The impact of EXtreme weather events on MINing operations

TEXMIN

European Commission

Research Fund for Coal & Steel

# Strategies & Remedial Actions for Impacts and Risks affecting Mining Structures

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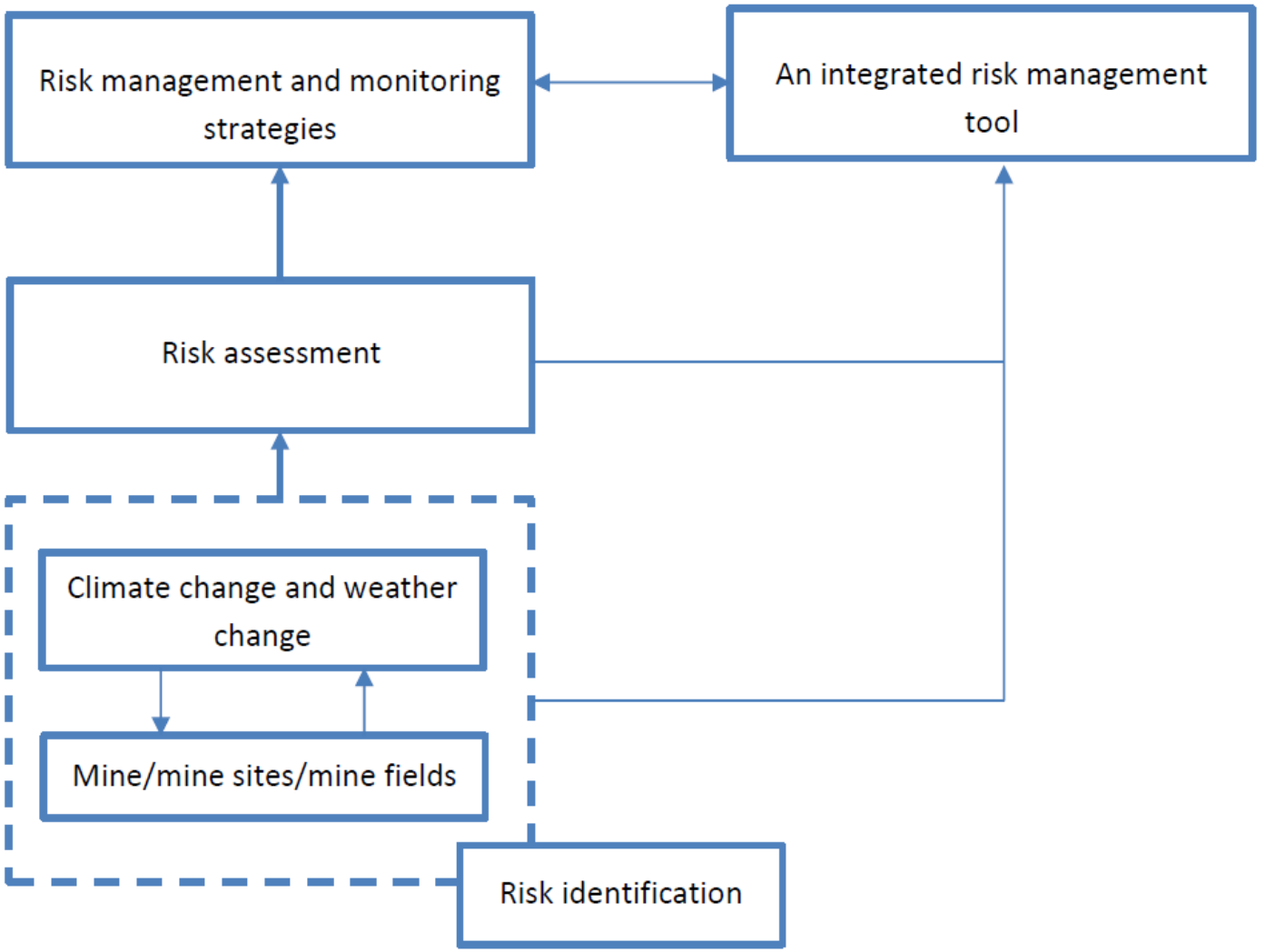
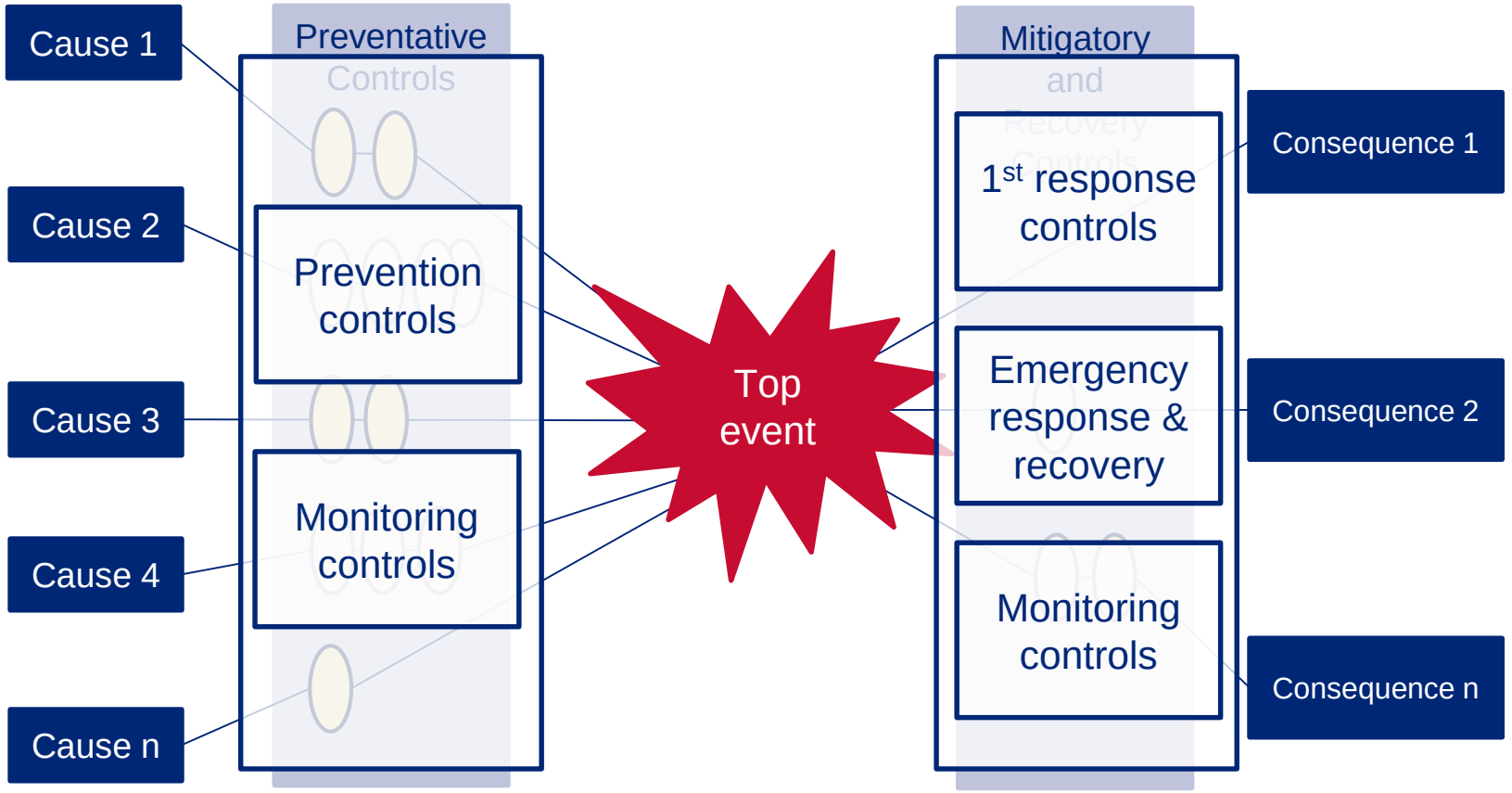
# Risk Management within TEXMIN

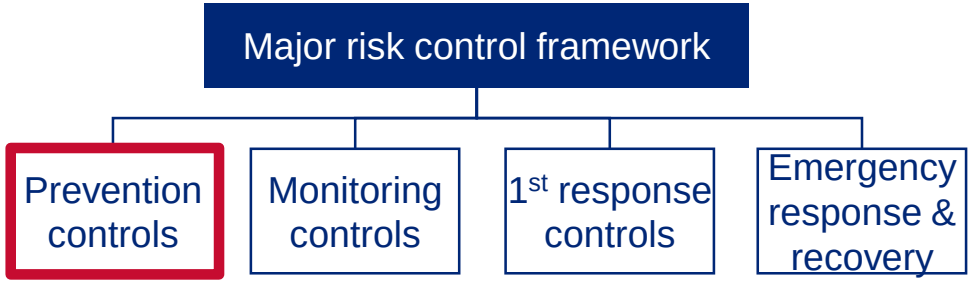


# A Control Framework


Cause 1
Cause 2
Cause 3
Cause 4
Cause n
Preventative Controls
Prevention controls
Monitoring controls
Top event
Mitigatory and Recovery Controls
1st response controls
Emergency response & recovery
Monitoring controls
Consequence 1
Consequence 2
Consequence n

# Prevention Controls

**Climate adaptation**
Can be thought of as activities to avoid, minimise or mitigate the business risks arising from extreme weather events and/or gradual changes in climate. In the context of risk management processes, these adaptations can be thought of as *controls*.





**Avoid impact:** Design options to avoid impacts from weather events and climate change, e.g. avoid landslide risk by choosing alternative transport routes or siting mine on even and flat ground.

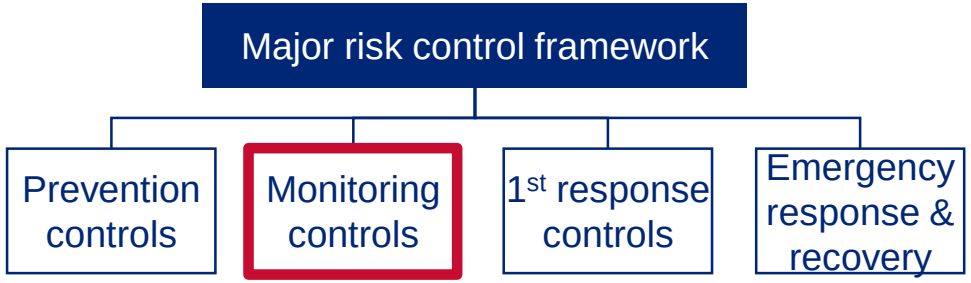
**Minimise impact:** Put in place measures to prevent/minimise the chance of the impact occurring, e.g. improve site drainage capacities to minimise the risk of flooding during periods of heavy rainfall.

**Mitigate consequences**: Put in place measures to lessen the severity of the consequences of weather and climate risks, e.g. employ water conservation measures to minimise the impacts of drought or ensure high value assets are outside flood risk areas.

# Monitoring Controls

Monitoring controls for:

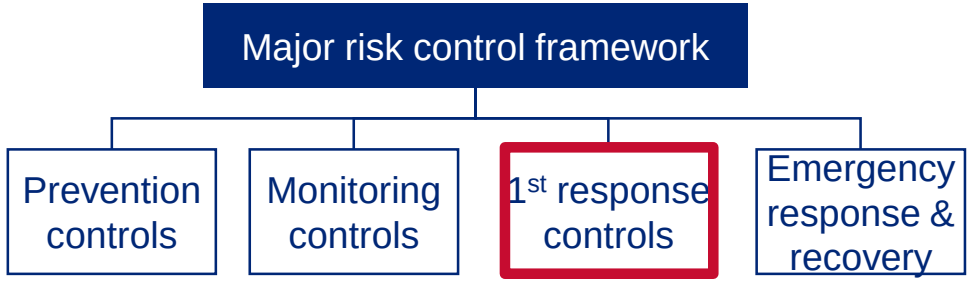
- Hazards
- Controls
  - Prevention controls
  - Recovery measures
- Monitoring of monitoring controls




Automatic monitoring is more reliable than manual monitoring

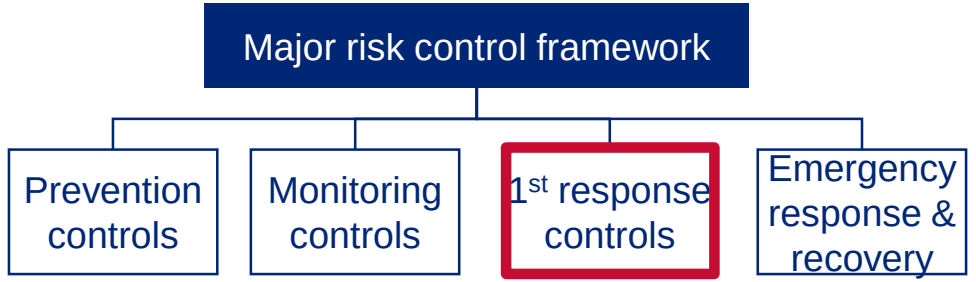
# 1st Response Controls

- Identify and address an unwanted event in very early stages
- Involve early detection and conservative action
- Can be manual or automatic
- Trigger Action Response Plans (TARPs)

# TARPS

Defined indicators that a major unwanted event may have started

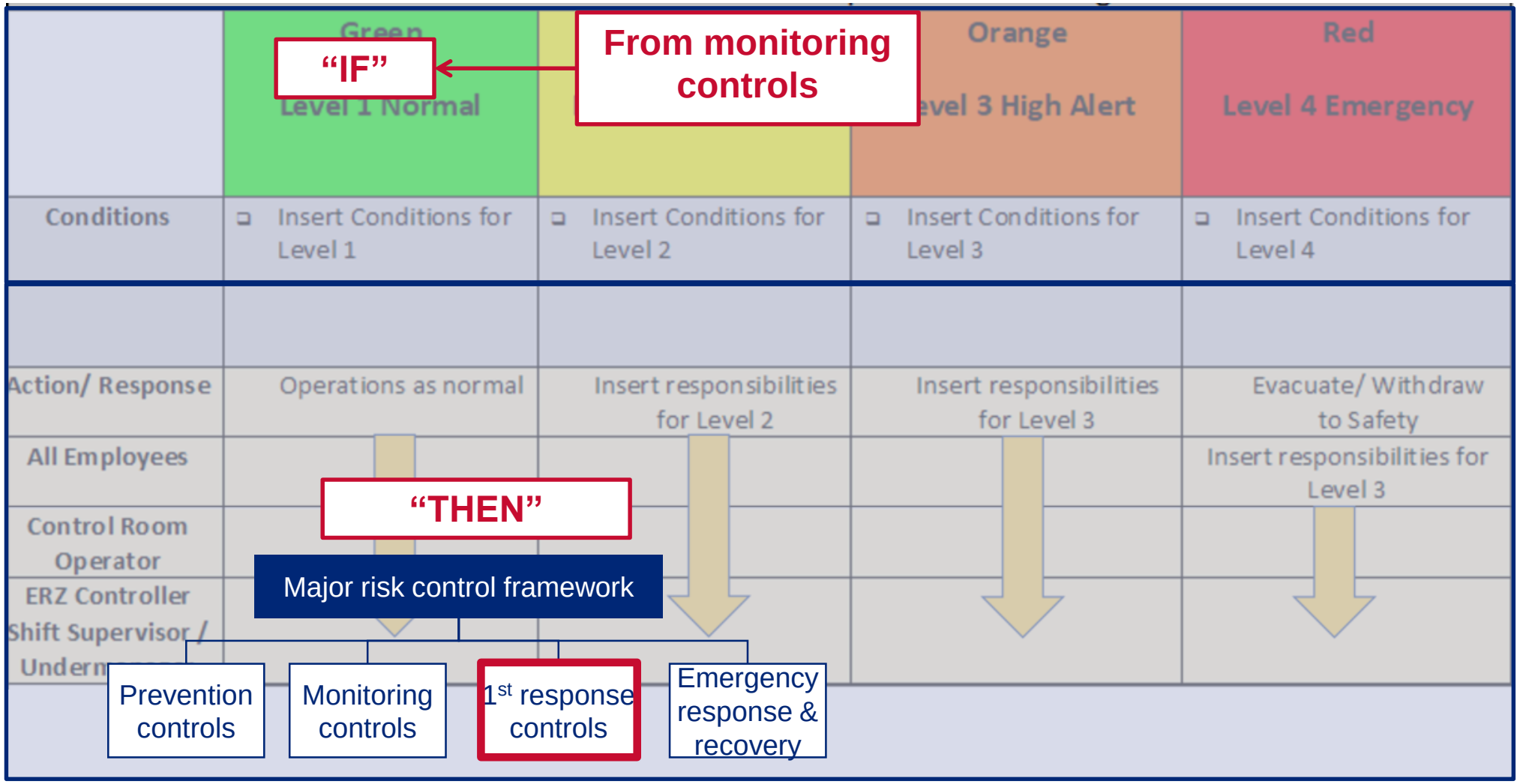



Could be

- Measure of a hazard (eg. CO%)
- Condition of a control (eg. failed sensors)

An ‘If –Then’ statement

# TARPS

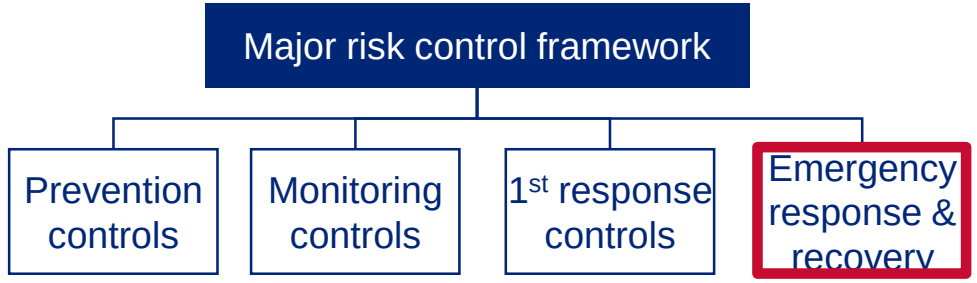

From monitoring controls
"IF"
Green
Level 1 Normal
Orange
Level 3 High Alert
Red
Level 4 Emergency
Conditions
Insert Conditions for Level 1
Insert Conditions for Level 2
Insert Conditions for Level 3
Insert Conditions for Level 4
Action/ Response
Operations as normal
Insert responsibilities for Level 2
Insert responsibilities for Level 3
Evacuate/ Withdraw to Safety
All Employees
Insert responsibilities for Level 3
Control Room Operator
ERZ Controller
Shift Supervisor /
"THEN"
Major risk control framework
Prevention controls
Monitoring controls
1st response controls
Emergency response & recovery

# Emergency Response & Recovery

Amelioration (emergency response + recovery controls to minimise the consequences of a major event including:

- Prevention of a second incident
- Emergency action & rescue
- Medical services & treatment
- Rehabilitation
- Communication
- Business continuity plan

Tailored to suit the specific risks




# TEXMIN Examples

# Monitoring Strategies

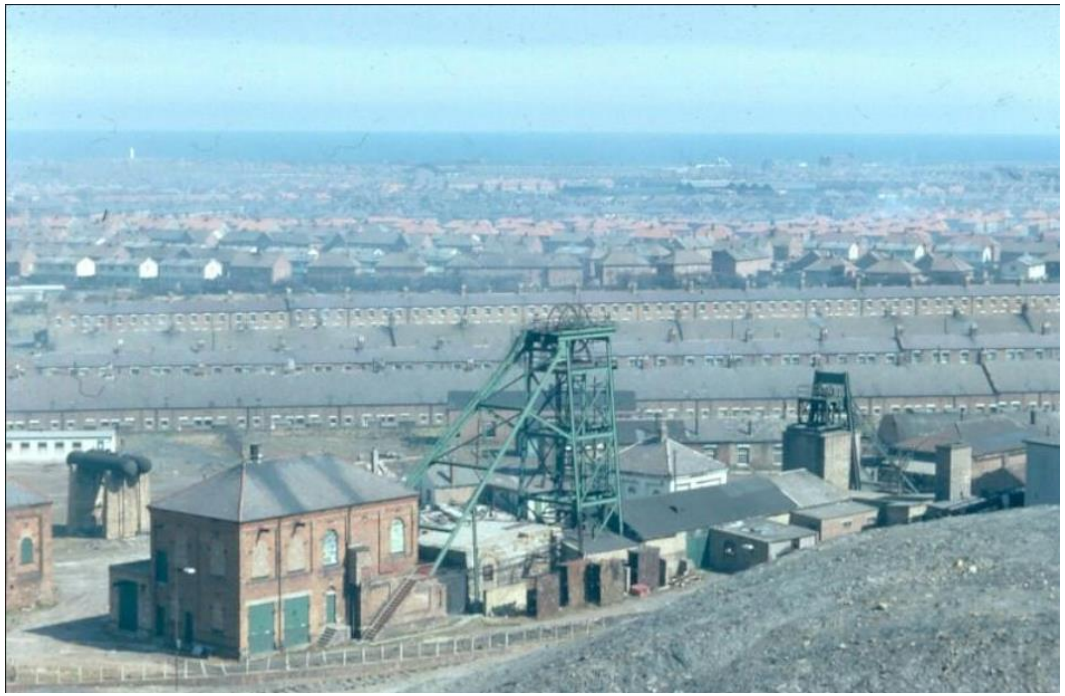
Examples Studied:

- flooding due to runoff from spoil heaps during heavy rainfall events,
- alteration to water level in mines, potentially resulting in flooding in the mine, and changes in the discharge to surface water courses with the possibility of increased pollution,
- spoil heap reclamation, with particular reference to studies in the Czech Republic and UK,
- gas emissions from closed mines,
- stability of tailings dams,
- surface movement on spoil heaps, with the potential of landslides.

# Example: Spoil Tip Flood Modelling

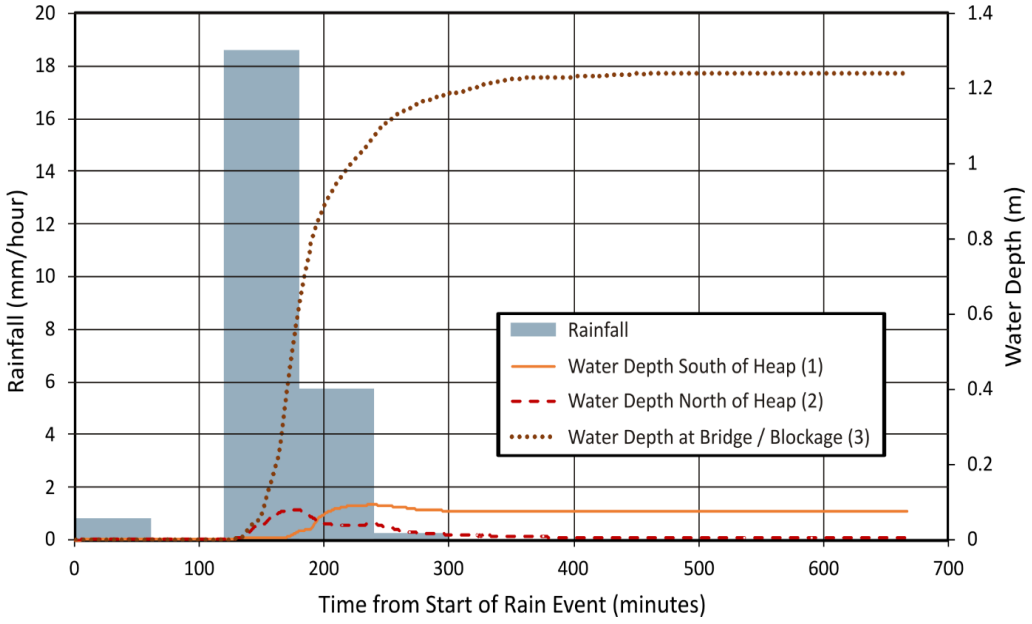
# Flooding from Spoil Tips

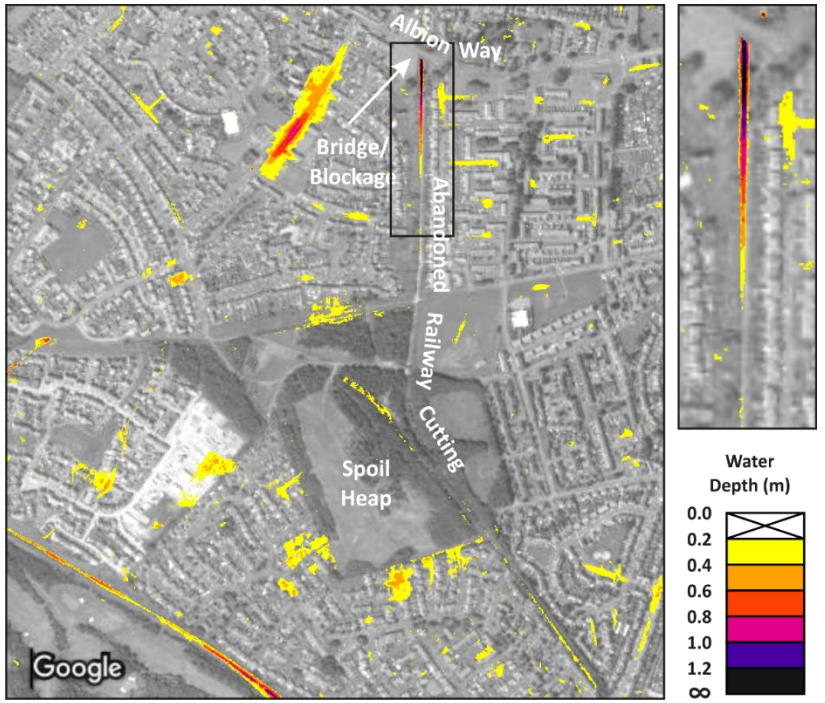
# Isabella Colliery Flood (2012 & 2015)



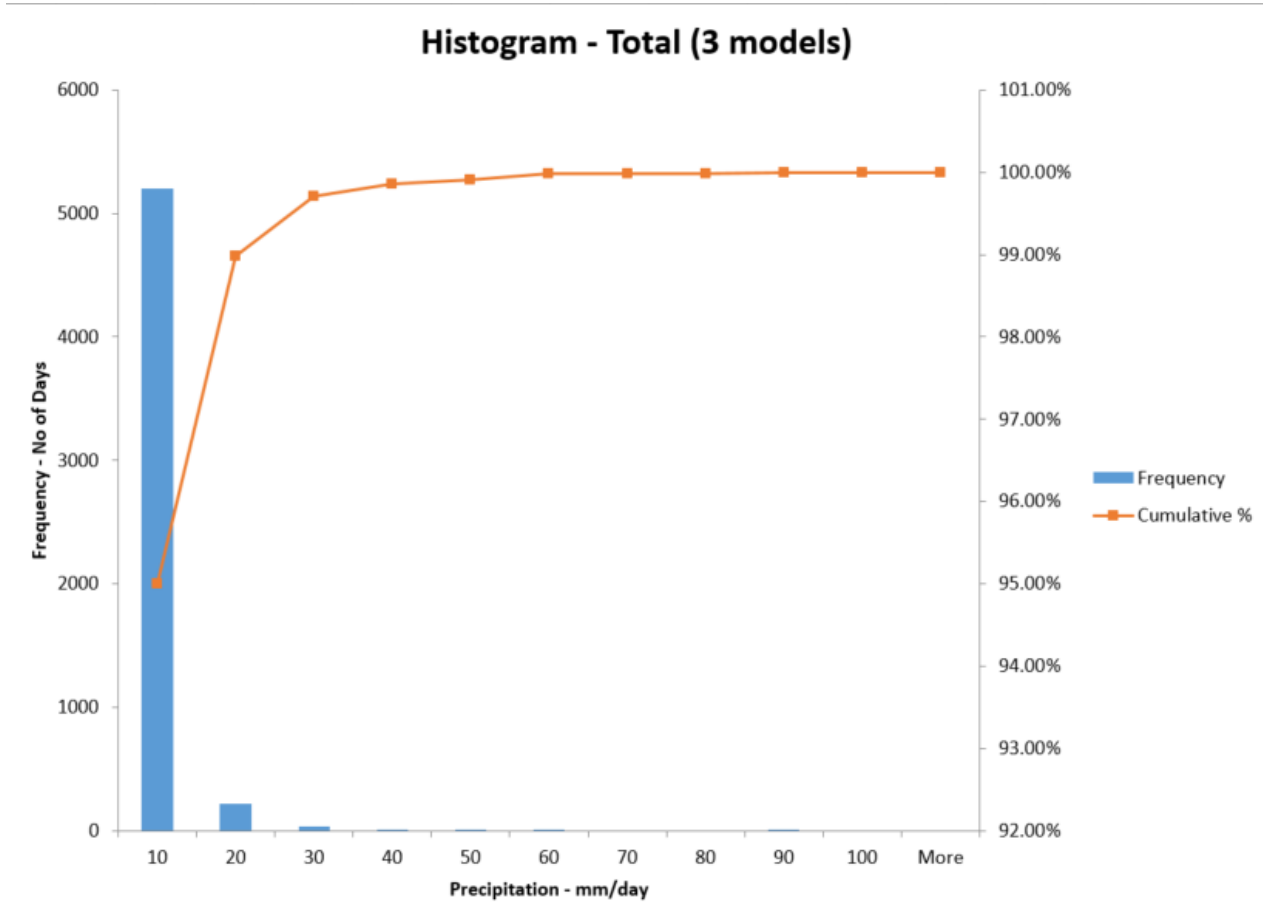
# Flood Modelling

- Used CADDIES software;
  - Inputs DTM, Rainfall data, Infiltration rates
- Modelled the 2012 flooding event.
  - 25.4mm of precipitation, mostly within a five-hour period, with a maximum hourly value of 18.6 mm.



- Euro Cordex 11 data from 3 models was downloaded.
  - CNRM-CM5, EC-Earth and HadGEM2-ES.
- RCP4.5 scenario for the period 1 January 2046–31 December 2050.
- Projected Max was 45 mm in a 24-hour period

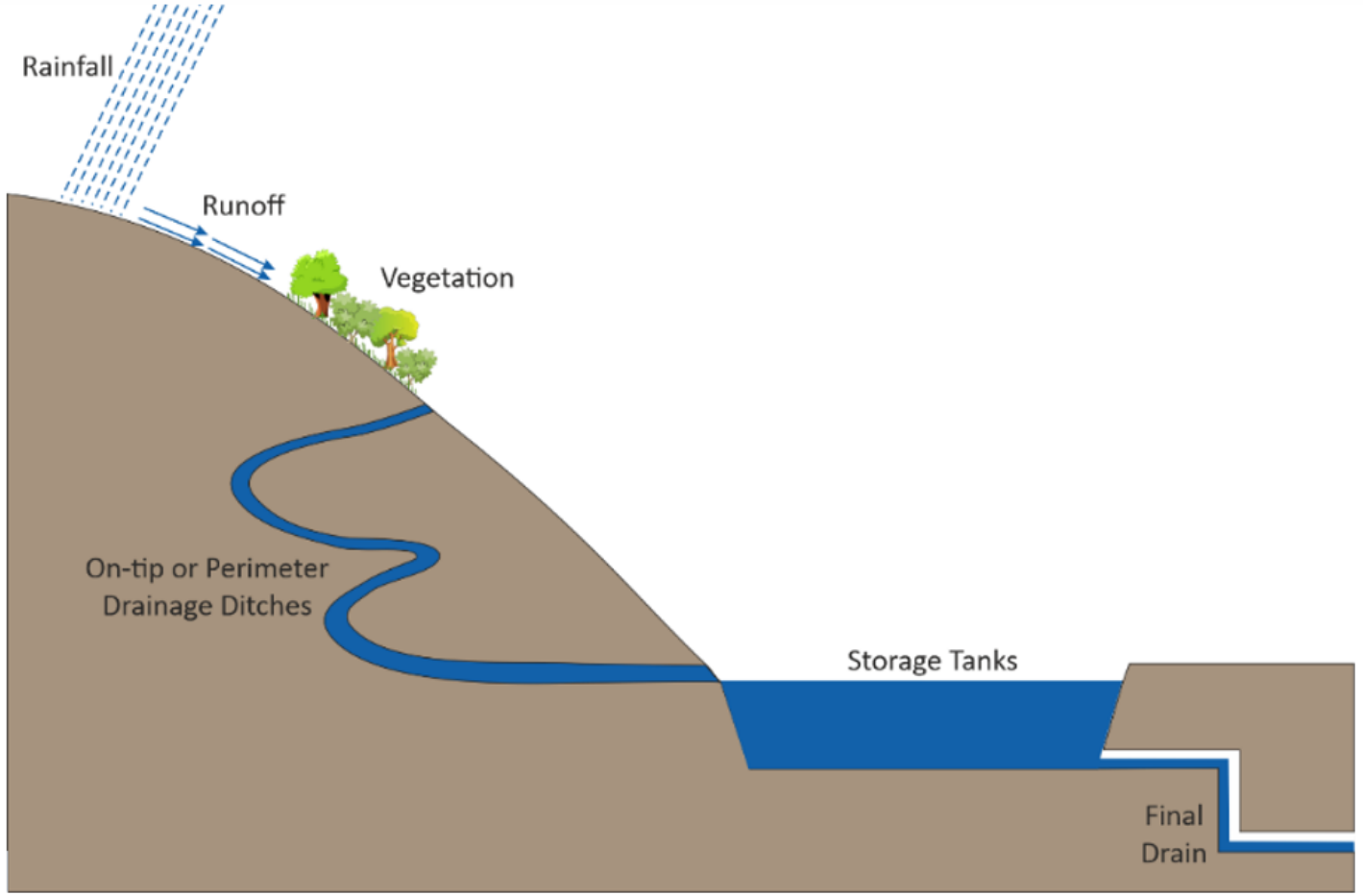



The simulation results were similar to those of the historical flood event, although the depth of water at the northern end of the railway cutting increased to a maximum of approximately 2.0 m.

# Remedial Actions & Monitoring

**Prevention Controls:**

- Spoil Tip Vegetation;
- On tip or perimeter drainage channels
- Settling Ponds
- Off Tip Drainage Systems



# Trigger – Actions – Spoil Tip Vegetation

| TRIGGERS |
| --- |
| • thinning of the vegetation cover,<br>• bare spots emerging in the vegetation cover,<br>• changes to the species of the on-tip vegetation (e.g. from bushes or trees to grass),<br>• The emergence of gullying or an increase in the depth or number of gullies. |
| ACTIONS |
| • undertaking a study to gain more information on the reason for the changes,<br>• planting with suitable species (i.e. those that are effective in improving ground absorption) and are more able to survive the changed climate scenario,<br>• the use of soil additives,<br>• in the case of severe gullying, reprofiling the spoil heap (but only as a last resort). |

# Trigger – Actions – Drainage Channels

| TRIGGERS |
| --- |
| • an increased frequency of clogging of the drainage channels with silt or rocks,<br>• an increased frequency of the drainage channels overflowing during heavy rainfall events,<br>• A more frequent requirement for maintenance/repair of the drainage channels, with the assumption that this is due to higher water volumes or a higher loading of debris being carried in the channels. |
| ACTIONS |
| • increasing the capacity of the drainage channels by making them wider of deeper,<br>• increasing the number of on-tip drainage channels,<br>• Carrying out a fundamental review of the on-tip and perimeter drainage channels with a view to a redesign. |

# Trigger – Actions – Settling Ponds

| TRIGGERS |
| --- |
| • a more frequent requirement for servicing/cleaning of bar screens and grit chambers where on-tip or perimeter drainage channels enter settling tank,<br>• an increased frequency of the settling tanks overflowing during heavy rainfall events,<br>• output from settling tank into final drainage system carrying high volumes of silt,<br>• an increased rate of sediment accumulation in setting tanks, with the potential for clogging,<br>• an increase in the amount of aquatic vegetation in settling tanks, with the potential for clogging. |
| ACTIONS |
| • carrying out a redesign of the bar screens and grit chambers where on-tip or perimeter drainage channels enter settling tank,<br>• increasing the size or number of settling ponds,<br>• reducing the frequency at which settling ponds are dredged,<br>• using chemical treatment to reduce vegetation in settling ponds,<br>• redesigning the settling ponds with the aim of converting them to wetlands, so that a degree of vegetation can be tolerated. |

# Trigger – Actions – Off Tip Drainage

| TRIGGERS |
| --- |
| • a more frequent requirement for servicing/cleaning of bar screens and grit chambers where on-tip or perimeter drainage channels enter the final drainage (assuming there is no settling tank),<br>• clogging of off-tip final drainage system due to silt or rock,<br>• off-tip final drainage system capacity exceeded during heavy rainfall events. |
| ACTIONS |
| • increasing the capacity of the final drainage system by making the channels wider of deeper,<br>• Carrying out a fundamental review of the final drainage system with a view to a redesign. |

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