Risk Assessment/Hazards for Deep Water Port LNG Receiving Terminals

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Presentation Overview

- **Overview of <u>general hazards</u> and risk analysis for large LNG spills over water**
- **Guidance on <u>site-specific hazards</u> and risk management approach**
- **Considerations and scale of results for**
  - **near-shore and off-shore systems**
  - **large LNG vessels, Deep Water Port storage and regasification systems**

Use of Guidance Information and Results

- The information and results presented are intended to be used as guidance for conducting site-specific hazard and risk analyses
- The results are not intended to be used prescriptively, but rather as a guide for using performance-based approaches to analyze and responsibly manage risks to the public and property from potential LNG spills over water

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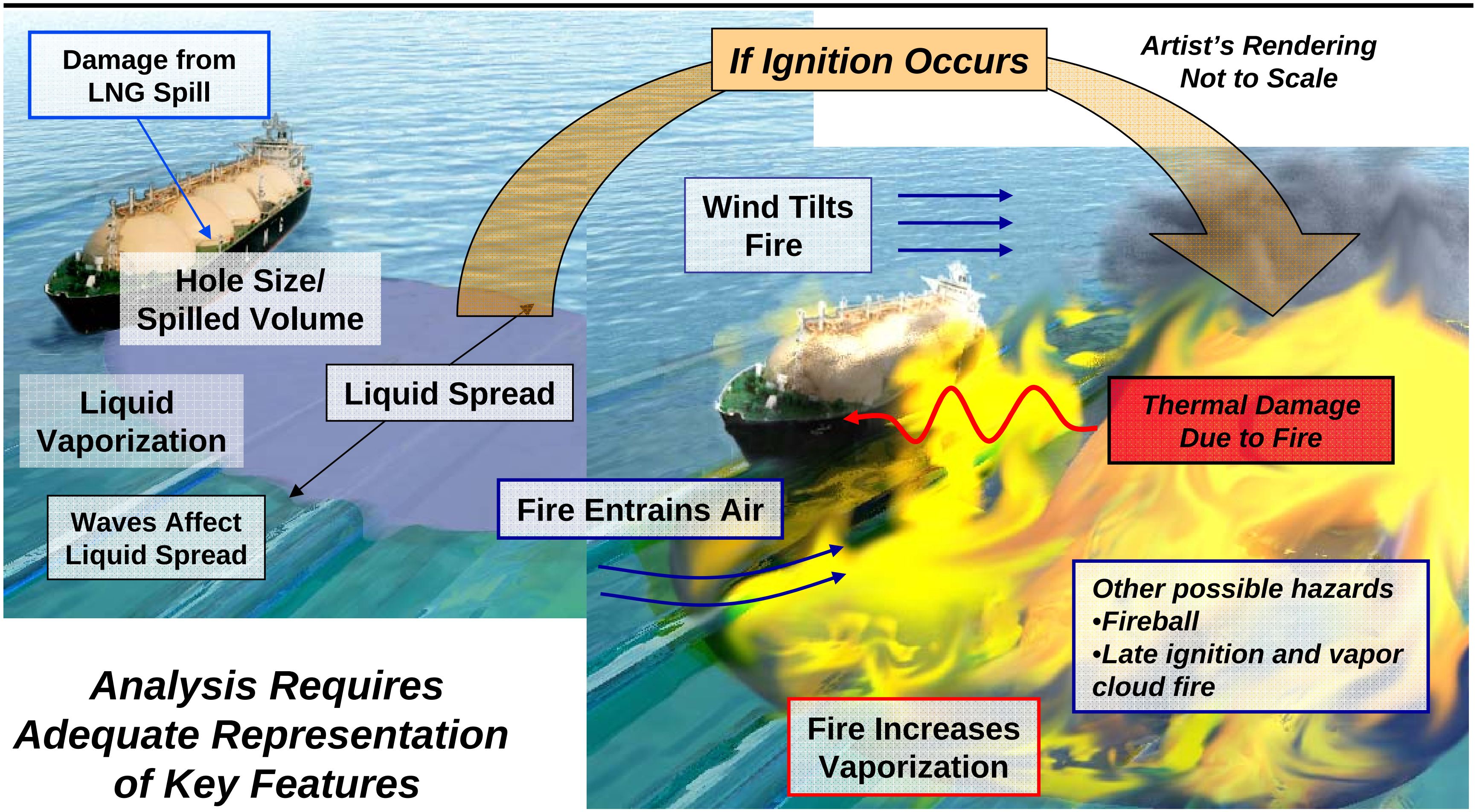
Key Features Impacting Possible LNG Carrier Spills



Analysis Requires Adequate Representation of Key Features

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2004 Sandia LNG Safety and Risk Analysis Guidance Report

- **Identify "scale" of hazards from an LNG spill over water**
- **Provide direction on use of hazard analysis techniques**
- **Provide direction on use of risk management to improve public safety**
- **Provide process for site-specific evaluations**

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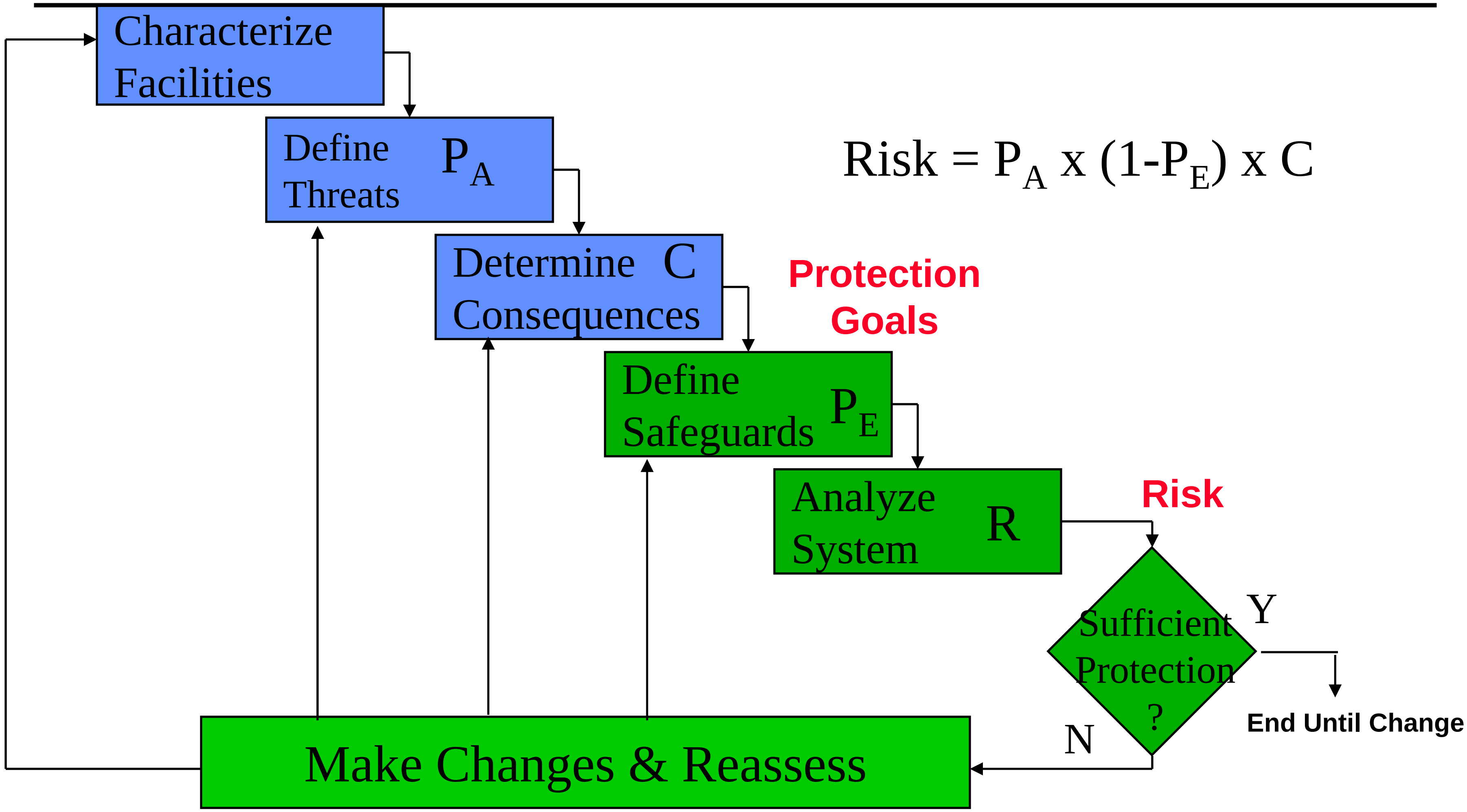
Risk-based Assessment Approach for LNG Spills over Water



Guidance Designed to Help Sites Evaluate LNG Import Issues

Chapter 6 of report provides guidance on assessing LNG terminal safety and security concerns:

- Site-specific conditions to consider
  - location, environmental conditions, proximity to infrastructures or residential or commercial areas, and available resources
- Site-specific threats to evaluate
- Cooperating with stakeholders, public safety, and public officials to identify site-specific “protection goals”
- Appropriate modeling and analysis approaches for a given site, conditions, and operations
- System safeguards and protective measures to consider
- Identification of approaches to manage risks, through prevention and mitigation, enhancing energy reliability and the safety of people and property

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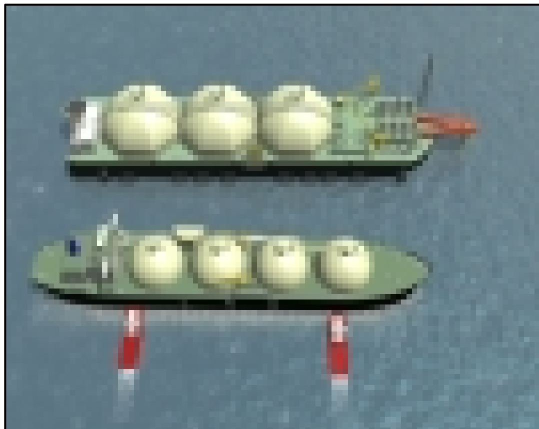
Common Deep Water Port Concepts

Off-shore floating buoy, with LNG carrier-based LNG regasification into pipeline



Off-shore terminal-based storage and LNG regasification into pipeline

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Growing size of LNG Vessels and Terminals

Class	145,000m^3	155,000m^3	215,000m^3	260,000m^3	300,000m^3 Terminal
Tanks	4-5	4	5	5	2-3
Length	285 m	290 m	315 m	345 m	Variable
Width	44 m	45 m	50 m	55 m	Variable
Draft	11 m	11.5 m	12 m	12.5 m	Variable

Differences in Facilities Impact Hazards and Energy Delivery Issues

- **Near-shore, On-shore**
  - Traffic control, safety zones, escorts to enforce
  - Smaller threats but closer to people, infrastructure
  - Smaller LNG ships – smaller LNG tanks, less standoff, older designs and safety features
  - Allows LNG storage
- **Off-shore – Deep Water Ports**
  - Limited traffic control or enforcement
  - Larger threats but further from public
  - Larger ships – more LNG, more standoff, new designs and safety features
  - Deliver to public as natural gas
- **Combinations**
  - Large vessels near-shore, small regasification vessels off-shore

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Behavior of LNG Pool Fires

- Burn rate controls pool area and flame height
- Flame height decreases as pool diameter increases, with transition at very large diameters
- Hydrocarbons produce smoke, but production unknown for LNG pool fires >35 m diameter
- Lower flame height and smoke shielding combine to reduce the radiative heat flux levels for large spills

Montoir - 35 m LNG pool fire

SNL - 6 m LNG pool fire

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Potential Thermal Hazards for Spills from Common LNG Vessels

HOLE SIZE (m^2)	TANKS BREACHED	DISCHARGE COEFFICIENT	BURN RATE (m/s)	SURFACE EMISSIVE POWER (kW/m^2)	POOL DIAMETER (m)	BURN TIME (min)	DISTANCE TO 37.5 kW/m^2 (m)	DISTANCE TO 5 kW/m^2 (m
ACCIDENTAL EVENTS								
1	1	.6	$3X10^{-4}$	220	148	40	177	554
2	1	.6	$3X10^{-4}$	220	209	20	250	784
INTENTIONAL EVENTS								
5	3	.6	3×10^{-4}	220	572	8.1	630	2118
5*	1	.6	3×10^{-4}	220	330	8.1	391	1305
5	1	.9	3×10^{-4}	220	405	5.4	478	1579
5	1	.6	8×10^{-4}	220	202	8.1	253	810
12	1	.6	3×10^{-4}	220	512	3.4	602	1920

*Nominal case: Expected outcomes of a potential breach and thermal hazards based on credible threats, best available experimental data, and nominal environmental conditions for a common LNG vessel

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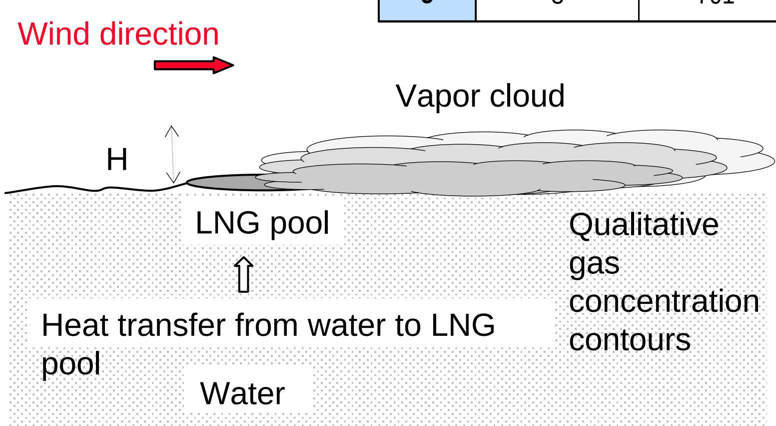
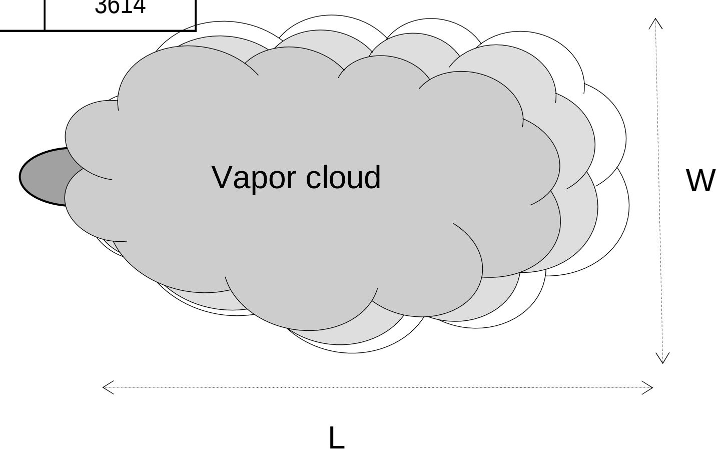
Potential Dispersion Hazards for Spills from Common LNG Vessels

HOLE SIZE (m^2)	TANKS BREACHED	POOL DIAMETER (m)	SPILL DURATION (min)	DISTANCE TO LFL (m)
Accidental Events				
1	1	181	40	1536
2	1	256	20	1710
Intentional Events				
5	1	405	8.1	2450
5	3	701	8.1	3614



Side View



Top View

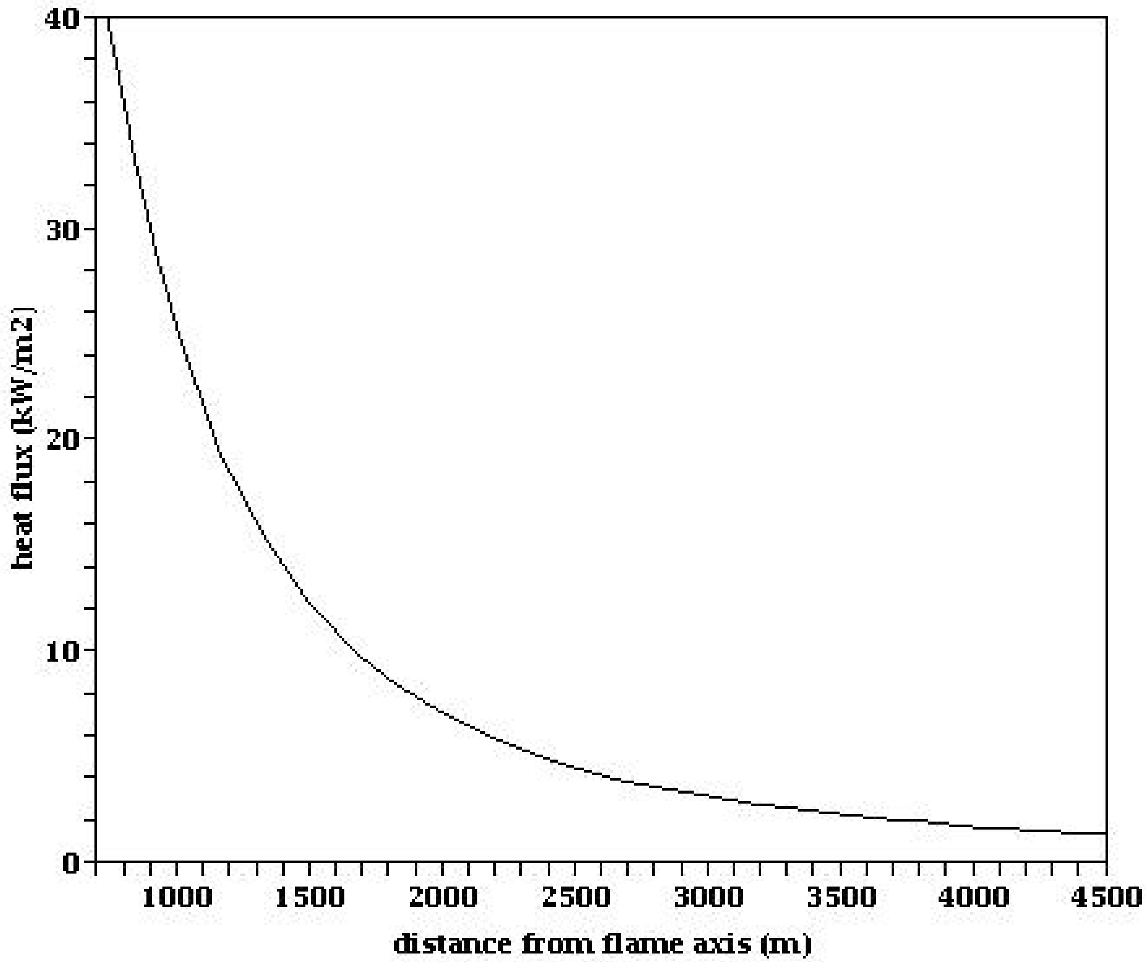
Dispersion distances are limited by closest ignition source

Use of Risk and Safety Guidance to Evaluate LNG DWP Terminals

Assessing LNG DWP terminal safety and security concerns:

- **Site-specific conditions to consider**
  - **location, environmental conditions, proximity to shipping lanes, fishing areas and recreation areas, and available protection resources**
- **Site-specific threats – large maritime ships, ease of access**
- **Identify "protection goals"- on-shore public, shipping, fishing, boating and recreation**
- **Appropriate modeling and analysis approaches for a given site, conditions, and operations**
- **System safeguards and protective measures available or can be incorporated**
- **Identification of approaches to manage risks to enhance energy reliability and safety of people and property**

Potential Thermal Hazards From Large LNG Vessels or DWP– 200,000m^3 spill



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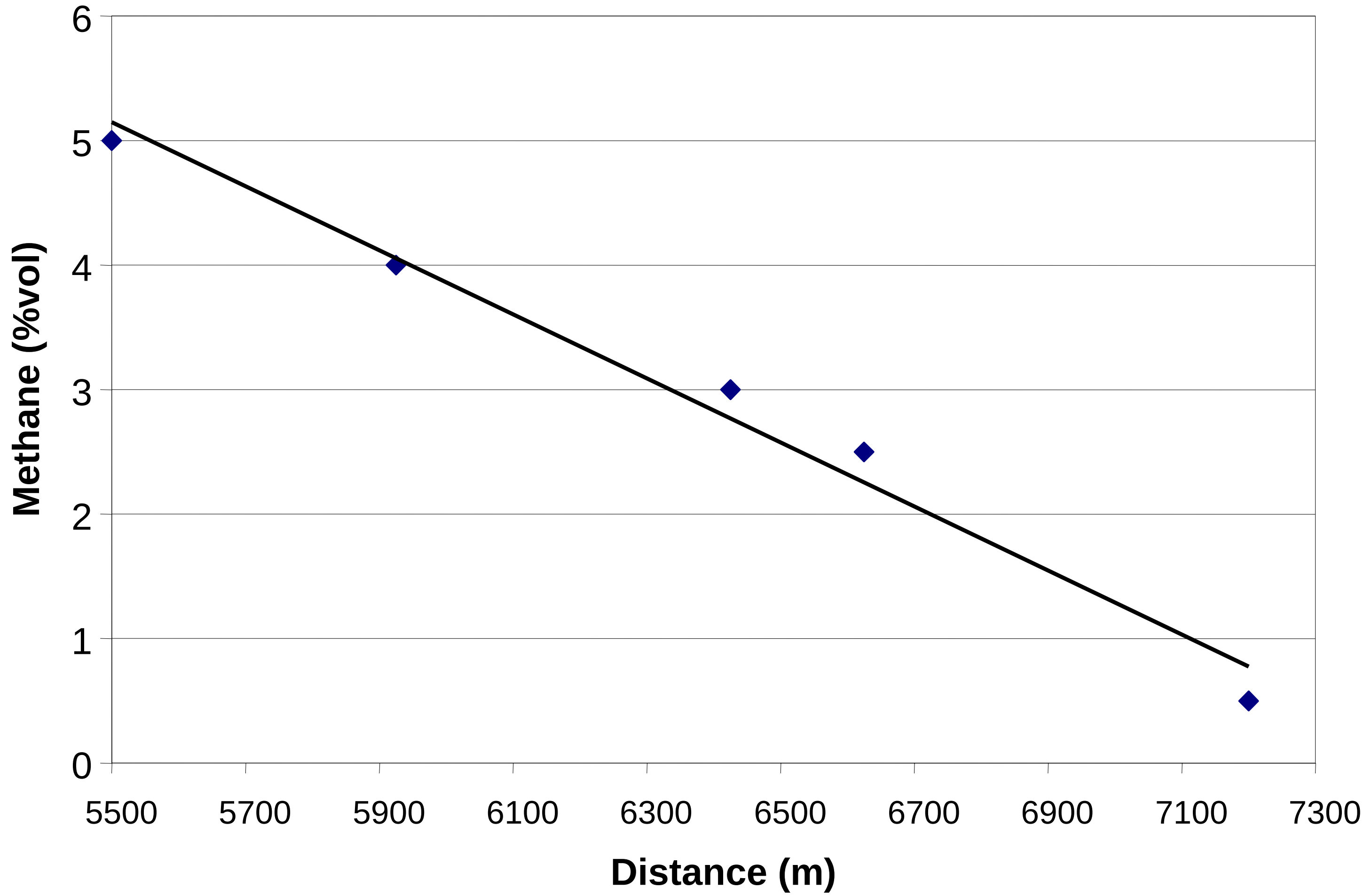
Potential Dispersion Distances From Large LNG Vessels or DWP– 200,000m³ spill



Lower Flammability Limit for methane is 5%

LNG DWP Large Spill Risk and Hazard Conclusions

- **Site-specific analysis of threats, conditions, and protection goals are always needed**
- **Existing consequence analysis methods are generally conservative for large spills**
  - **Use for screening, coordination of risk management approaches**
  - **Use to look at possible range of hazards**
- **The scale of the hazards to the public from a large LNG DWP spill is ~ 2 miles for fire and ~ 3-4 miles for a vapor dispersion**
- **Risk management approaches should be used to balance hazards and public protection**

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