

**Quantitative Risk Assessment  
Techniques for Determining Public  
Liability Quantum – A Case Study  
(Presented at FICCI Seminar in Chennai)**

**July 24, 2008**

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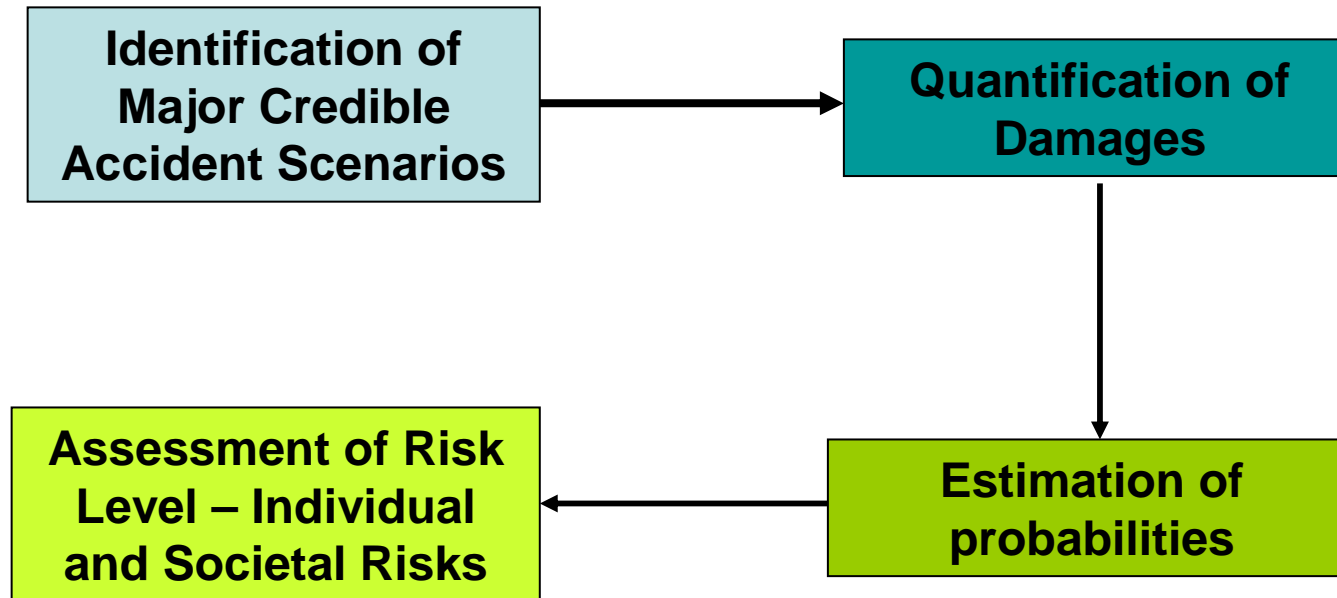
# In this presentation...

- Quantitative Risk Assessment
  - Damage Mapping
  - Technique and its applications
- Public Liability Insurance
  - Present Scenario on Quantum Fixation
- Case Study - Application of QRA Technique

# Definition of Risk

- *“a measure of potential economic loss or human injury in terms of the probability of the loss or injury occurring and magnitude of the loss or injury if it occurs.”*
- Risk thus comprises of two variables; magnitude of consequences and the probability of occurrence.

# QRA Process



# Consequence Estimation

- Determines the potential for damage or injury from specific incidents.
- A single incident (e.g. rupture of a pressurized flammable liquid tank) can have many distinct incident outcomes eg
  - Unconfined Vapour Cloud Explosion (UVCE),
  - Boiling Liquid Expanding Vapour Explosion (BLEVE),
  - Pool fire

# Impact of heat radiation on humans and property

- The lethality of a jet fire is assumed to be 100% for the people who are caught in the flame. Outside the flame area, the lethality depends on the heat radiation distances.
- The lethality of a pool fire is assumed to be 100% for the people who are caught in the pool. Outside the pool diameter area, the lethality depends on the heat radiation distances.

# Effects of heat radiation

INCIDENT RADIATION – kW/m <sup>2</sup>	TYPE OF DAMAGE
0.7	Equivalent to Solar Radiation
1.6	No discomfort for long exposure
4.0	Sufficient to cause pain within 20 sec. Blistering of skin (first degree burns are likely)
9.5	Pain threshold reached after 8 sec. second degree burns after 20 sec.
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubings etc.

# Damage due to Overpressure

The VCE will result in overpressures

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

# Damage due to Overpressure

- 100% lethality is assumed for all people who are present within the cloud proper.
- Overpressure more than 0.3 bar corresponds approximately with 50% lethality.
- An overpressure of 0.1 bar would result in 10% fatalities.
- An overpressure less than 0.1 bar would not cause any fatalities to the public.



# Toxic Cloud Dispersion

- Accidental releases of toxic substances like Ammonia, Chlorine, etc. to the atmosphere can have harmful effects on human beings.
- The degree of damage caused by the release depends on the concentration and duration of exposures.
- IDLH – Immediately dangerous to life & health : a limit for personal exposure to a substance beyond which an individual will not be capable of escaping death or permanent injury without help in less than thirty minutes.

# Accident frequency assessment

- Estimates the frequency or probability of occurrence of an incident.
- Estimates may be obtained from historical incident data on failure frequencies or from failure sequence models, such as fault trees and event trees.
- Historical data developed by software models and those collected by CPR 18E – Committee for Prevention of Disasters, Netherlands are used.

# Risk Estimation

- This combines the consequences and likelihood of all incident outcomes from all selected incidents to provide a measure of risk.



## SAFETI Micro V 6.51

- **SAFETI (Software for the Assessment of Flammable, Explosive and Toxic Impact) –tool developed by DNV UK**
- **PHAST – used for Consequence Analysis**
- **SAFETI – Individual & Societal Risk, F-N curves**
- **The software is used to assess**
  - **the effects of flammable and toxic releases,**
  - **estimating the distance chemicals may travel given local weather conditions and**
  - **the number of people who may be injured by these events.**

# Applications of QRA

- Quantifying the risk involved in a process
- Determining the Location of Plant and its facilities
- Provide input for Onsite / Offsite Emergency Plan preparation
- Determining the Heat Radiation arising out of different Large pool fire, jet fires & BLEVE scenarios
- Determining the toxic dispersion of various toxic leak scenarios
- Determining the overpressures created due to various blast scenarios

# List of some major accidents

Date	Place	No. of People		Nature of Accident
		Killed	Injured	
Dec. 1985	Shri Ram Food and Fertilizers, Delhi	2	500	Oleum gas leak
Jul. 1987	Bhorari Industrial Area, Pune, Maharashtra	-	420	Sulphur trioxide leak
Jun. 1987	Kaluparghat, Bhubaneshwar, Orissa	4	NA	Ammonia gas leak
Nov. 1987	Behrampur, Ahmadabad, Gujarat	-	5000	Oleum gas leak
May 1988	Deese Town, Ahmadabad, Gujarat	19	53	Acid tanker overturned
Oct. 1989	Chlorinators India, Ganjam, Orissa	6	100	Chlorine gas leak
Nov. 1990	India Petro Chemicals Ltd., Nagothane, Maharashtra	35	50	Explosion in gas cracker
Nov. 1991	Gwalior Rayon and Silo Mills, Gwalior, Madhya Pradesh	9	100	Explosion in filling unit
Nov. 1991	Dahanu, Maharashtra	100	19	Chemical explosion from overturned tanker
Apr. 1992	Naya Bazar, Delhi	12	-	Chemical explosion in warehouse
Sep. 1992	National Fertilizer Plant, Panipat, Haryana	11	11	Ammonia gas leak
Mar. 1993	Century Rayon, Sahad, Maharashtra	11	123	Sulphuric acid gas leak
Oct. 1994	Jhansi, Uttar Pradesh	30	25	Explosion in a factory
Mar. 1995	Mumbai	4	-	Leakage of Methane gas from a refinery pipeline
Nov. 1995	Kochin	-	-	Leakage of ammonia gas from a sea food processing plant (200 people evacuated from a nearby housing colony)

# Public Liability Insurance

- **Present Scenario**

- Sum insured is fixed based on minimum value mentioned in the Act
- Risk assessment is not being carried out / not used for calculating the quantum
- Court's verdict and the assumed public liability quantum negligible based on past experience
- Values given for relief in the act are the minimum
  - Fatal Accidents – Rs.25,000 per person
  - Total Permanent Disability – Rs.25,000 per person
  - Temporary Partial Disablement – Fixed monthly relief not exceeding Rs.1000 per month upto a max. of 3 months
  - Damage to Property – upto Rs.6000

# Public Liability Act Insurance Policy

- This is a mandatory insurance policy to be taken by owners, users or transporters of hazardous substance as defined under Environment (Protection) Act 1986, in excess of the minimum quantity specified under the Public Liability Insurance Act 1991.
- This insurance policy is intended to provide immediate relief to persons affected due to accident (death/injury to third party or damage to property belonging to third party) while handling hazardous substances by the insured on no fault liability basis.
- Insurance Limits:
  - Any one accident : Minimum equal to Paid up Capital upto a maximum of Rs.5 crores
  - Any one year: 3 times of 'Any one accident' limit subject to a maximum of Rs.15 crores
- Claims exceeding the above statutory limits to be met by the Environmental Relief Fund.
- The liability beyond the total of the insurance and the Relief / Fund is to be borne by the Insured.

# Public Liability (Industrial & Non Industrial ) Policy (Market agreement policy)

- Cover against legal liability to third parties, on account of bodily injury or property damage arising out of Insured's business operations.
- Sum Insured (Liability limits) can be decided by the insured.
- Policy cannot be issued for unlimited liability
- Extensions available under the policy include the following
  - Goods kept in Custody of Insured Extension
  - Food and Beverages Extension
  - Industrial Seepage, Pollution and Contamination Extension
  - Sports facilities, Swimming Pool and other facilities Extension
  - Transportation Extension
  - Act of God perils Extension

# Key Factors Affecting Public Liability Quantum

- Type of habitation surrounding a facility – Residential or Industrial
- Average age group of people
- Earning Capacity of the people
- Deep pocket theory

# Case study 1

- Petroleum Storage Terminal Located In North Chennai
- 14 Atmospheric Petroleum storage tanks
- Largest Tank Volume 7500 KL – Storing HSD, Dia 27 mtrs, Height 13 mts
- Surrounded by Residential areas

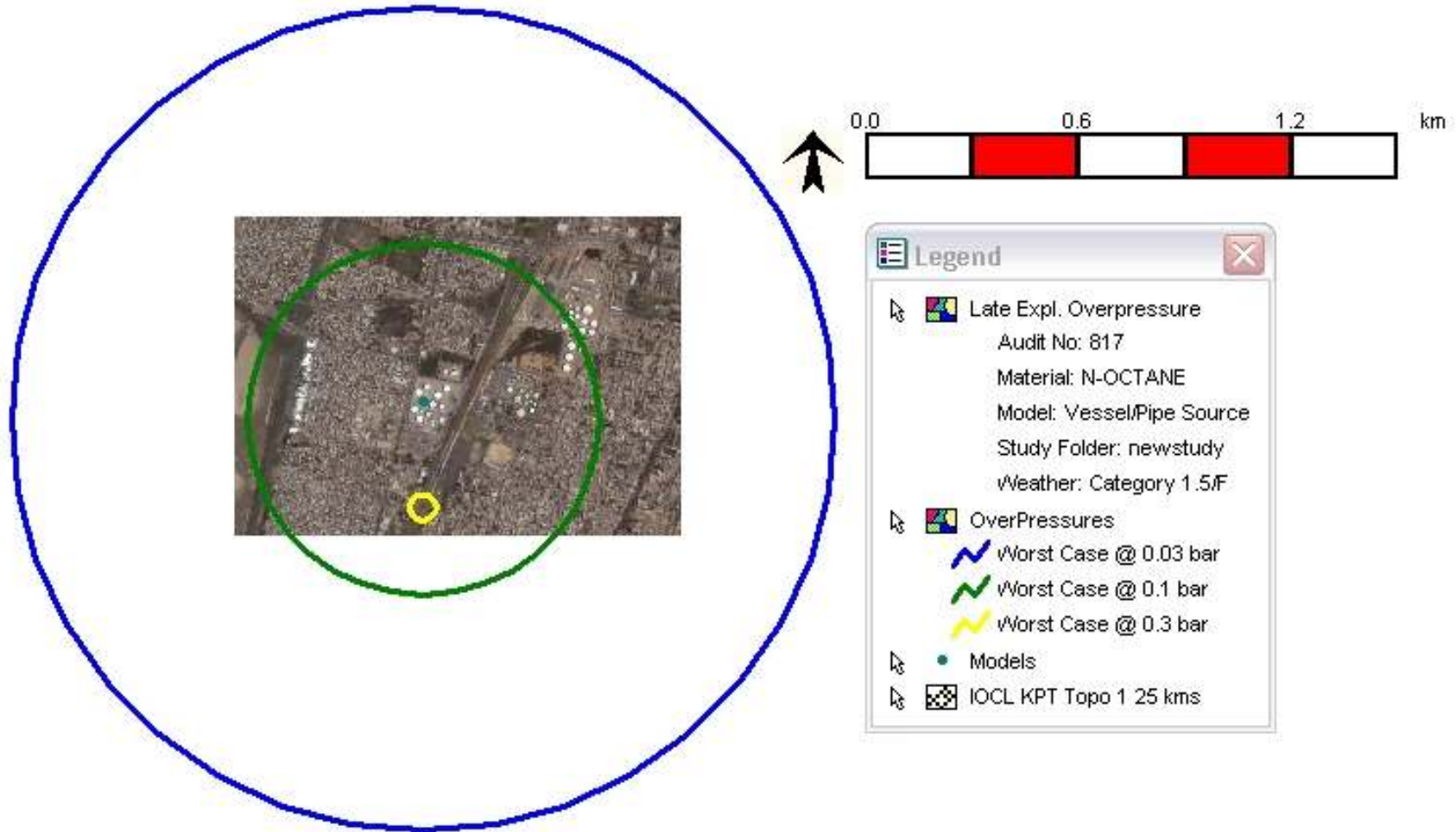
# Aerial View of the Site Location



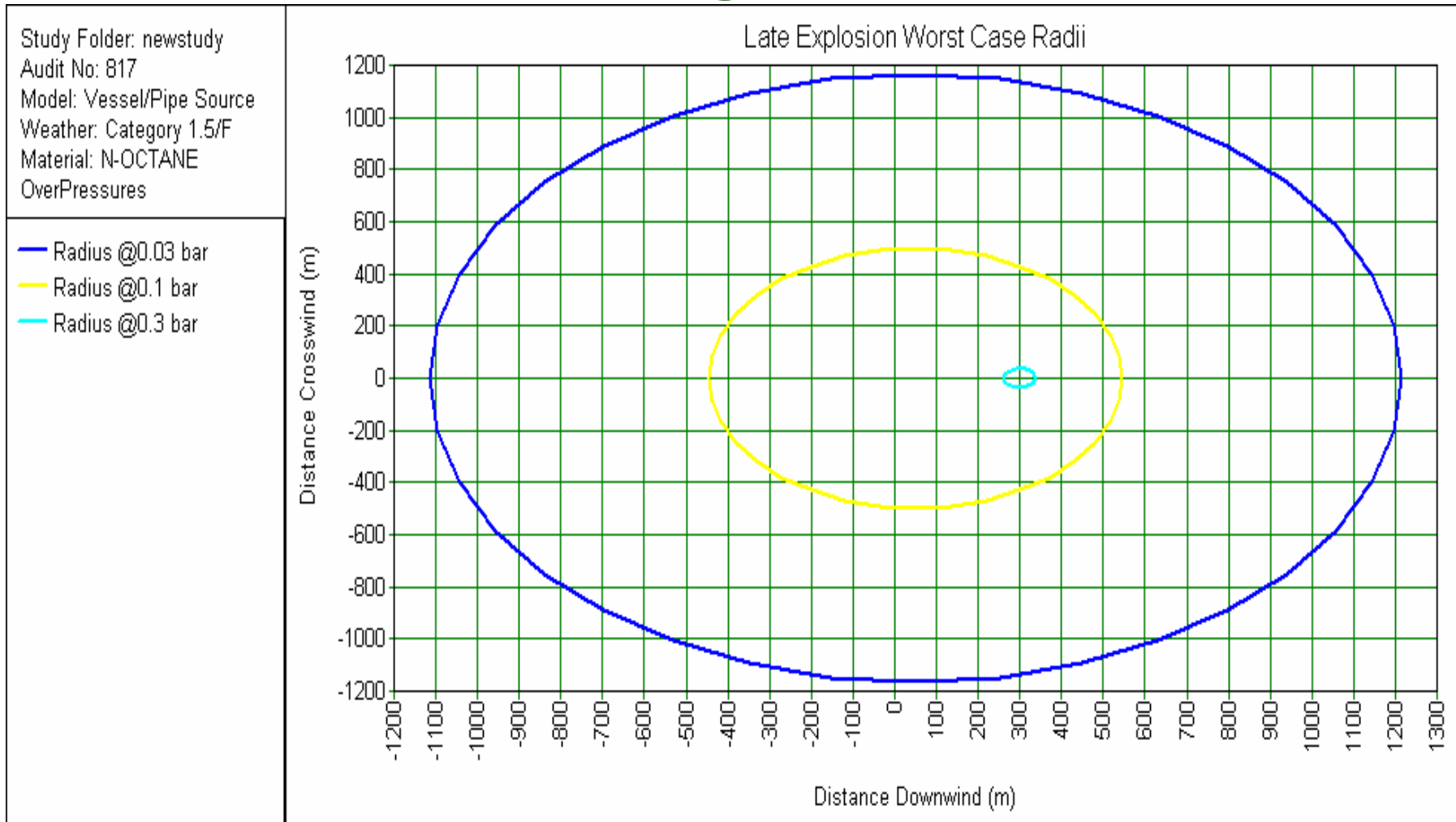
# Risk Analysis

- MCA Scenarios Considered – Largest Tank 7500 KL and Road Tanker 20 m<sup>3</sup>
- Outcomes from these scenarios include Vapor Cloud Explosion, Pool Fire

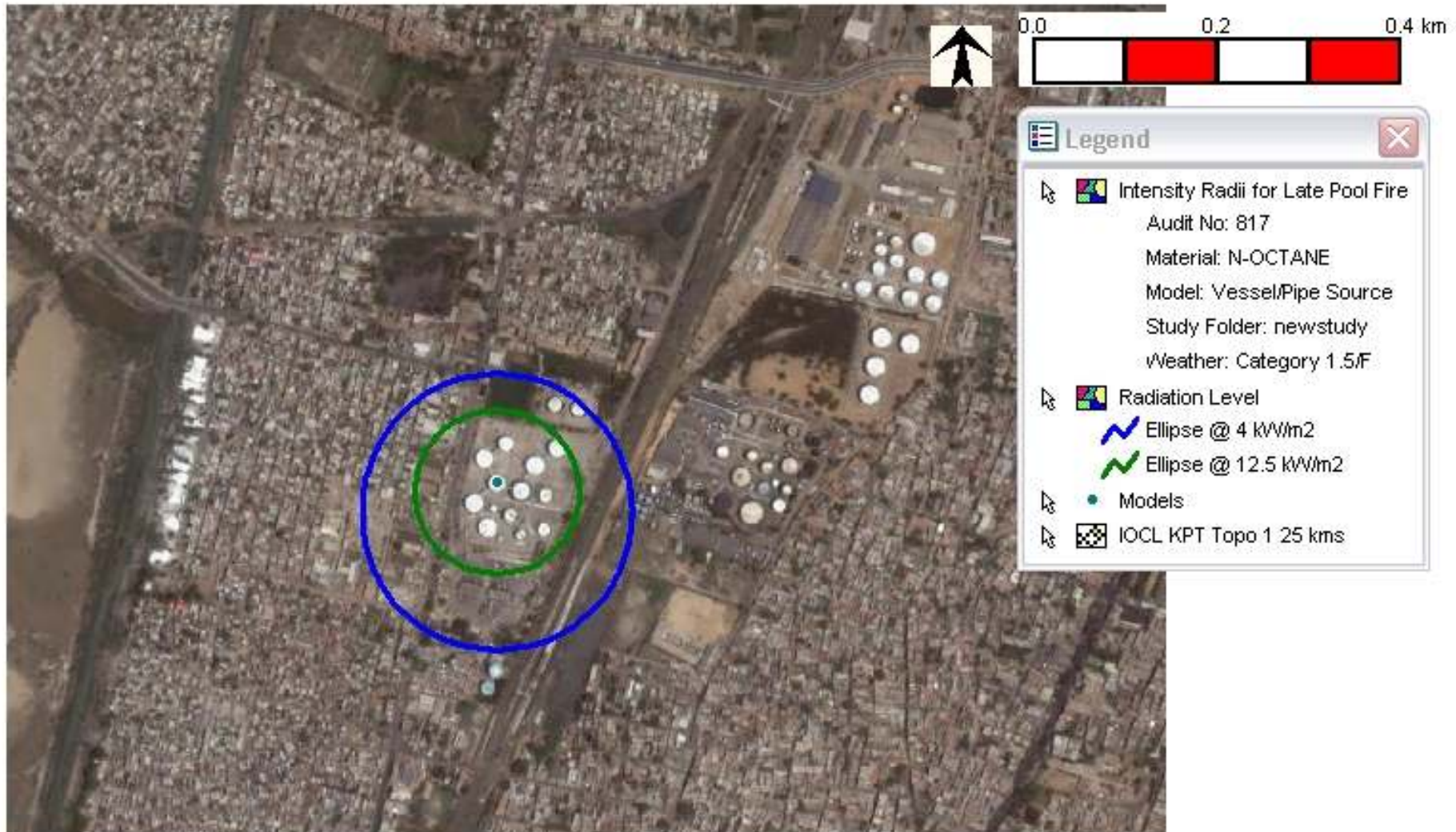
# Late Explosion worst Case for Class B Storage Tank



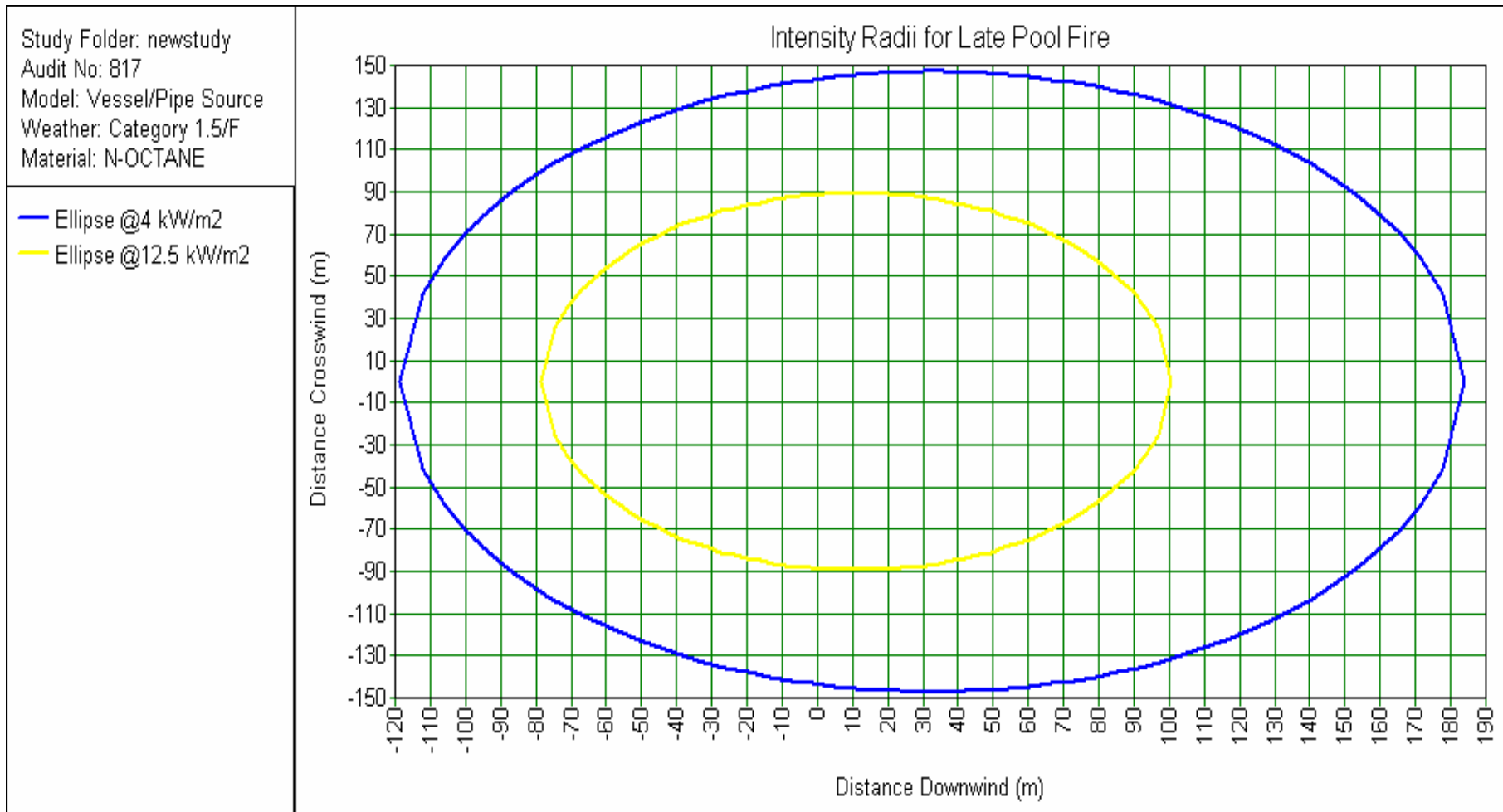
# Late Explosion worst Case for Class B Storage Tank



# Late Pool Fire – Class B Storage Tank



# Late Pool fire – Class B Storage Tank



# Risk Analysis Inferences

- Expected Fatalities – Societal Risk –  $2.42981 \text{ E } -03$  / year equivalent to 32 Fatalities (approx)
- Estimated Claims due to fatalities is about 3.78 cr
- Estimated Claims due to Injuries and property damages can be upto 5 Cr

# Assumptions

- **Average Population Density – as per Census Data 2001 – For the area around plant it is about 12981.**
- **Exact quantum of compensation that will be awarded to the victims by courts cannot be predicted. However taking into account the awards given in the case of motor accidents, based on the victims' age, earning capability etc., the following points are arrived at:**
  - **A maximum of eighteen times the annual income is taken for calculation.**
  - **In the above amount two third is taken as expenses towards dependents and taken as the basis for compensation.**
  - **Taking the average annual income of Rs.1,00,000 per person the compensation towards death victims works out to be 3.78 crores**

# Case Study 2 – Manufacturing Industry in Chennai

- ✚ Major Hazardous materials handled – Diesel (15 KL Tank) and hazardous wastes like used oil and solid wastes.
  
- ✚ Existing Public Liability (Market Agreement Policy) Sum Insured – Rs.75 Lakhs
  
- ✚ Probable Accident Scenarios in the factory and its impact -
  - Major rupture of the HSD tank (15 KL capacity) resulting in scenarios like fire and explosion are possible. The impact of the fire or explosion can be felt up to a distance of over 15 m only.
  - Leaks of the hazardous wastes with in the factory premises – Impact is not significant
  - Catastrophic rupture of tanker carrying HSD resulting in either fire or explosion scenarios. These scenarios may cause damage up to 50 m and 100 m respectively as per the computerized theoretical modeling

# Case Study 2 – Manufacturing Industry in Chennai

- ✚ **Extent of Damage**

- ✚ **Quantitative Risk Analysis study of the tanker rupture scenario gives the following results:**

<b>Distance</b>	<b>Possible lethality</b>
<b>Within 10 metres</b>	<b>100 %</b>
<b>Within 50 metres</b>	<b>10 %</b>
<b>Within 100 metres</b>	<b>1 %</b>

- ✚ **The total number of occupants in the nearby areas is 800.**

- ✚ **Hence possible number of fatality in worst case can be 12 -15.**

- ✚ **Injuries can be about 25 – 30.**

# Case Study 2 – (Contd.)

## Quantum of loss

- ✦ Exact quantum of compensation that will be awarded to the victims by courts cannot be predicted. However taking into account the awards given in the case of motor accidents, based on the victims' age, earning capability etc., the following points are arrived at:
- ✦ Taking the average annual income of Rs.1,00,000 per person the compensation towards death victims works out to be Rs.1.62 crores.
- ✦ **Hence, the annual AOA/ AOY limit can be fixed as Rs.2 crores instead of Rs.75 Lakhs.**

# Conclusion

- QRA enables to assess the PLI sum insured in a more scientific way
- For the insured, it also helps to assess the risks involved in the process and possible liability arising out of it
- Acts as input for deciding on the implementation priority for risk control measures
- For the insurer, it helps to know the risk level of the insured property and arrive at a competitive premium