



**INITIATION, DETECTION,  
TREATMENT & PREVENTION  
OF LANDFILL FIRES**

Patrick Foss-Smith

# Setting the Scene

## Are landfill fires *really* a problem or just a nuisance?

- They are frequent:
  - 8,300 reported cases a year in the USA
  - Approximately 290 a year in the UK
  - 0.6 fires per site per year in Finland
- Burning landfills can become irreversibly connected to the environment
- Fugitive emissions are potentially serious
- Established fires are extremely expensive to extinguish
  - Tangible Costs
  - Intangible on-costs

# Introduction – Fugitive Emissions

Emissions to:

- **Air – Inhalation (primary exposure route)**
  - UNEP's view of POPs
  - Formation of Dioxin / Furans
  - Bioaccumulation / Biomagnification
  - Smoke from tyre fires
- **Air – Dermal absorption (primary exposure route)**
  - Mucus Membranes
  - Bhopal
- **Air – Ingestion (secondary exposure route)**
  - Agricultural products
  - Lipids, cheese, olives
- **Water**
  - Leachate, fire fighting water

# Introduction – Types of Fire

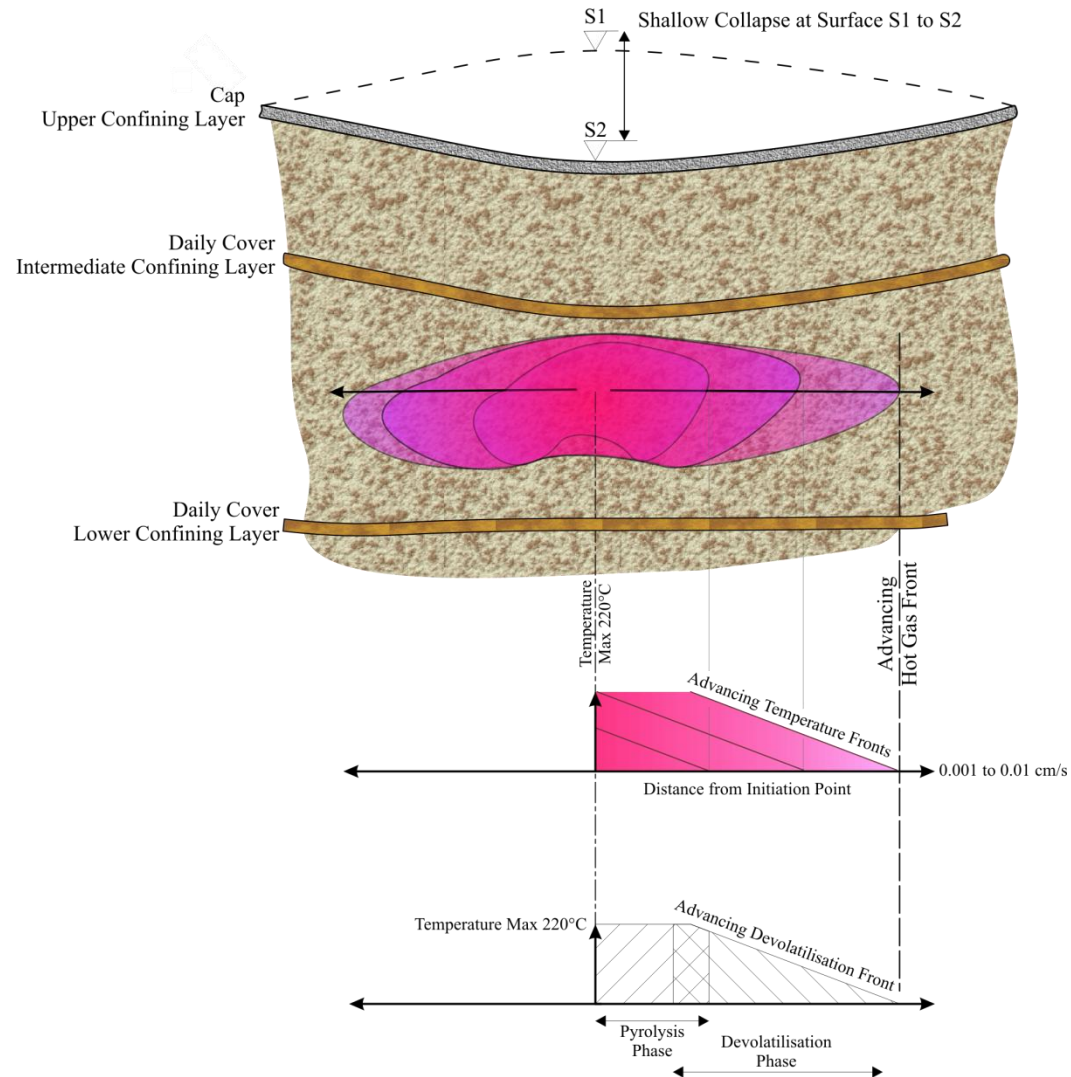
Three main types of landfill fire:

- Surface
- Deep seated
  - Misnomer
  - Pyrolysis
  - Fire Triangle
- Tyre fires
  - Both Deep and Shallow seated

# Initiation

- Accidentally initiated fires:
  - Spontaneous combustion
  - Legacy heat
  - External ignition source (*piloted* ignition)
- Deliberately initiated fires:
  - Airspace conservation in the Third World
  - Arson

# Propagation – *Confined* Deep Seated Fire

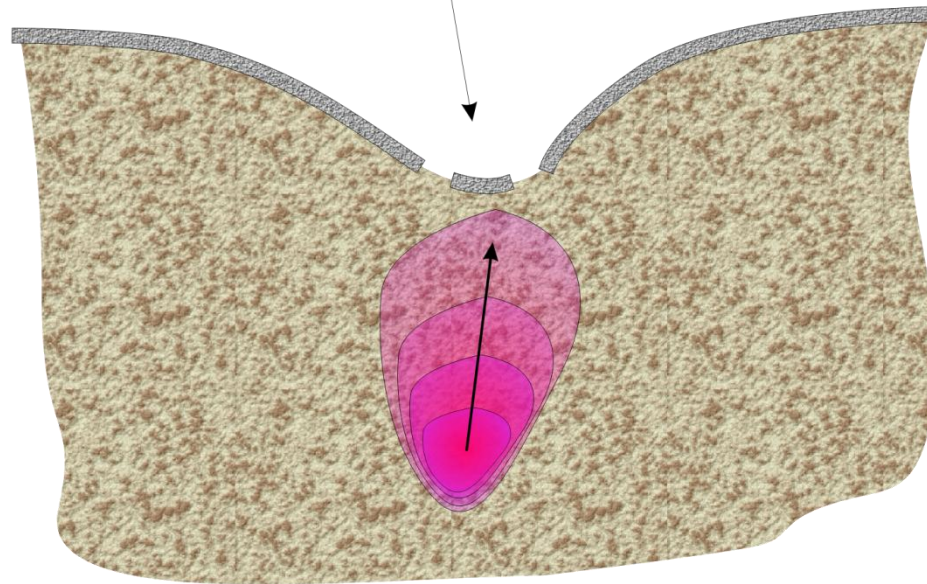


# Propagation – *Unconfined* Deep Seated Fire

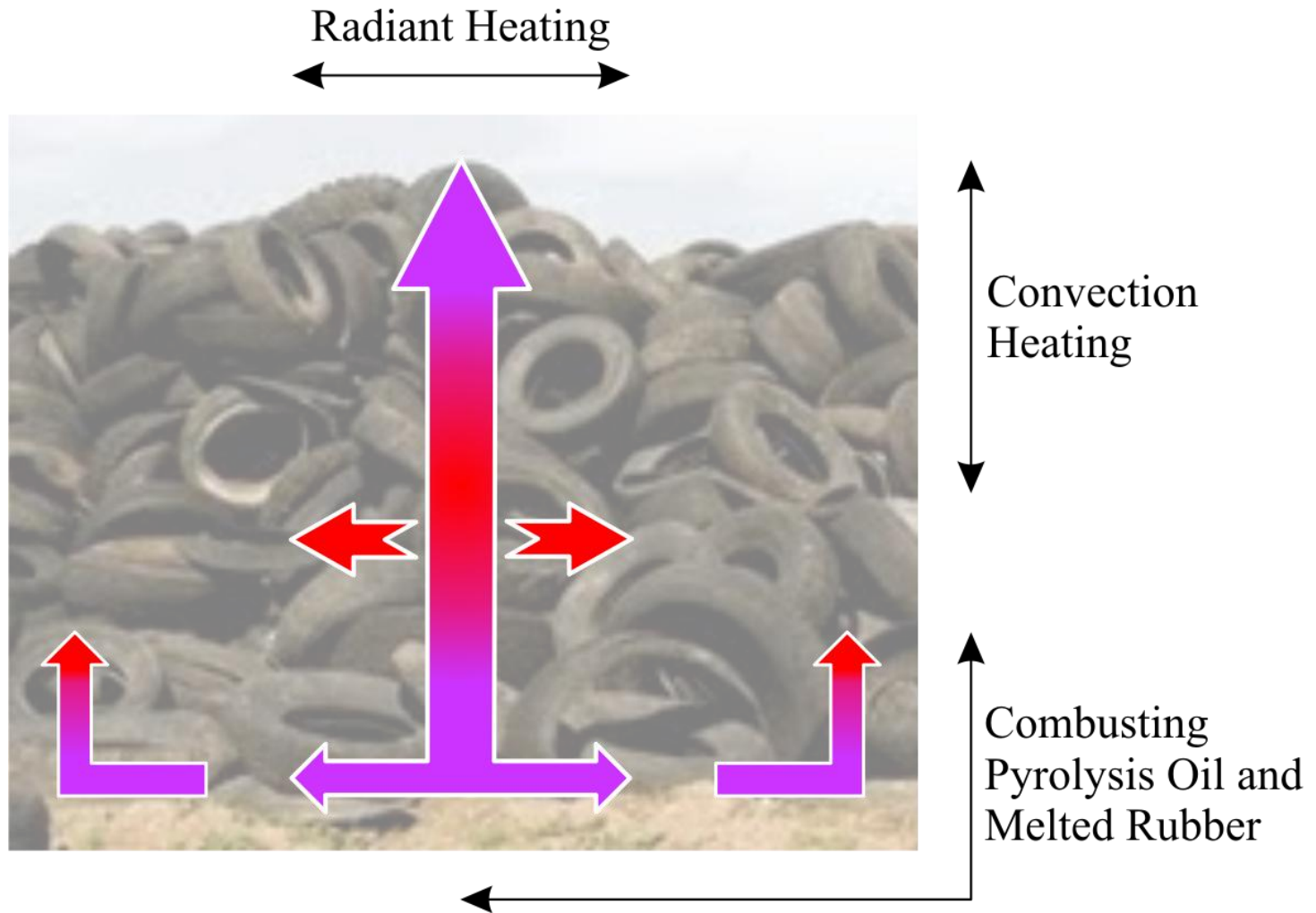
Sink Hole



Surface Cap



# Propagation – Tyre Fires



# Detection

**Sub surface fires can be difficult to detect and delineate:**

- Observation
  - Vapour
  - Smoke
  - Cracks, well alignment
- Topographic survey
- Thermal imaging
  - Far infrared
  - Near infrared
- Spectrographic
- Gas Analysis
- Leachate analysis
- Other indications:
  - LFG engine lubricating oil
  - Collapsed LFG pipes
  - Plastic bags



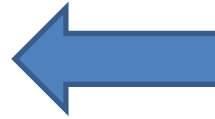
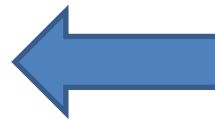
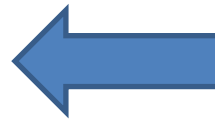
# Detection



# Detection – Gas Anomalies

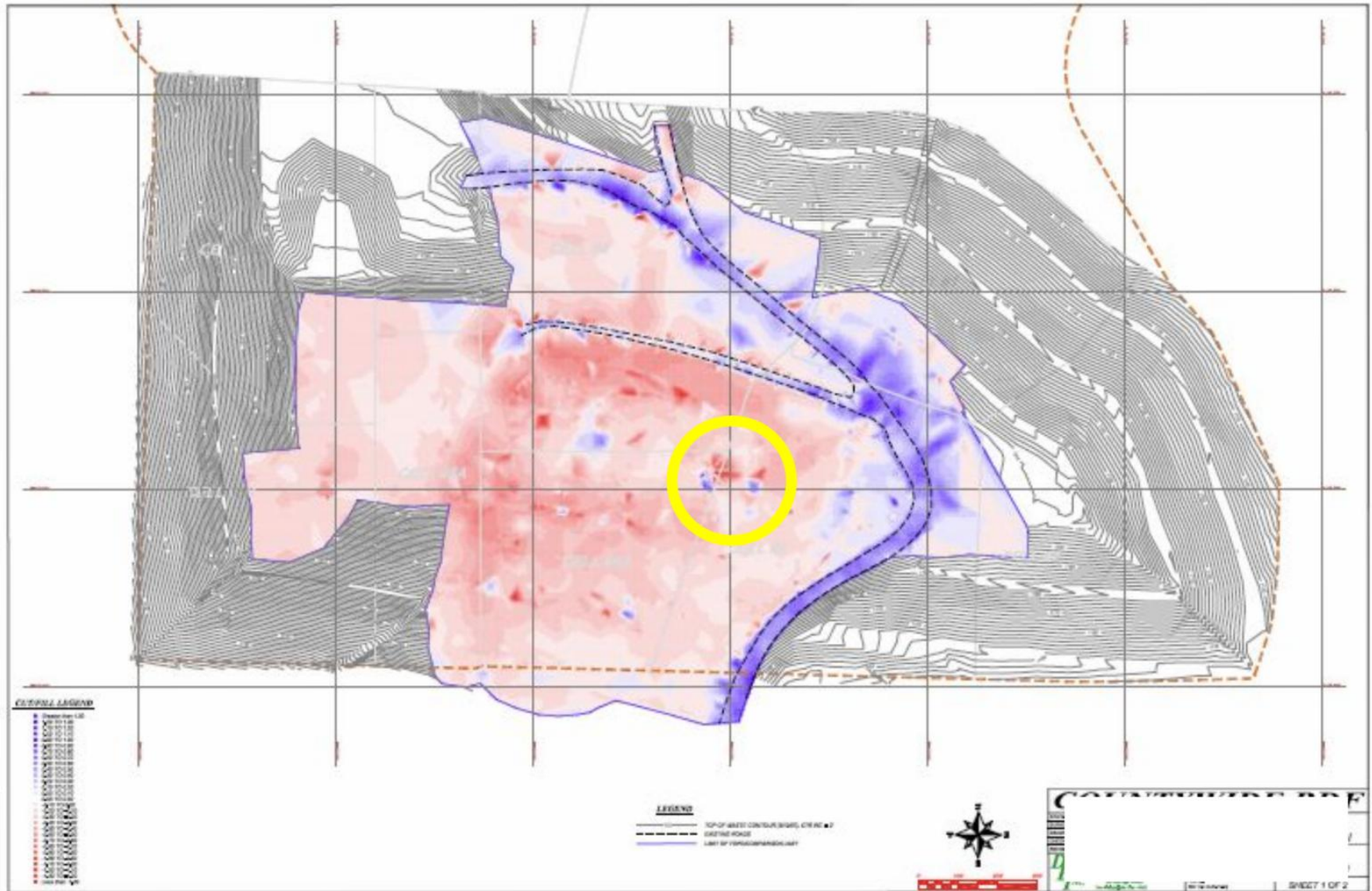
Unexpected +/- changes in gas concentrations are a useful indication of unwelcome activity:

- Oxygen, Methane and Carbon Dioxide
- Nitrogen
  - Free Nitrogen
  - Orphan Nitrogen
- Hydrogen
- Carbon Monoxide

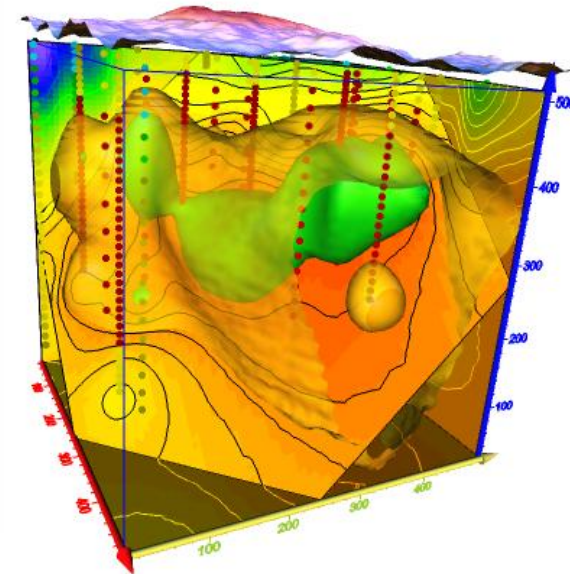
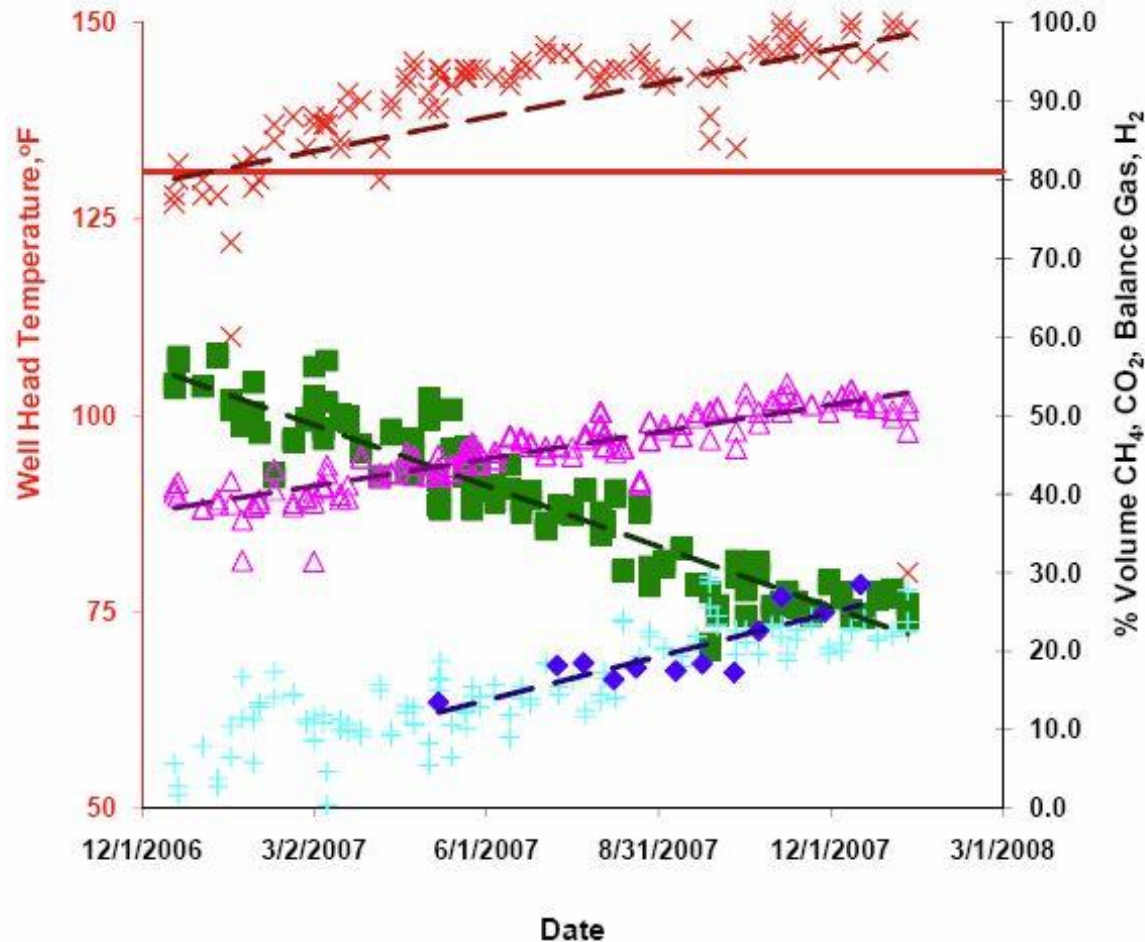


Balance Gas

# Detection – Putting it all together



# Detection – Putting it all together





# Treatment

## Extinguishing:

- In-situ
  - Bury
  - Inert gas/ freeze
  - Foam
  - Deluge
  - Water injection
- Ex-situ
  - Foam and Excavate
  - Excavate and Douse

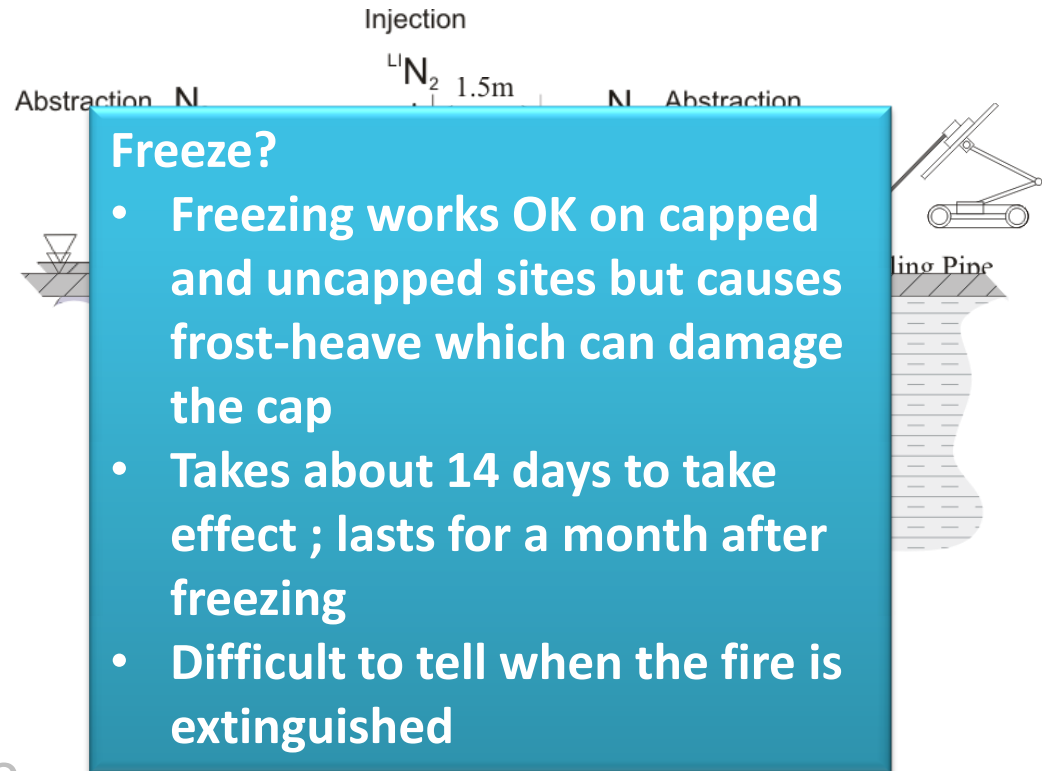
### Bury?

- Very effective
- OK for surface fire a few minutes after ignition
- Dangerous for both shallow and deep seated fires

# Treatment

## Extinguishing:

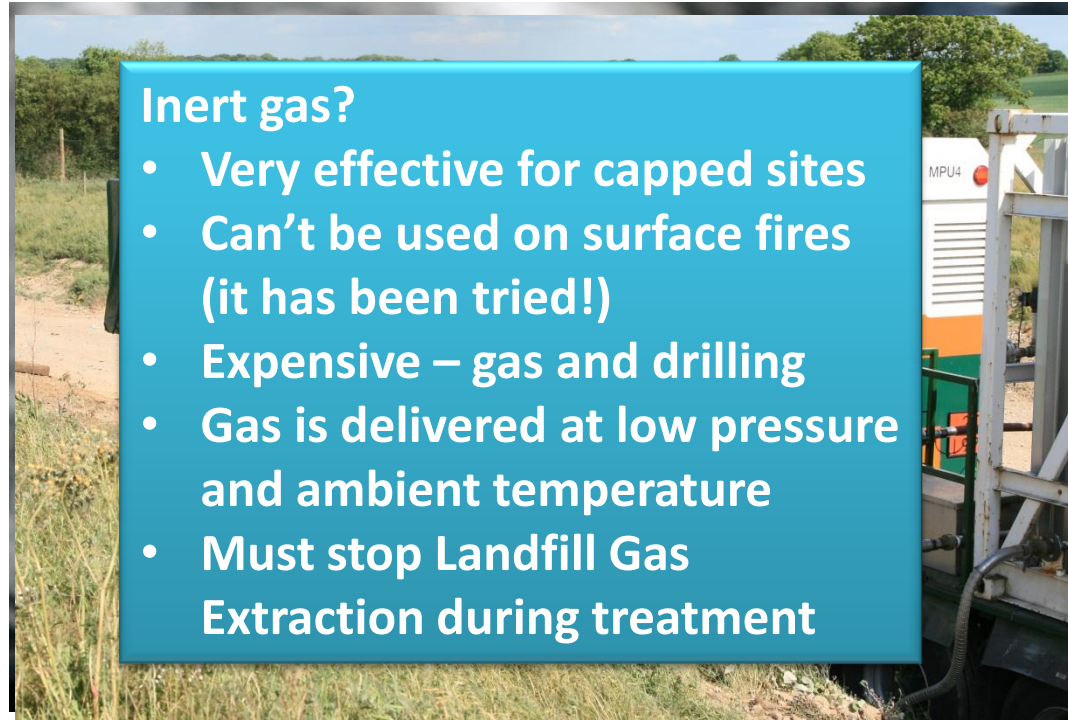
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### Inert gas?

- Very effective for capped sites
- Can't be used on surface fires (it has been tried!)
- Expensive – gas and drilling
- Gas is delivered at low pressure and ambient temperature
- Must stop Landfill Gas Extraction during treatment

# Treatment

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### Foam?

- Cannot be used on windy days



### fish

- Works well on tyre fires



# Treatment

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  - Deluge
  - Water injection
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### Water Injection

- Might cause a water shift reaction on contact with hot carbon – Hydrogen
- Unreliable and only used successfully a small number of times



# Excavation Treatment

Need to form a barrier or cut-off curtain:

- Unsupported excavation
- Gas migration control
- Thermal break
- Fire fighting water

By:

- Ground Freezing
- Grouting
- **Infilling with dense inert material – Clay, Fine Sand**

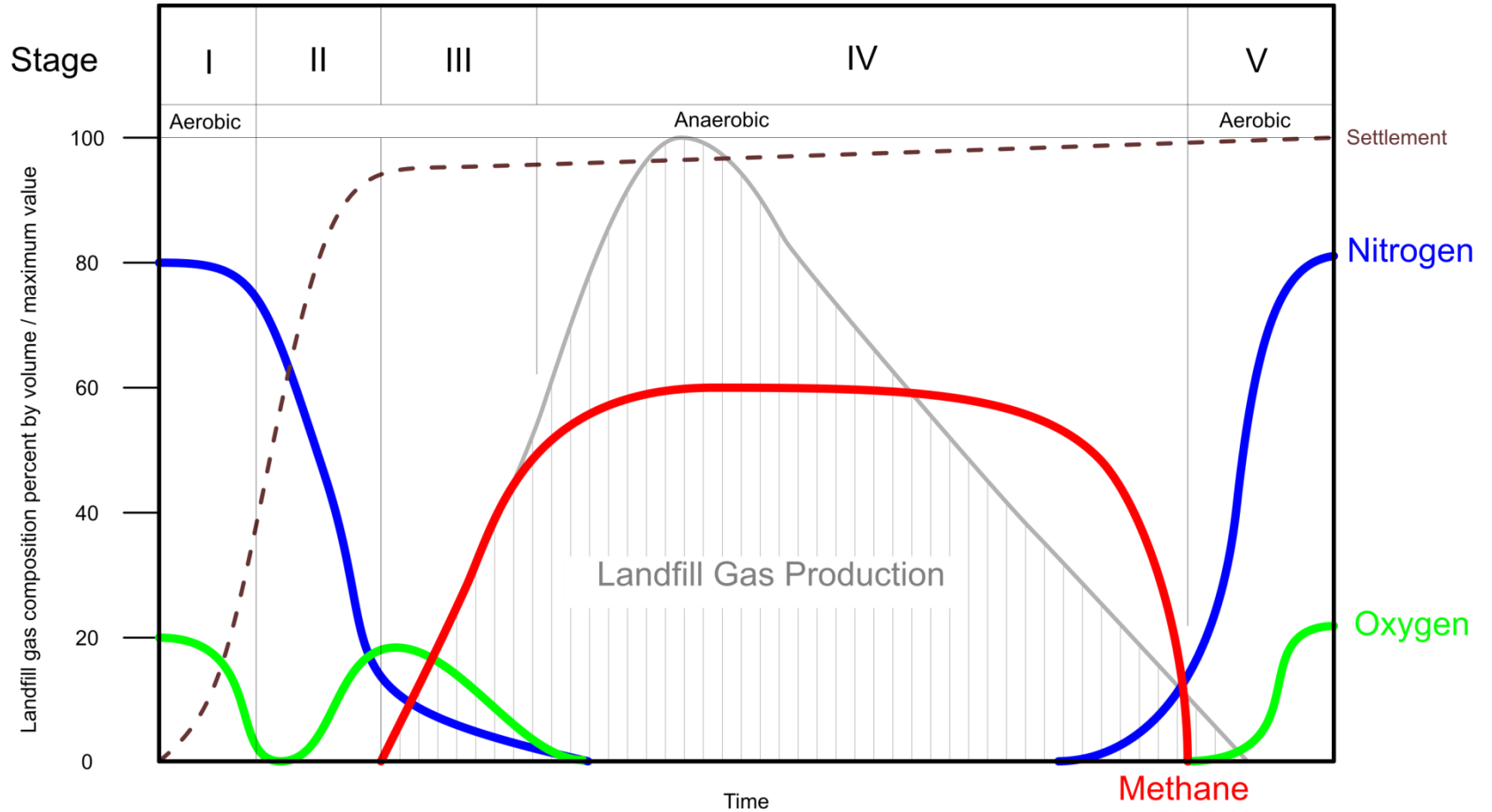
# Conclusions

Opportunities for mitigation are mainly strategic:

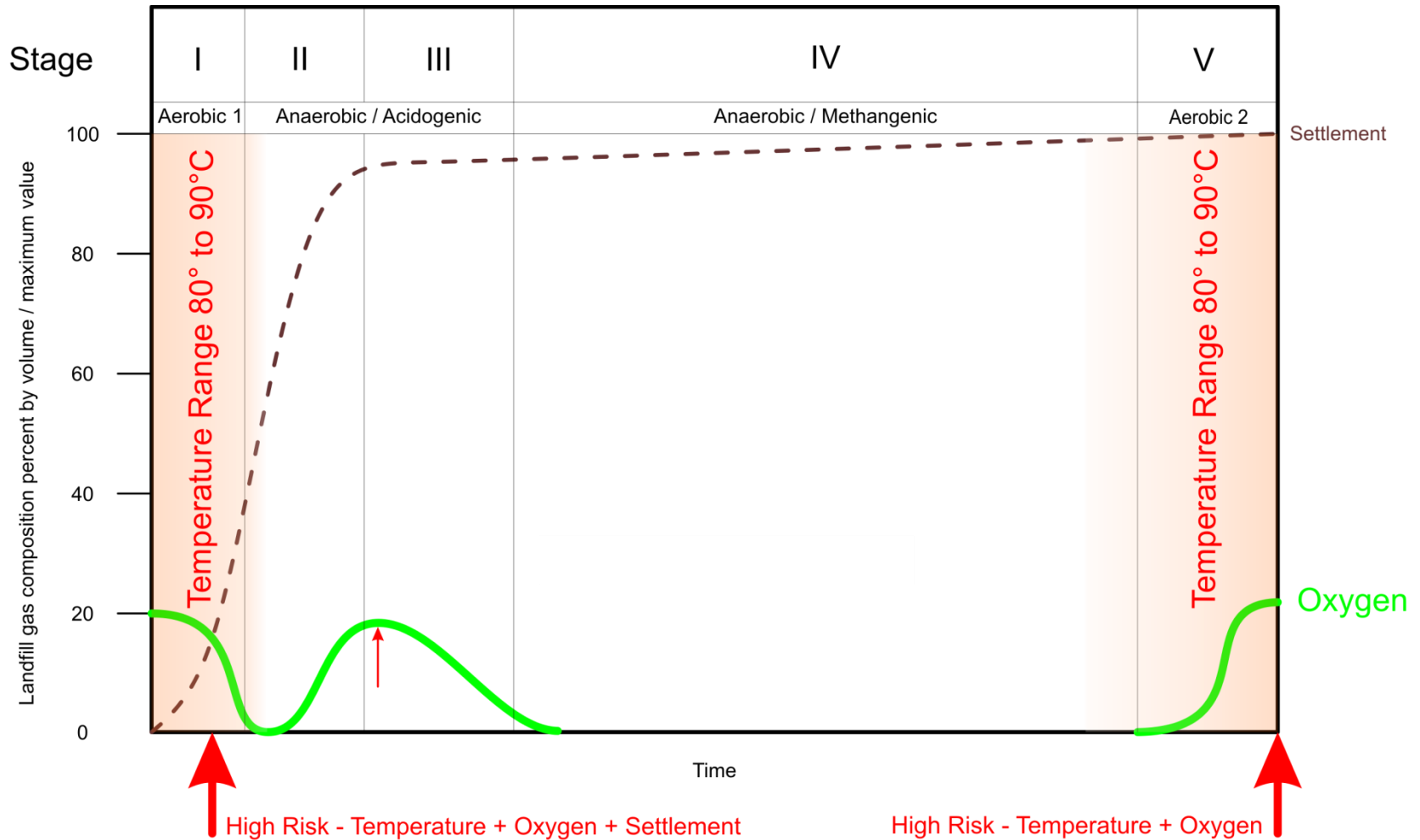
- Change in mindset - Plan for the 'Big Day'
  - Perpetual fuel storage
  - Security, permanent resources, monitoring
  - Special Emergency Events
- Licensing and Regulatory opportunity
  - Leadership – someone has to do it
  - Emergency liaison role?
- Interagency liaison at licencing Stage
- Engineering design
- Emergency contingency planning documentation
- Financing



# Landfill Gas Production



# Landfill Fire Risk



# Critical Temperatures

- **Flash point** – the lowest temperature to which a flammable material must be raised in order to give off a vapour which will burn for an instant.
- **Fire point** – is a few degrees higher than Flash Point and is the temperature to which the material must be raised to continue to burn after the ignition source is removed.
- **Self-Ignition Point** – is higher than the Fire Point and is the temperature to which the material must be raised to give off vapour that will self ignite without an ignition source.
- **Adiabatic Flame Temperature (AFT)** - is the maximum attainable combustion temperature for *general* Municipal Solid Waste (MSW) which is around 1,200°C.

# Gas Concentration – Cause for Concern

Gas	Range of triggers	Comment
Oxygen	>1% to 5%	UK EA >5%
Methane	>32% to 45%	or fast fall >10%
Carbon Monoxide	>0.01% to 0.02%	
Nitrogen	>3% to 19%	Common aim is 7.5 to 15%
Nitrogen : Oxygen ratio	<10 to <20	
Temperature	>3°C	In any 6 week period