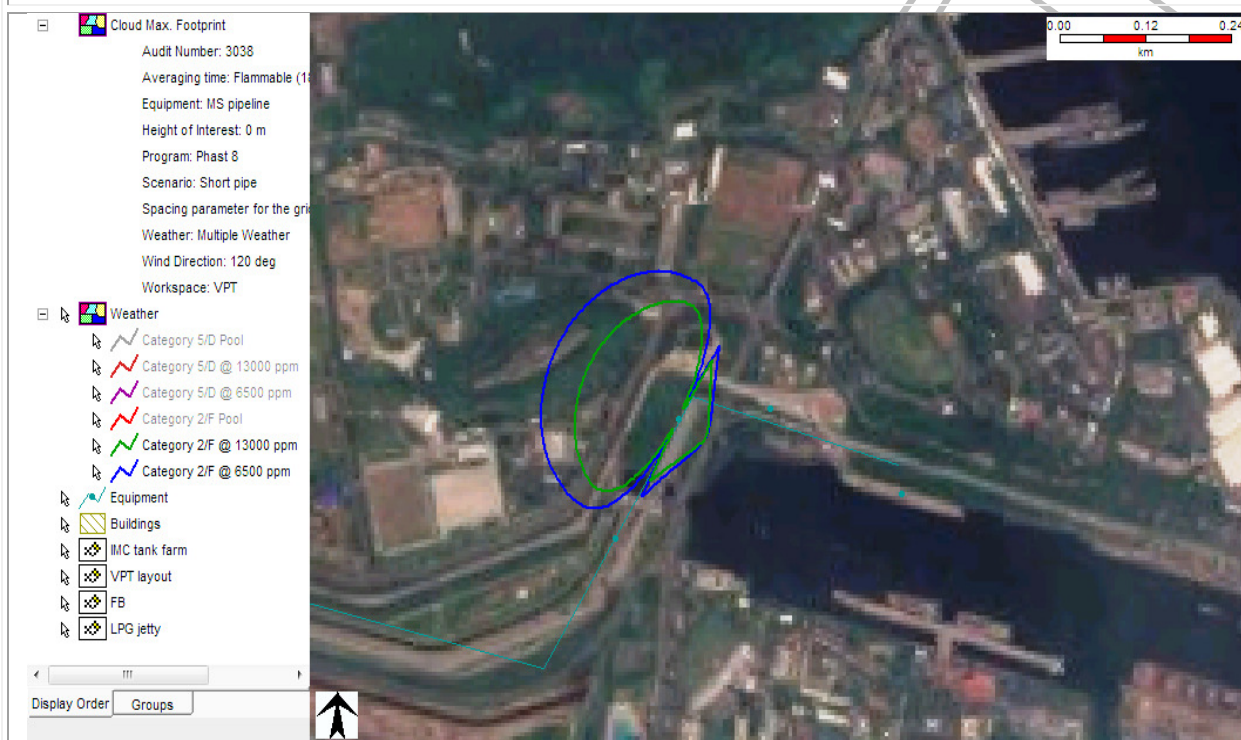


36. Vapor Cloud Explosion (VCE) from Full Bore Rupture of Naphtha pipeline with wind speed 5 m/s and D stability class.



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37. Flash fire from Full Bore Rupture of MS pipeline with wind speed 2 m/s and F stability class.

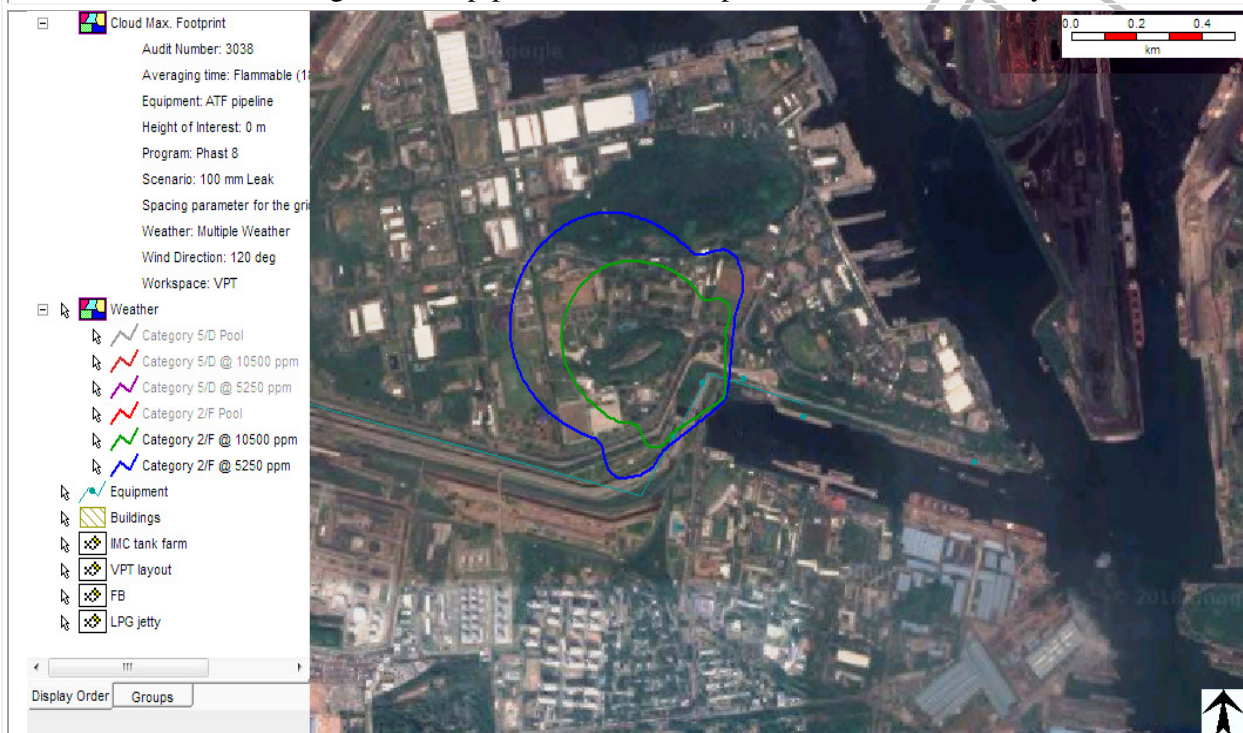


38. Vapor Cloud Explosion (VCE) from Full Bore Rupture of MS pipeline with wind speed 2 m/s and F stability class.

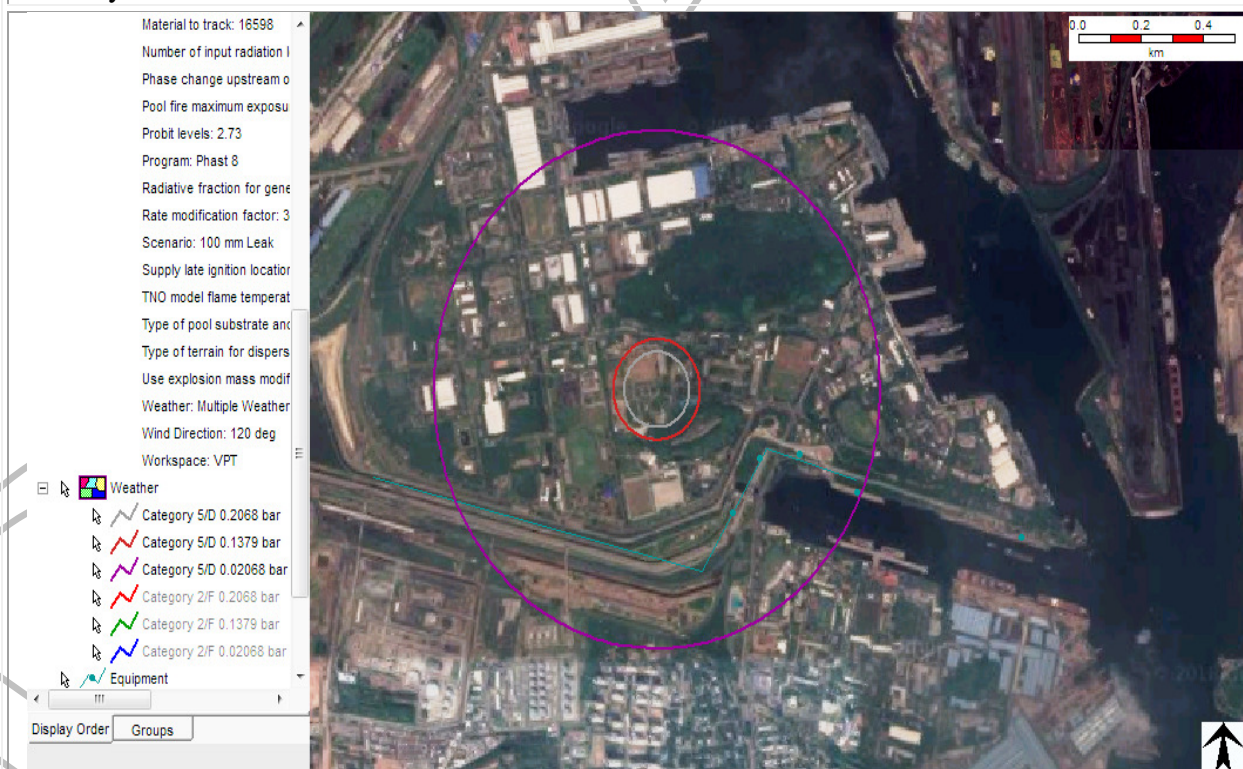


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39. Flash fire from leakage of ATF pipeline with wind speed 2 m/s and F stability class.

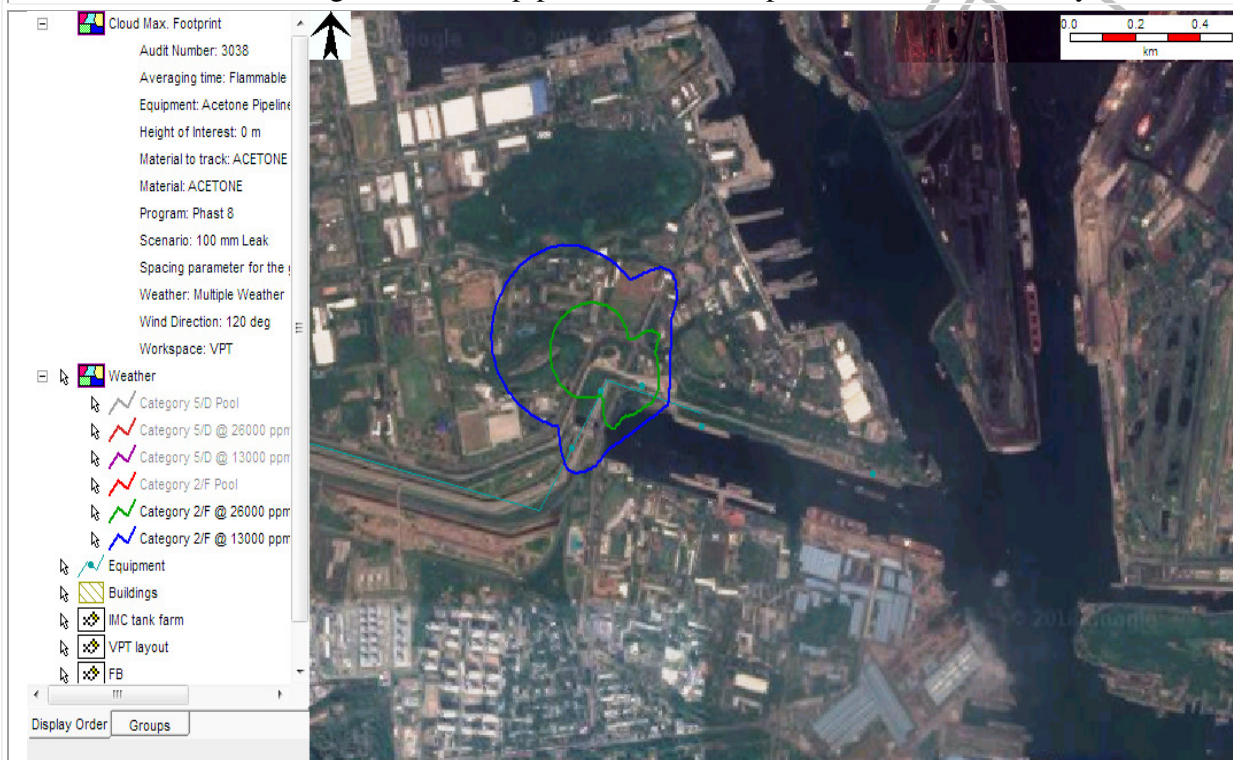


40. Vapor Cloud Explosion (VCE) from leakage of ATF pipeline with wind speed 5 m/s and D stability class.



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41. Flash fire from leakage of Acetone pipeline with wind speed 2 m/s and F stability class.

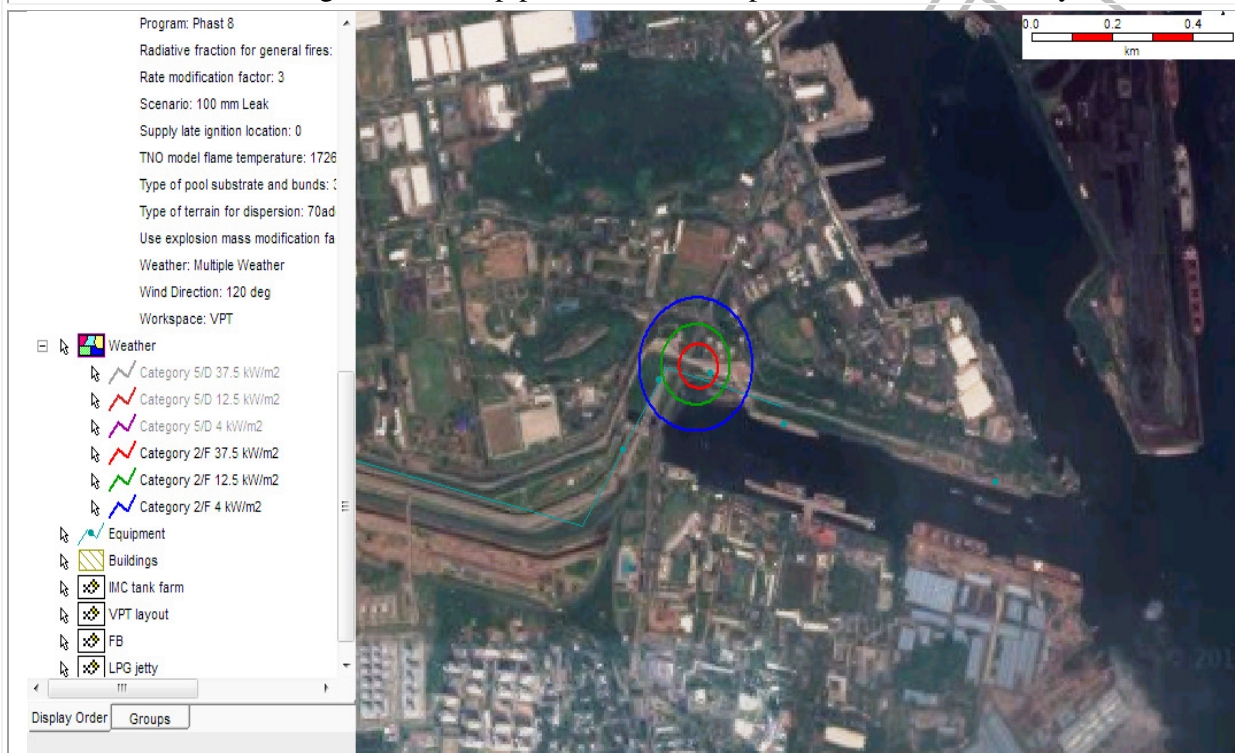


42. Vapor Cloud Explosion (VCE) from leakage of Acetone pipeline with wind speed 2 m/s and F stability class.

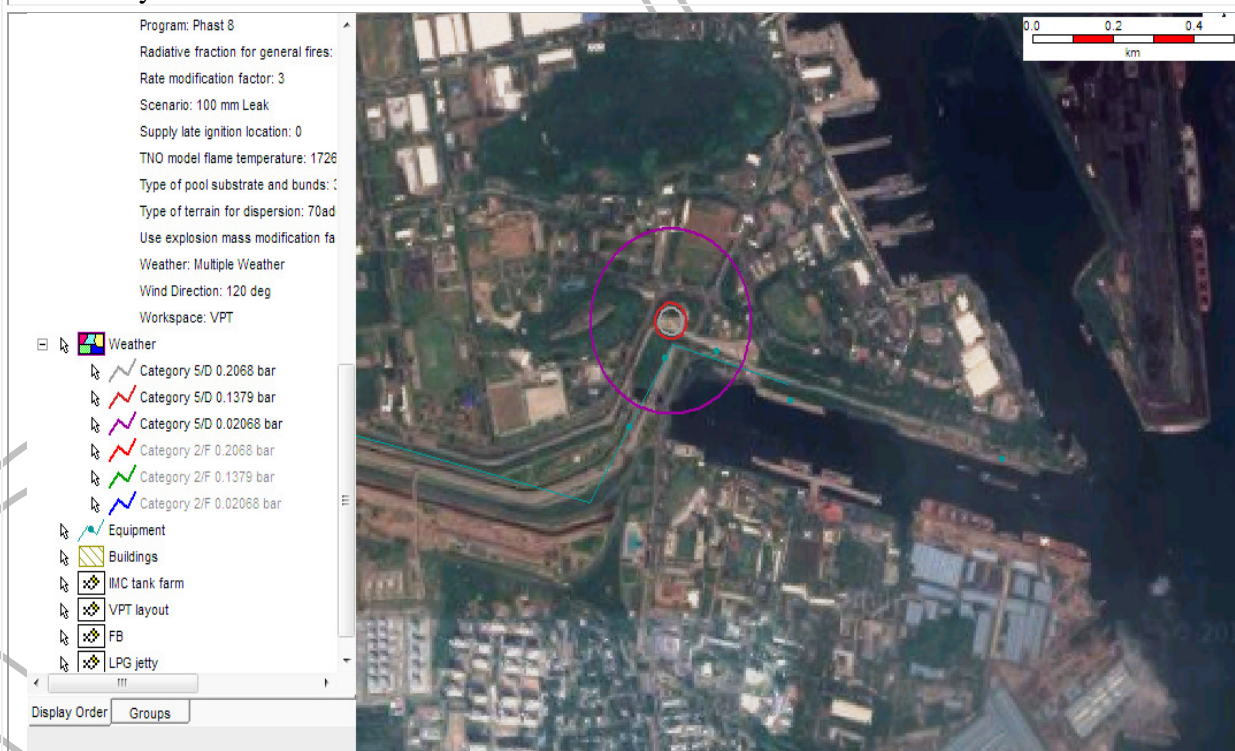


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43. Pool fire from leakage of Ethanol pipeline with wind speed **2 m/s** and **F** stability class.

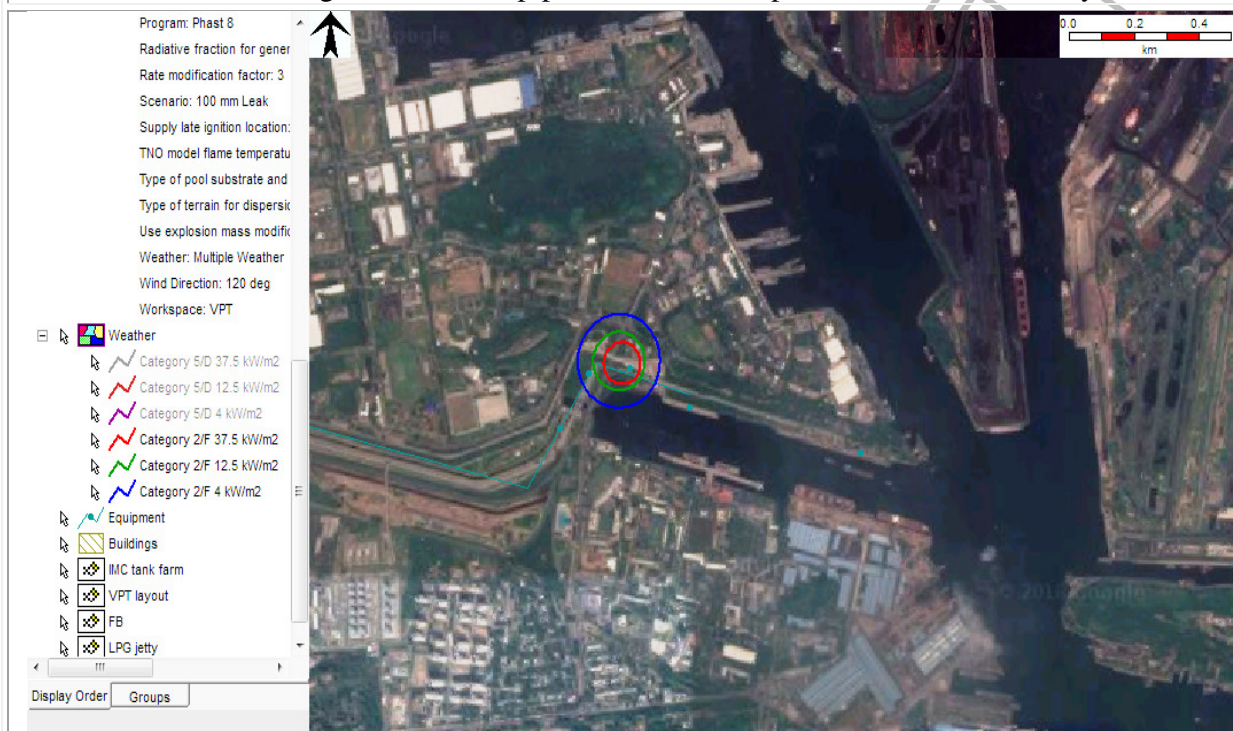


44. Vapor Cloud Explosion (VCE) from leakage of Ethanol pipeline with wind speed **5 m/s** and **D** stability class.

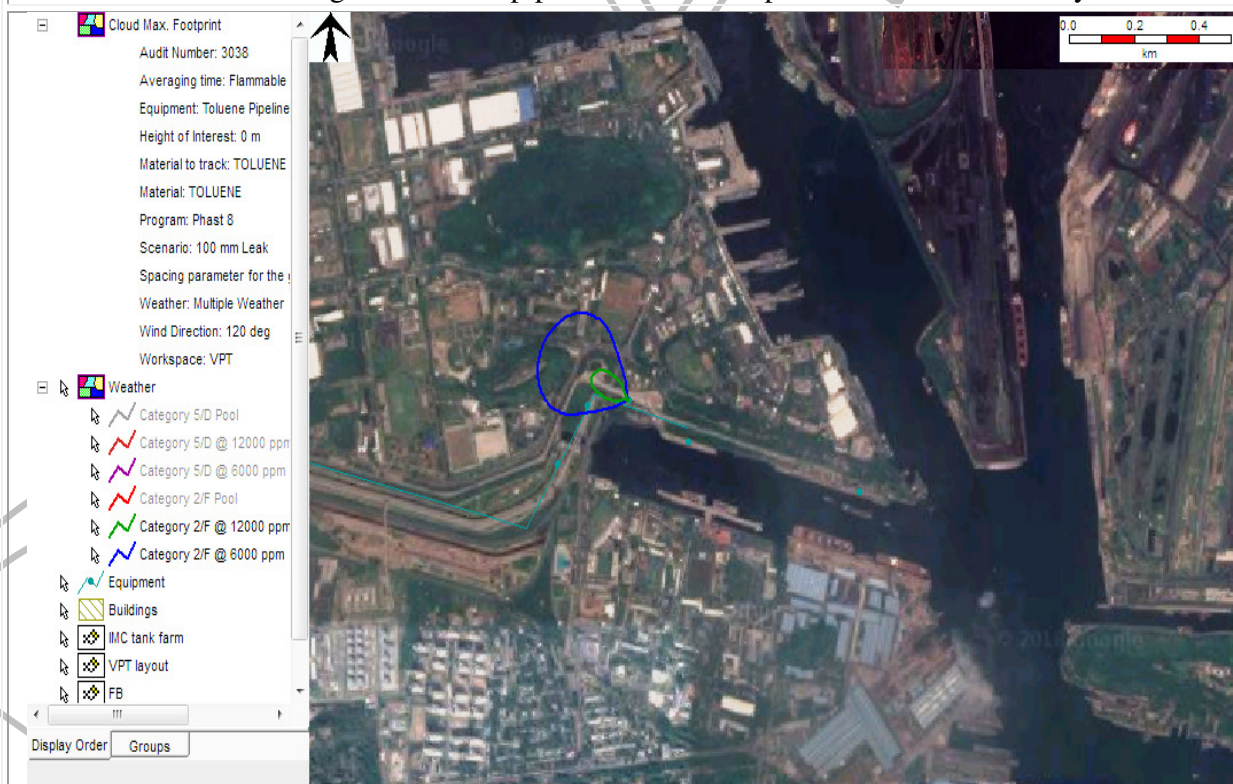


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45. Pool fire from leakage of Methanol pipeline with wind speed 2 m/s and F stability class.



46. Flash fire from leakage of Toluene pipeline with wind speed 2 m/s and F stability class.

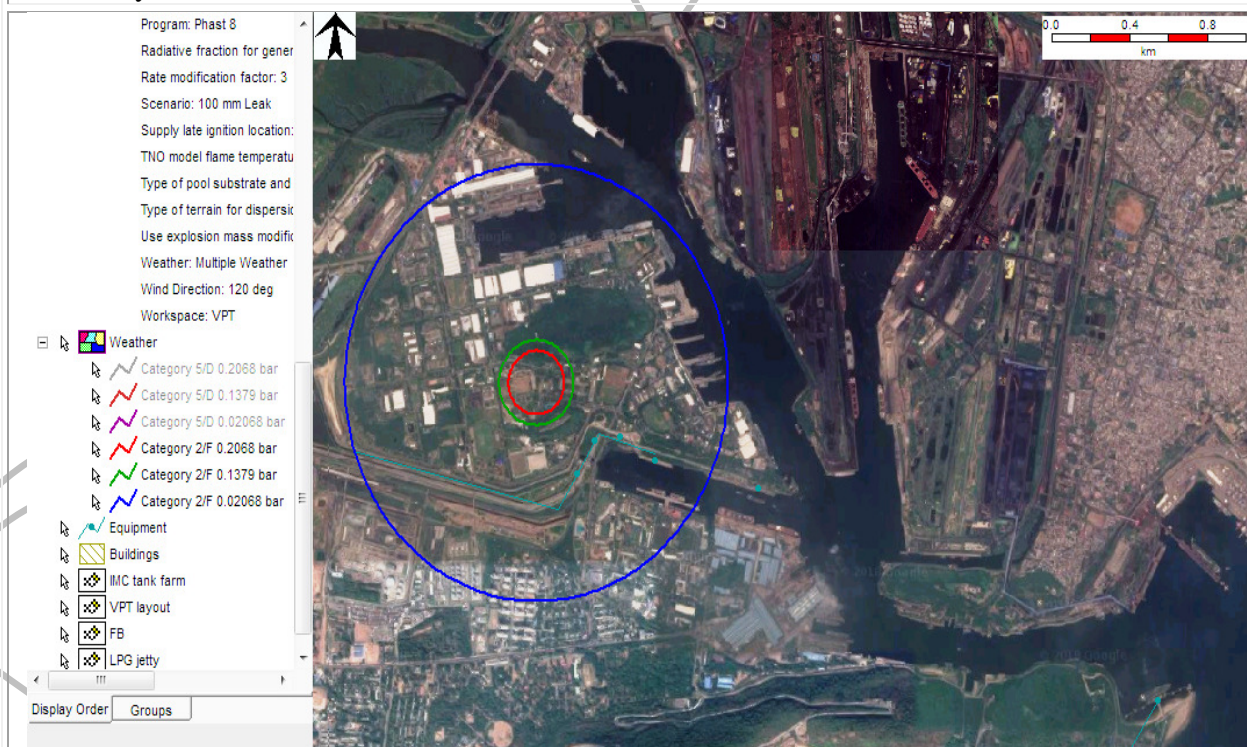


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47. Flash fire from leakage of Benzene pipeline with wind speed **2 m/s** and **F** stability class.



48. Vapor Cloud Explosion (VCE) from leakage of Benzene pipeline with wind speed **2 m/s** and **F** stability class.



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APPENDIX F: CHEMICAL SAFETY SHEETS

Sr. No.	C.A.S. No.	CHEMICAL NAME	HAZARD CLASSIFICATION		
			FLAMMABLE	TOXIC	CORROSIVE
F.1	-	LIQUIFIED PETROLEUM GAS	- Y	- Y	- N
SAFETY RELATED PROPERTIES					
FLASH POINT °c	U.E.L. (% V/V)	L.E.L. (% V/V)	SPECIFIC GRAVITY		PHYSICAL STATE AT STORAGE CONDITION
Propane=-104.4, Butane=-60	Propane=9.5, Butane=8.4	Propane=2.2, Butane=1.6	Liquid 0.51-0.58	Vapour 1.5	NO LIQUID
N _h = 1	N _f = 4	N _r = 0	IDLH = 19,000 ppm	TLV = 1000 ppm	REACTIVITY WITH WATER NO
HEALTH HAZARD DATA					
	INHALATION	INGESTION	SKIN	EYES	
EFFECTS	Concentration in air greater than 10%, cause dizziness in a few minutes. 1% concentrations give the same symptom in 10 min. High concentrations cause asphyxiation.				
EMERGENCY MEASURES	Remove victim from exposure and apply artificial respiration. Guard against self-injury if confused.				
P.P.E.s	Self contained breathing apparatus for high vapour concentration.				
EMERGENCY / FIRST AID MEASURES					
COMBUSTION PRODUCTS					
FIRE FIGHTING	Allow to burn while cooling adjacent equipment with water spray. Extinguish small fires with dry chemical powder. Water not to be used.				
FIRST AID/ ANTIDOTES	Seek immediate medical help.				
SPILL CONTROL MEASURES	Stop discharge if possible. Keep people away. Shut-off ignition sources and call fire department. Stay upwind and use water spray to 'knock down' vapour. Evacuate area if large discharge. Avoid contact with LIQUID.				

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Sr. No.	C.A.S. No.	CHEMICAL NAME	HAZARD CLASSIFICATION		
F.2	-(Mixture)	MOTOR SPIRIT	FLAMMABLE - Y	TOXIC - N	CORROSIVE - N
SAFETY RELATED PROPERTIES					
FLASH POINT °C	U.E.L. (% V/V)	L.E.L. (% V/V)	SPECIFIC GRAVITY		PHYSICAL STATE AT STORAGE CONDITION
-40	7.6	1.4	Liquid ---	Vapour >1	NO LIQUID
N _h = 1	N _f = 3	N _r = 0	IDLH = N.A.	TLV = N.A.	REACTIVITY WITH WATER NO
HEALTH HAZARD DATA					
	INHALATION	INGESTION	SKIN	EYES	
EFFECTS	Irritation to upper respiratory tract	Harmful	Irritation. Repeated contact may cause dermatitis	Irritation	
EMERGENCY MEASURES	Move victim to fresh air. Give artificial respiration, if breathing has stopped.	Have victim drink water or milk. Do not induce vomiting	Remove contaminated clothing. Wash affected skin with soap and water.	Flush eyes with plenty of water for at least 10 min.	
P.P.E.s	Breathing apparatus if required.		Use PVC or rubber gloves	Goggles	
EMERGENCY / FIRST AID MEASURES					
COMBUSTION PRODUCTS	-				
FIRE FIGHTING	Fire extinguishing by water fog, alcohol resistant foam or dry agent such as with dry chemical powder and CO ₂				
FIRST AID/ ANTIDOTES	Seek immediate medical help. No specific antidote. Treat symptomatically				
SPILL CONTROL MEASURES	Remove all sources of ignition. Increase ventilation. Evacuate all personnel. Wear full protective equipment and clothing to minimise exposure. Place inert, non combustible, absorbent material onto spillage. Use clean non-sparking tools to collect the material and place into a suitable labelled container				

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Sr. No.	C.A.S. No.	CHEMICAL NAME	HAZARD CLASSIFICATION		
			FLAMMABLE - Y	TOXIC - N	CORROSIVE - N
F.3		DIESEL OIL	FLAMMABLE - Y	TOXIC - N	CORROSIVE - N
SAFETY RELATED PROPERTIES					
FLASH POINT °C	U.E.L. (% V/V)	L.E.L. (% V/V)	SPECIFIC GRAVITY		PHYSICAL STATE AT STORAGE CONDITION
>66	5	0.7	Liquid 0.81 - 0.91	Vapour >1	NO LIQUID
$N_h = 0$	$N_f = 2$	$N_r = 0$	IDLH = N.A.	TLV = 5 mg/m ³	REACTIVITY WITH WATER NO
HEALTH HAZARD DATA					
	INHALATION	INGESTION	SKIN	EYES	
EFFECTS	Dizziness, Headache	Nausea, vomiting	Irritation. Repeated contact may cause dermatitis	Irritation	
EMERGENCY MEASURES	Move victim to fresh air. Give artificial respiration, if breathing has stopped.	Do not induce vomiting	Remove contaminated clothing. Wash affected skin with water.	Flush eyes with plenty of water for atleast 10 min.	
P.P.E.s	Breathing apparatus if required.		Use PVC or rubber gloves	Goggles	
EMERGENCY / FIRST AID MEASURES					
COMBUSTION PRODUCTS	-				
FIRE FIGHTING	Fire extinguishing by water fog, alcohol resistant foam or dry agent such as with dry chemical powder and CO ₂				
FIRST AID/ ANTIDOTES	Seek immediate medical help. No specific antidote. Treat symptomatically				
SPILL CONTROL MEASURES	Stop leak, if safe to do so. Contain spillage. Absorb in sand or earth for disposal. Eliminate all sources of ignition. Use personal protective equipment. Cordon off the area. Stay upwind.				

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Sr. No.	C.A.S. No.	CHEMICAL NAME	HAZARD CLASSIFICATION		
F.4	108-88-3	TOLUENE	FLAMMABLE – Y	TOXIC – Y	CORROSIVE – N
SAFETY RELATED PROPERTIES					
FLASH POINT °C	U.E.L. (% V/V)	L.E.L. (% V/V)	SPECIFIC GRAVITY		PHYSICAL STATE AT STORAGE CONDITION
4.4	7.1	1.1	Liquid 0.8636	Vapour 3.1	NO LIQUID
$N_h = 2$	$N_f = 3$	$N_r = 0$	IDLH = --- mg/m ³	TLV = --- mg/m ³	REACTIVITY WITH WATER YES
HEALTH HAZARD DATA					
	INHALATION		INGESTION	SKIN	EYES
EFFECTS	Prolonged or repeated exposure via inhalation may cause central nervous system and cardiovascular symptoms similar to that of acute inhalation			Irritation, tissue damage, may produce burns	Irritation, redness, watering and etching.
EMERGENCY MEASURES	Remove the affected into fresh air. Give artificial respiration to affected patient. Move patient to hospital immediately.		Do not induce vomiting. Never give water to an unconscious person.	Flush with water for at least 15 mins. Seek medical aid. Don't remove clothing if it sticks to the skin	Flush with water for at least 15 mins. Seek medical aid. Hole the eyelids apart.
P.P.E.s				Rubber hand gloves protective over closing and shoes	Face Shield.
EMERGENCY / FIRST AID MEASURES					
COMBUSTION PRODUCTS	-				
FIRE FIGHTING	Alcohol resistant Foam, Dry chemical, Carbon dioxide				
FIRST AID/ ANTIDOTES					
SPILL CONTROL MEASURES	Absorb in absorbent material for minor spill. Dam up the liquid spill. Absorb liquid into dry sand, earth or similar material.				

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Sr. No.	C.A.S. No.	CHEMICAL NAME	HAZARD CLASSIFICATION		
			FLAMMABLE - Y	TOXIC - Y	CORROSIVE - N
F.6	110-54-3	HEXANE	FLAMMABLE - Y	TOXIC - Y	CORROSIVE - N
SAFETY RELATED PROPERTIES					
FLASH POINT °C	U.E.L. (% V/V)	L.E.L. (% V/V)	SPECIFIC GRAVITY		PHYSICAL STATE AT STORAGE CONDITION
-23	7.5	1.2	Liquid 0.659	Vapour 2.97	NO LIQUID
N _h = 2	N _f = 3	N _r = 0	IDLH = 1100 mg/m ³		REACTIVITY NO
HEALTH HAZARD DATA					
	INHALATION		INGESTION	SKIN	EYES
EFFECTS	Inhalation causes irritation of respiratory tract, cough, mild depression, cardiac arrhythmias.		Nausea, vomiting, swelling of abdomen.	Irritation, may cause an allergic skin reaction	Irritation, respiratory tract.
EMERGENCY MEASURES	Remove the affected into fresh air. Give artificial respiration to affected patient. Move patient to hospital immediately.		Do not induce vomiting. Never give water to an unconscious person.	Flush with water for at least 15 mins. Seek medical aid.	Flush with water for at least 15 mins. Seek medical aid. Hole the eyelids apart.
P.P.E.s	Self contained breathing apparatus			protective gloves	Safety goggles, face shield
EMERGENCY / FIRST AID MEASURES					
COMBUSTION PRODUCTS	-				
FIRE FIGHTING	Alcohol resistant Foam, Dry chemical, Carbon dioxide				
FIRST AID/ ANTIDOTES					
SPILL CONTROL MEASURES	Absorb in absorbent material for minor spill. Absorb liquid into dry sand, earth or similar material. Store and dispose of according to local regulations.				

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Sr. No.	C.A.S. No.	CHEMICAL NAME	HAZARD CLASSIFICATION		
			FLAMMABLE - Y	TOXIC - Y	CORROSIVE - N
F.7	67-64-1	ACETONE	FLAMMABLE - Y	TOXIC - Y	CORROSIVE - N
SAFETY RELATED PROPERTIES					
FLASH POINT °C	U.E.L. (% V/V)	L.E.L. (% V/V)	SPECIFIC GRAVITY		PHYSICAL STATE AT STORAGE CONDITION
-20	12.8	2.6	Liquid 0.791	Vapour 2	YES LIQUID
N _h = 1	N _f = 3	N _r = 0	IDLH = --- mg/m ³		TLV = --- mg/m ³ REACTIVITY NO
HEALTH HAZARD DATA					
	INHALATION		INGESTION	SKIN	EYES
EFFECTS	Vapor irritating to eyes and mucous membranes.		Low order toxicity but very irritating to mucous membranes.	De-fatting of skin, possibly leading to dermatitis.	Irritation, respiratory tract.
EMERGENCY MEASURES	Remove the affected into fresh air. Give artificial respiration to affected patient. Move patient to hospital immediately.		Do not induce vomiting. Never give water to an unconscious person.	Flush with water for at least 15 mins. Seek medical aid.	Flush with water for at least 15 mins. Seek medical aid. Check the victim for contact lenses and remove if present.
P.P.E.s	Self contained breathing apparatus			protective gloves	Safety goggles, face shield
EMERGENCY / FIRST AID MEASURES					
COMBUSTION PRODUCTS	-				
FIRE FIGHTING	Alcohol Foam, Dry chemical, Carbon dioxide				
FIRST AID/ ANTIDOTES					
SPILL CONTROL MEASURES	Absorb in absorbent material for minor spill. Absorb liquid into dry sand, earth or similar material. Store and dispose of according to local regulations. Do not wash away into sewer.				

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Sr. No.	C.A.S. No.	CHEMICAL NAME	HAZARD CLASSIFICATION		
			FLAMMABLE - Y	TOXIC - Y	CORROSIVE - N
F.8	67-56-1	METHANOL	FLAMMABLE - Y	TOXIC - Y	CORROSIVE - N
SAFETY RELATED PROPERTIES					
FLASH POINT °C	U.E.L. (% V/V)	L.E.L. (% V/V)	SPECIFIC GRAVITY		PHYSICAL STATE AT STORAGE CONDITION
11	36.5	6	Liquid 0.792	Vapour 1.11	LIQUID
N _h = 1	N _f = 3	N _r = 0	IDLH = 6000 mg/m ³		REACTIVITY NO
HEALTH HAZARD DATA					
	INHALATION		INGESTION	SKIN	EYES
EFFECTS	Acute exposure to humans by inhalation or ingestion may result in blurred vision, headache, dizziness and nausea.			Irritation, may produce burns	Irritation, swallowing may cause death or eye damage.
EMERGENCY MEASURES	Remove the affected into fresh air. Give artificial respiration to affected patient. Move patient to hospital immediately.		Do not induce vomiting. Never give water to an unconscious person. Seek medical aid.	Flush with water for at least 15 mins. Seek medical aid. Don't remove clothing if it sticks to the skin	Flush with water for at least 15 mins. Seek medical aid. Hole the eyelids apart.
P.P.E.s	Self contained Breathing apparatus, protective clothing.			Rubber hand gloves protective over closing and shoes	Face Shield.
EMERGENCY / FIRST AID MEASURES					
COMBUSTION PRODUCTS	-				
FIRE FIGHTING	Alcohol resistant Foam, Dry chemical, Carbon dioxide				
FIRST AID/ ANTIDOTES					
SPILL CONTROL MEASURES	Absorb in absorbent material for minor spill. Dam up the liquid spill. Use vapor protective clothing. Absorb liquid into dry sand, earth or similar material.				

APPENDIX G COMMODITY WISE TRAFFIC DETAIL

VISAKHAPATNAM PORT TRUST RESEARCH AND PLANNING DIVISION COMMODITY WISE TRAFFIC HANDLED IN APRIL TO MARCH 2017				
Sr. No.	COMMODITY	APR- MAR 2017	APR-MAR 2016	APR- FEB 2018
	I. EXPORTS			
	A. DRY BULK			
1	Iron ore(Foreign)	31,06,658	11,49,210	2321258
2	Iron ore (Coastal)	22,60,235	13,65,163	1412572
	Iron ore (Conv.)	21,20,704	2,51,407	845298
	Iron ore (Mech.)	32,46,189	22,62,966	2888532
	Total Iron ore	53,66,893	25,14,373	3733830
3	Iron pellets(Foreign)	-	3,16,592	0
4	Iron pellets(Coastal)	60,53,370	31,47,910	5632046
	Iron pellets.(Conv.)	8,79,159	2,73,882	188185
	Iron pellets (Mech)	51,74,211	31,90,620	5443861
	Total Iron pellets	60,53,370	34,64,502	5632046
5	Silicon Manganese ore	5,000	6,450	17489
6	Manganese ore	3,300	11,134	48030
7	Ferro Products(F.M.ORE)	-	-	23032

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8	Chrome ore	-	-	0
9	Thermal Coal	34,70,963	33,92,541	2743119
10	Alumina	12,46,169	12,20,274	1092966
	Alumina(mech)	12,46,169	11,74,224	1092966
	Alumina (con)	-	46,050	0
11	Feld Spar	-	-	0
12	Soyabean extract	-	-	0
	Soyabean (Mech.)	-	-	0
	Soyabean (Conv)	-	-	0
13	Wheat	-	-	0
14	Rice	-	-	0
15	Sugar	-	-	0
16	Ilmenite sand	2,37,424	3,82,951	212250
17	C.Pet. Coke	3,96,850	2,43,500	329650
18	River sand/Silica sand/Rock sand	-	-	0
19	Gran slag / BF slag	-	-	11000
20	Maize	-	-	0
21	Rice Bran	-	-	0
22	Cement Clinker	-	-	0
23	Fly ash	-	-	0

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24	Kumba coal	-	-	0
25	Soft coal/Anthracite Coal	-	-	0
26	Coking coal/Hard coking coal	6,901	-	0
27	Steam coal	-	1,29,260	0
28	Iron scrap	-	-	0
29	ZINC	-	-	0
30	Stone / Rock boulders	1,900	27,793	22220
31	Others	1,500	-	0
	TOTAL DRYBULK (A)	1,67,90,270	1,13,92,778	13865632
	B. LIQUID BULK	-	-	0
32	Petroleum Products	13,43,789	16,63,006	873490
33	Molasses	-	-	0
34	Palm Methyl Ester(Bio-diesel)	6,770	38,810	0
35	Bitumen	1,28,210	1,02,505	153317
36	Edible Oils/HEXENE/Paraxylane	14,159	-	0
	TOTAL LIQUID BULK (B)	14,92,928	18,04,321	1026807
	C. BREAK BULK	-	-	0
37	Pig Iron	47,000	43,000	50000
38	Steel Products	4,62,297	4,97,730	595774
39	Rice	15,783	23,205	1003

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40	Wheat	5,014	12,603	0
41	Sugar	-	-	0
42	Cement	1,595	5,108	0
43	Granite Blocks	1,33,742	1,26,427	120295
44	Alumina (Ingots)	1,60,996	30,078	84776
45	Maize	-	-	0
46	Garnet	-	-	0
47	CP Coke	-	-	0
48	Soyabean	-	-	0
49	Granulated slag / B.F.slag	-	-	0
50	Fly ash BAGS	-	-	0
51	Rice Bran bags	-	-	0
52	Others	1,120	1,219	573
i)	Temporary landing	-	-	0
ii)	General cargo	1,120	1,219	573
iii)	Tsunami cargo	-	-	0
iv)	Reliance/Arya off-shore cargo	-	-	0
v)	Others	-	-	0
	TOTAL BREAKBULK (C)	8,27,547	7,39,370	852421
53	D. TOTAL CONTAINER CARGO	36,67,129	27,77,852	3623866

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	(NO.OF TEUS)	1,85,735	1,46,906	177324
	(NO.OF CONTAINERS)	1,57,264	1,22,143	147436
	TOTAL EXPORTS(A+B+C+D)	2,27,77,874	1,67,14,321	19368726
	II. IMPORTS	-	-	0
	A. DRY BULK	-	-	0
1	Urea	5,45,886	6,74,489	644951
	mech	97,392	80,095	136944
	conv	4,48,494	5,94,394	508007
		-	-	0
2	NP 20: 20(Urea Ammonium Phosphate)	-	-	33402
	mech	-	-	0
	conv	-	-	33402
		-	-	0
3	Di-Ammonium Phos.	3,79,559	5,57,167	426065
		-	-	0
4	Ammonium Sulphate	88,322	-	58515
		-	-	0
5	Mono-Ammonium Phosphate	-	-	0
		-	-	0
6	Muriate of Potash	4,67,577	4,62,720	343933

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	mech	15,000	-	0
	conv	4,52,577	4,62,720	343933
7	Ammonium Nitrate	-	-	0
		-	-	0
8	Sulphate of Potash	10,000	15,000	0
		-	-	0
9	Super Phosphate	-	-	0
		-	-	0
10	Nitrogen phosphate	-	-	0
		-	-	0
11	NPS (GRADE)	59,959	-	152994
	(Ammonium Phosphate sulphur)	-	-	0
		-	-	0
12	NPK (Nitrogen Phosphorus Potassium)	21,962	98,821	82368
		-	-	0
13	GTSP(GRANULAR TRIPPLE SUPER PHOSPHATE)	-	-	0
		-	-	0
	Finished Fertilizers Total:	15,73,265	18,08,197	1742228
	mech	1,12,392	80,095	136944
	conv	14,60,873	17,28,102	1605284

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14	Sulphur	1,51,253	1,65,157	114514
	mech	54,061	44,733	22968
	conv	97,192	1,20,424	91546
15	Rock Phosphate	6,24,418	6,33,661	759129
	mech	3,37,040	2,98,611	444185
	conv	2,87,378	3,35,050	314944
	Fertilizers Dry Total:	7,75,671	7,98,818	873643
	mech	3,91,101	3,43,344	467153
	conv	3,84,570	4,55,474	406490
16	Coking Coal	42,81,820	51,07,604	5368400
	mech	17,60,673	28,07,204	2413621
	conv	25,21,147	23,00,400	2954779
17	Metallurgical coke	2,77,905	2,91,999	405682
18	Petroleum coke	20,96,108	16,73,943	1723339
19	C.P. Coke	3,61,137	10,696	351456
20	Iron Ore(Hot Briquetted iron)	1,99,743	1,07,096	225893
21	Iron Ore Pellets	-	-	0
22	Manganese Ore (incl: FM ore)	10,31,494	9,23,744	1951455
23	Chrome ore	-	-	0
24	Lime stone	5,33,397	3,30,320	442143

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25	Corn (Food grains)	5,500	49,500	0
26	Bentonite	65,000	30,000	77000
27	Thermal Coal	-	10,565	0
28	Peas	88,147	41,744	74979
29	Steam Coal	41,02,547	79,91,750	5279854
	mech	24,89,515	49,33,869	2469577
	conv	16,13,032	30,57,881	2810277
30	Anthracite Coal	95,500	51,300	151900
31	Sugar	-	-	0
32	Alumina	-	-	0
33	Gypsum	10,16,774	7,60,283	807621
	mech	-	-	0
	conv	-	-	807621
34	Coke /Coal fines	-	-	0
35	Iron scrap	32,845	70,862	0
36	Bauxite	10,07,566	4,76,522	519266
	mech	-	-	0
	conv	-	4,76,522	519266
37	Wheat	4,35,975	-	0
38	Cement Clinker	-	-	0

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39	Salt	87,100	-	42000
40	Zinc Concentrates	-	-	0
41	Illiminate sand	-	-	0
42	Coal tar pitch	10,500	4,400	0
43	Soda ash	-	-	0
44	STONE/ROCK BOULDERS	-	-	0
45	Nickle ore	-	-	0
46	Dolomite chips	-	-	0
47	COREX COAL	-	-	0
48	Others	-	-	0
i)	Temporary landing	-	-	0
ii)	Other	-	-	0
	TOTAL DRY BULK (A)	1,80,77,994	2,05,39,343	20036859
	B. LIQUID BULK	-	-	0
49	POL Products	22,18,338	22,59,981	1885824
50	LPG	16,33,127	13,40,855	1730754
	TOTAL POL	38,51,465	36,00,836	3616578
51	Crude oil	94,89,399	1,02,12,782	8896864
52	Dephenol	-	-	0
53	Edible Oils(Palm oil)	4,800	-	26582

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54	Caustic Soda	8,18,510	7,58,898	708603
55	Mono Ethylene Glycol	-	-	0
56	Styrene Monomer	1,23,954	1,18,497	120291
57	Acetone	25,461	28,822	25900
58	Ethylene/Methylene	-	-	0
59	Toluene	34,677	42,118	35767
60	Xylene	-	-	0
61	Alcohol	20,251	22,768	20599
62	Methanol	1,30,475	1,25,308	169623
63	Hexane	9,059	11,942	10992
64	Molasses	-	-	0
65	Bio-diesel	35,582	76,097	24741
66	Others	-	-	0
	Fertilizers Liquid:	-	-	0
67	Sulphuric Acid	1,85,255	1,81,973	227536
68	Phosphoric acid	1,09,264	1,23,001	113887
69	Liquid Ammonia	1,71,745	1,78,631	186881
70	Molten Sulphur	99,961	1,09,276	112598
	Fertilizers Liquid Total:	5,66,225	5,92,881	640902
	TOTAL LIQUID BULK (B)	1,51,09,858	1,55,90,949	14297442

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	C. BREAKBULK	-	-	0
71	Steel cargo	33,134	85,477	24401
72	Magnesite (DBM Bags)	-	-	0
73	Timber	-	7,549	2284
74	Coal tar pitch	-	-	0
75	Baked annodes / Carbon annodes	-	-	0
76	Wheat	-	-	0
77	Sugar bags	-	-	0
78	Bauxite Bags	-	-	0
79	Soda Ash bags	-	-	0
80	Wood Pulp	-	28,500	0
81	Garnet	-	-	0
82	Ammonium Nitrate (Bags)	3,13,094	1,87,581	163121
83	Di-Ammonium Phos. Bags	-	-	0
84	Pet Coke	-	-	0
85	Alumina	-	-	0
86	Bindar pitch	-	-	0
87	Ferro Silicon	-	-	0
88	Rice	-	-	0
89	Edible Oil (Oil Seeds)	8,000	-	0

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90	Dried raw cashew nuts bags	-	-	0
91	Others	20,269	44,275	14705
i)	Temporary landing	-	-	0
ii)	General cargo	6,113	495	2692
iii)	Project cargo	14,156	43,780	12013
iv)	Reliance/Off-shore	-	-	0
v)	Others (other break bulk)	-	-	0
	TOTAL BREAK BULK(C)	3,74,497	3,53,382	204511
92	D.TOTAL CONTAINER CARGO	27,61,227	23,67,361	2588315
	(NO.OF TEUS)	1,81,464	1,45,633	177452
	(NO.OF CONTAINERS)	1,53,378	1,20,781	148308
	TOTAL IMPORTS(A+B+C+D)	3,63,23,576	3,88,51,035	37127127
	III.TRANSHIPMENT CARGO	-	-	0
1	P.O.L. Products	19,19,036	14,67,804	1133052
2	Crude oil	-	-	69592
3	Coal	-	-	0
4	Sulphur	-	-	0
5	Iron Ore	-	-	0
6	Wheat	-	-	0
7	Others GC	-	-	0

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	Total Transshipment	19,19,036	14,67,804	1202644
	TOTAL TRAFFIC(I+II+III)	6,10,20,486	5,70,33,160	57698497
NOTE:1.Total Traffic excludes bunkers				
Figures shown separately in case of container Cargo vessels indicates No. of Containers & TEUs				
Figures shown separately for conventional and mechanical handling for fertilizer and fertilizer raw				
materials, iron ore and iron ore pellets and soya				