Fire Engineering Consultants

Ulster University – An Engineers Approach

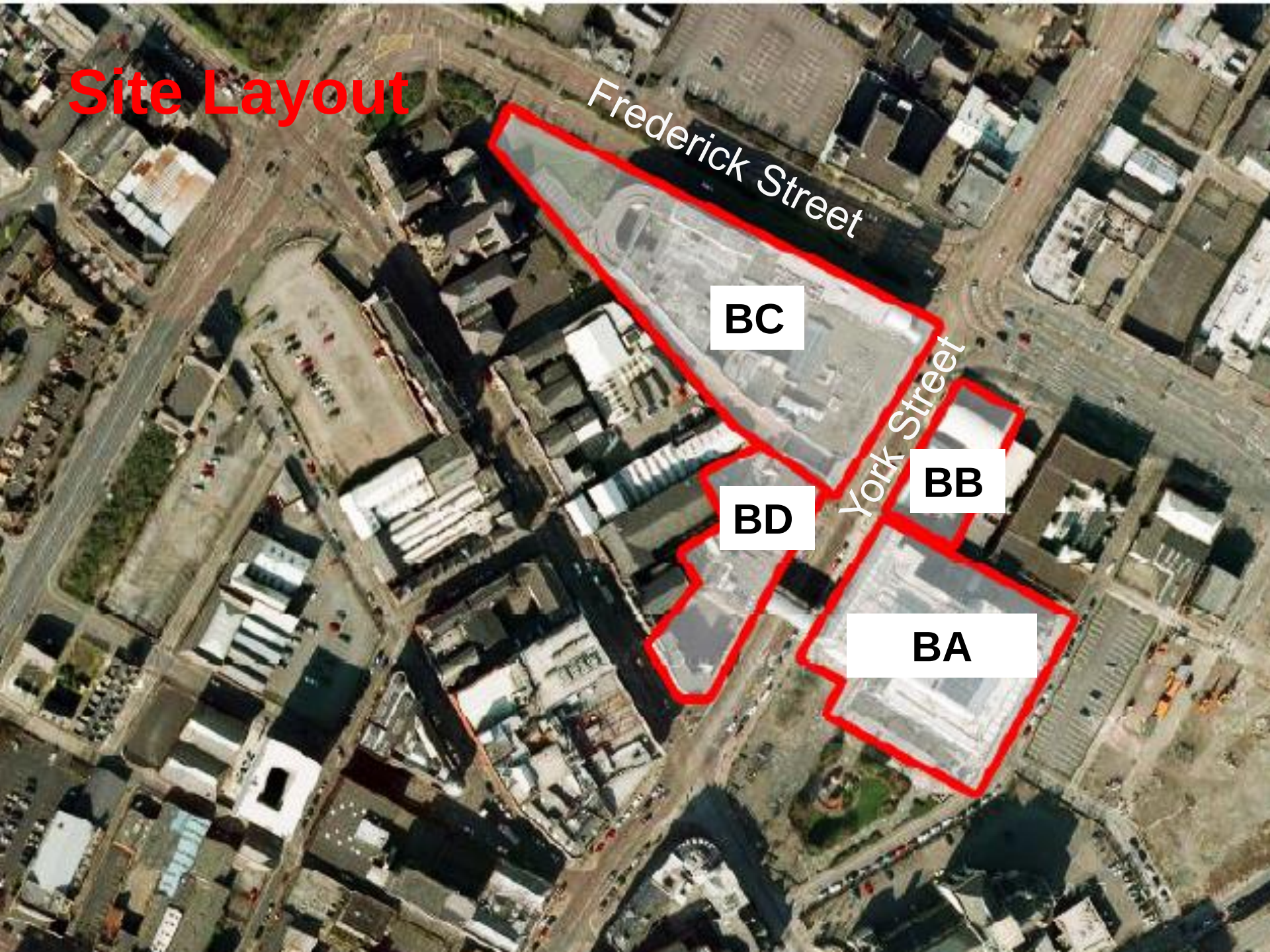
Tony McParland

Fire Safety Conference – Armagh, 7th February 2019

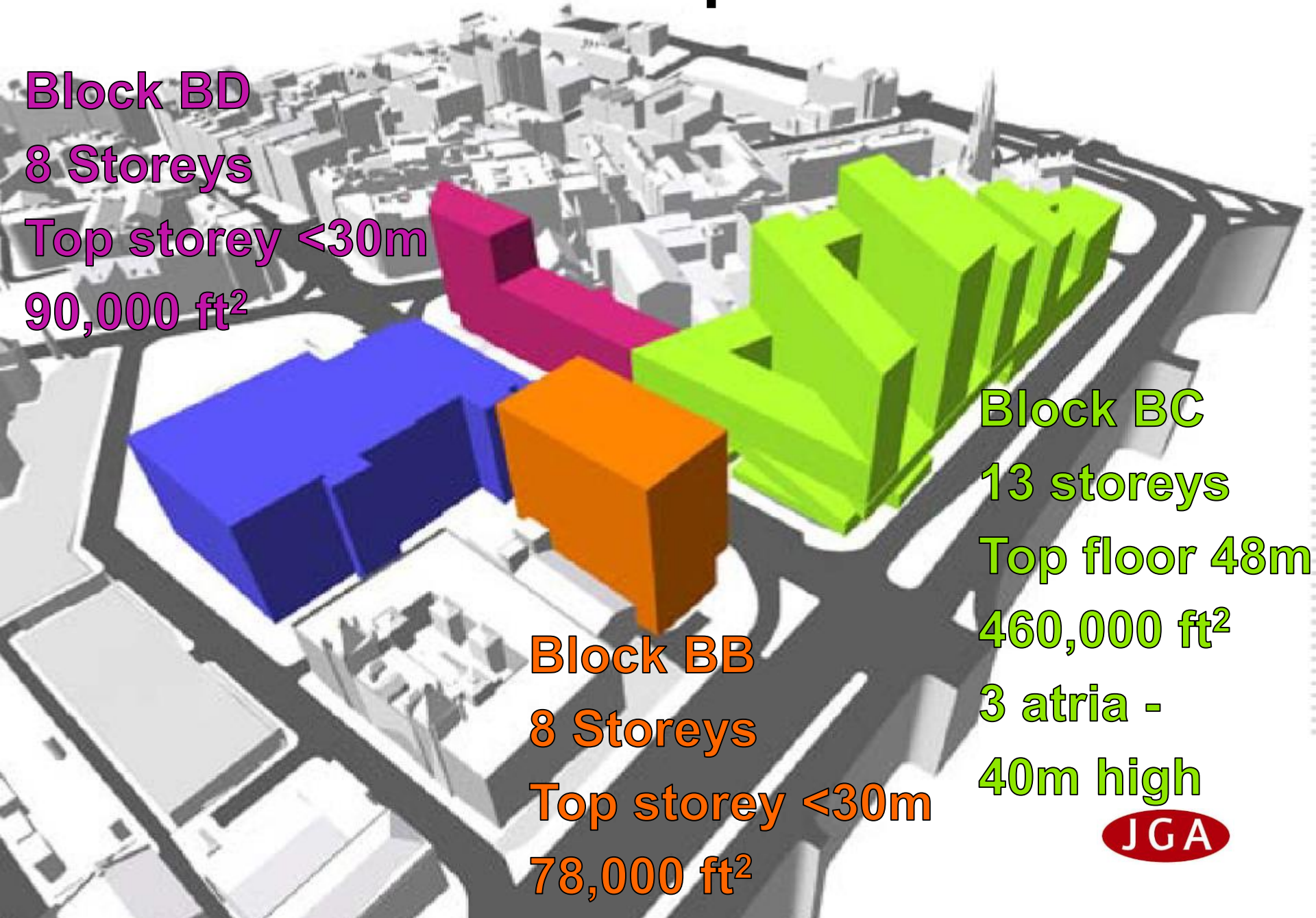
Belfast • London • Dublin • Edinburgh • Galway • Manchester • Glasgow

Ulster University - Greater Belfast Development

Site Layout



Block Composition



Design Challenges

- Means of Escape
  - Occupancy v stair requirements
  - Atria design – Block BC
  - Escape towards voids
- Construction & Compartmentation
  - One building or three?
    - Fire resistance & sprinklers
- Elevations
  - Large compartments
  - Proximity issues
- Fire Fighting
  - No. of Cores
  - Smoke venting measures.

Means of Escape

- Occupancy
  - 15,000 Students (10,500 FT) & 2,500 Staff
  - Unrealistic for all areas to be simultaneously occupied
  - Calculated campus occupancy total = Approx 14,500
- Stair Design Considerations
  - Travel distances
  - Building height
    - Geometry
  - Occupancy distribution
  - Provisions for disabled occupants
  - Evacuation strategy
    - Influenced by other elements of design.

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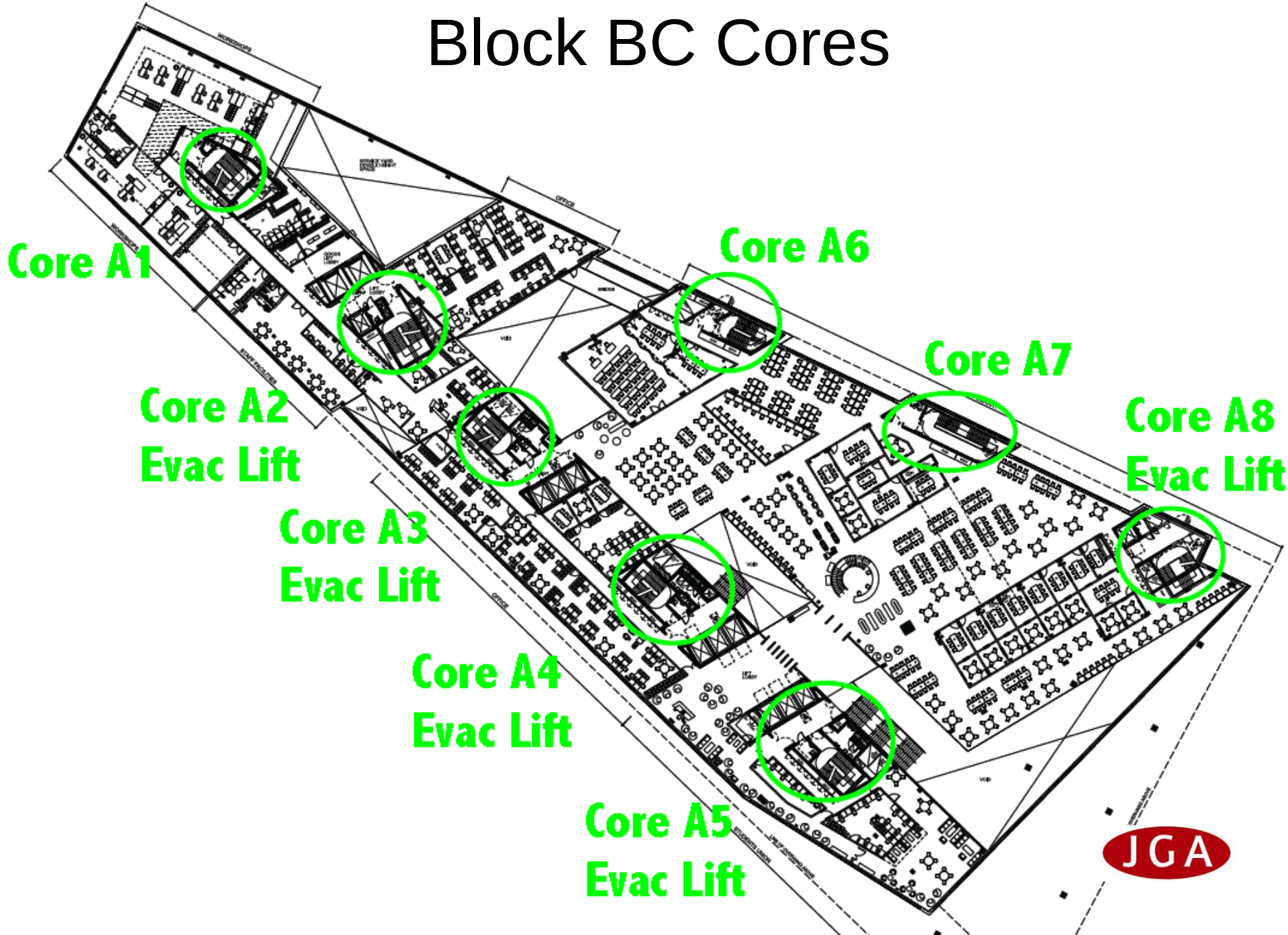
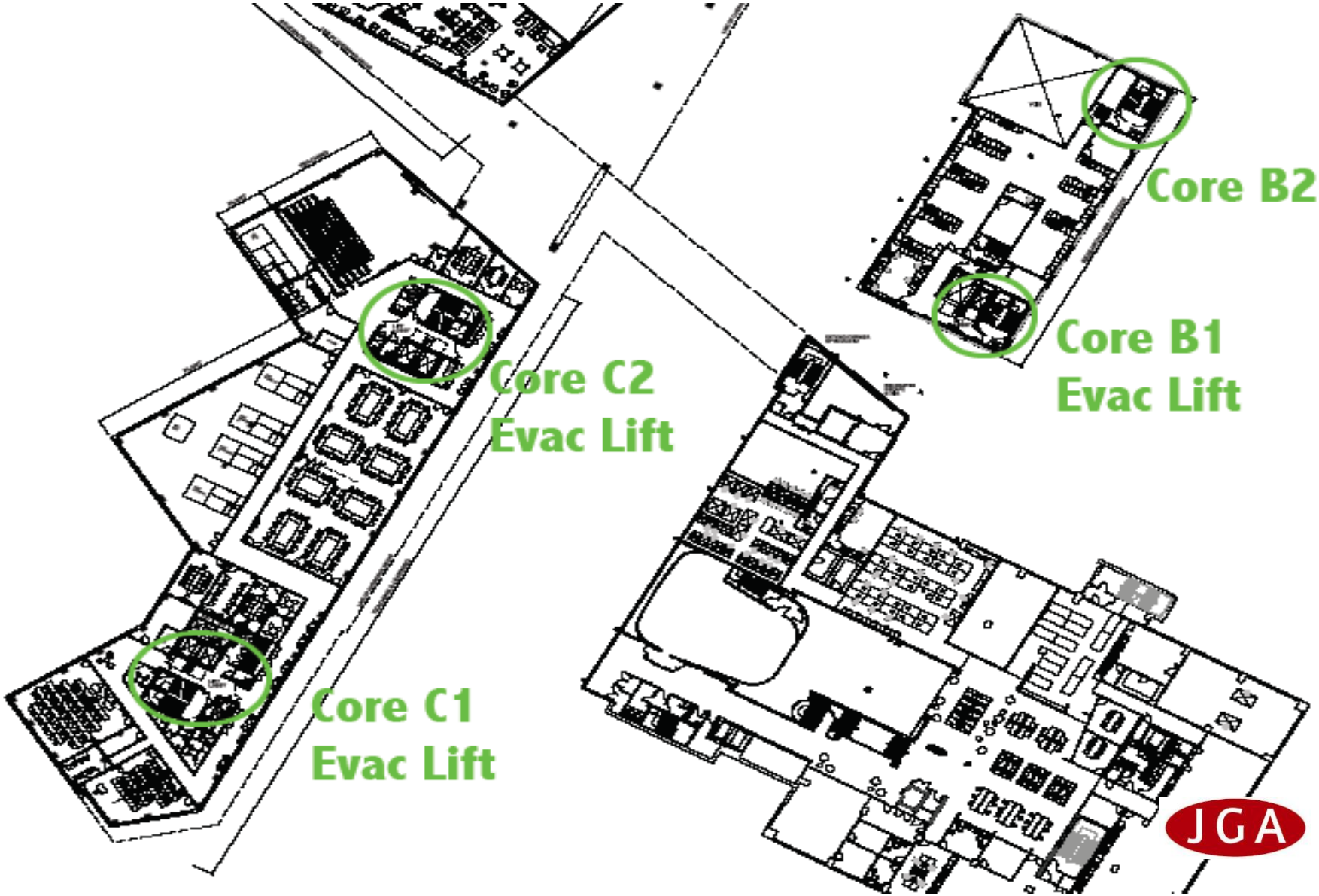
Block BC Cores



Blocks BD & BB Cores



Means of Escape

- Storey Exits
  - Transient accommodation
- Core Final Exits
  - Fire Protection
  - Factors impacting on width
- Protection of cores – dual entry lifts
- Travel distance extensions
- Dead end corridors
- Escape towards the void
  - CFD validation.

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Fire Safety Features

- Automatic Fire Detection
- Voice Alarm
- Sprinklers – Block BC only
- Smoke Control Provisions
- Emergency lighting & Exit Signage
  - Block BC internally lit signage.
- Building geometry.

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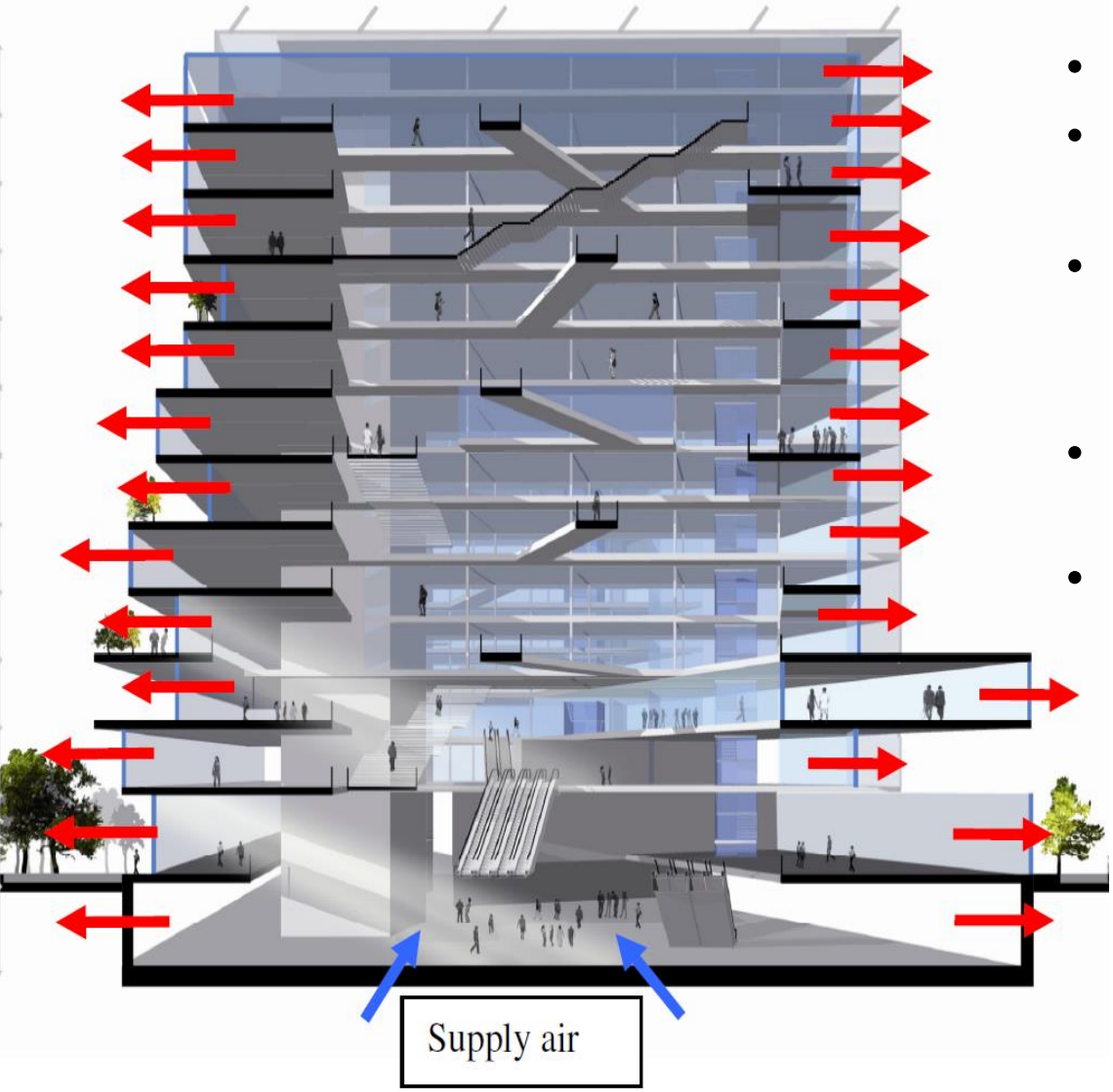
Block BC Atria Design

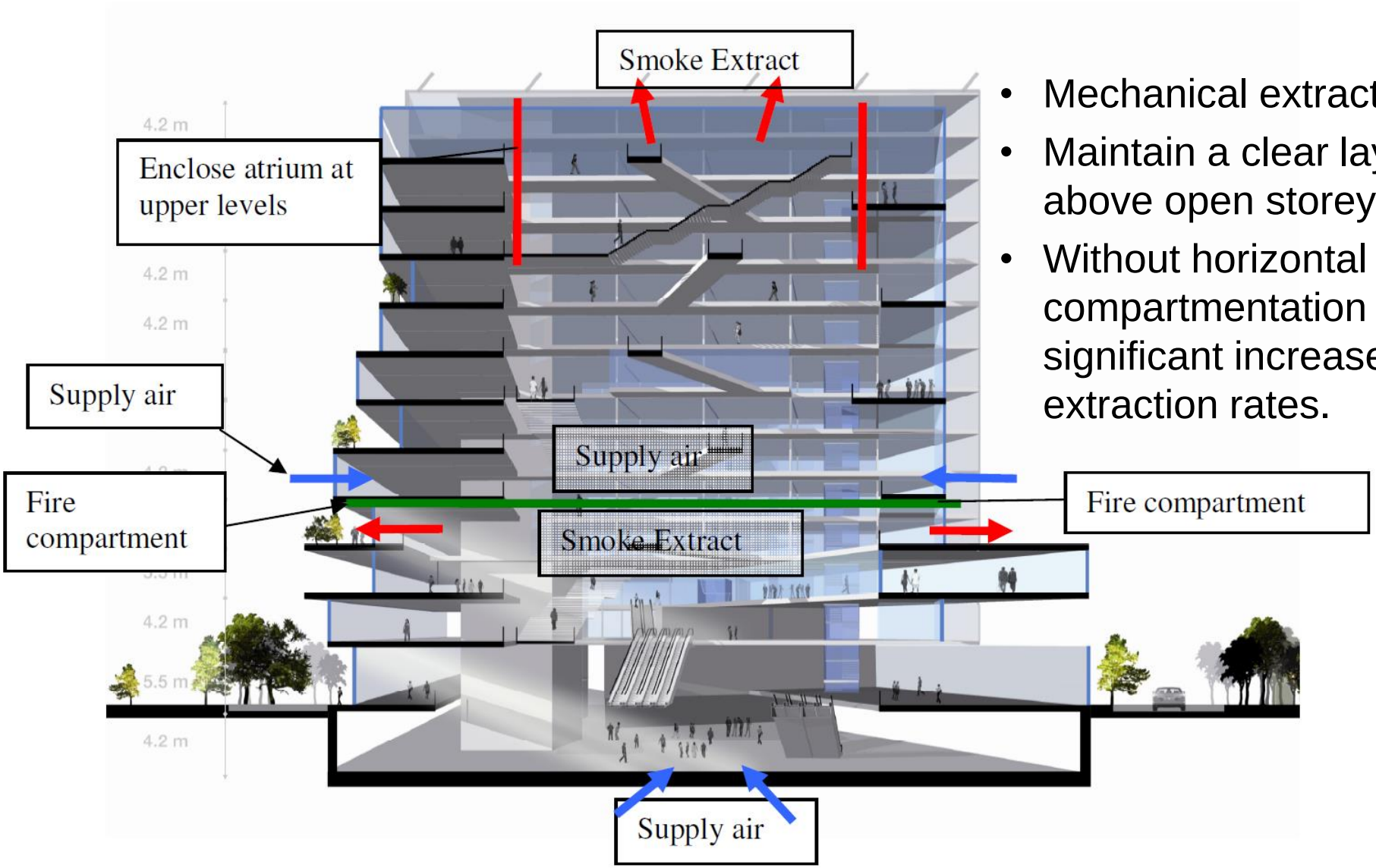
- Full height atrium
  - Connecting basement to roof level
  - 3 atria formed between accommodation blocks
  - Top roof level - 40m above ground
- Accommodation
  - Open between levels - 01 & + 03
  - Substantially enclosed above level +03
- Proposed separating construction
  - Permanent construction (solid walls & glazing)
    - Sound & safety purposes
- Footprint reduces as height increases
  - Structure above atria roofs.

Code Compliance



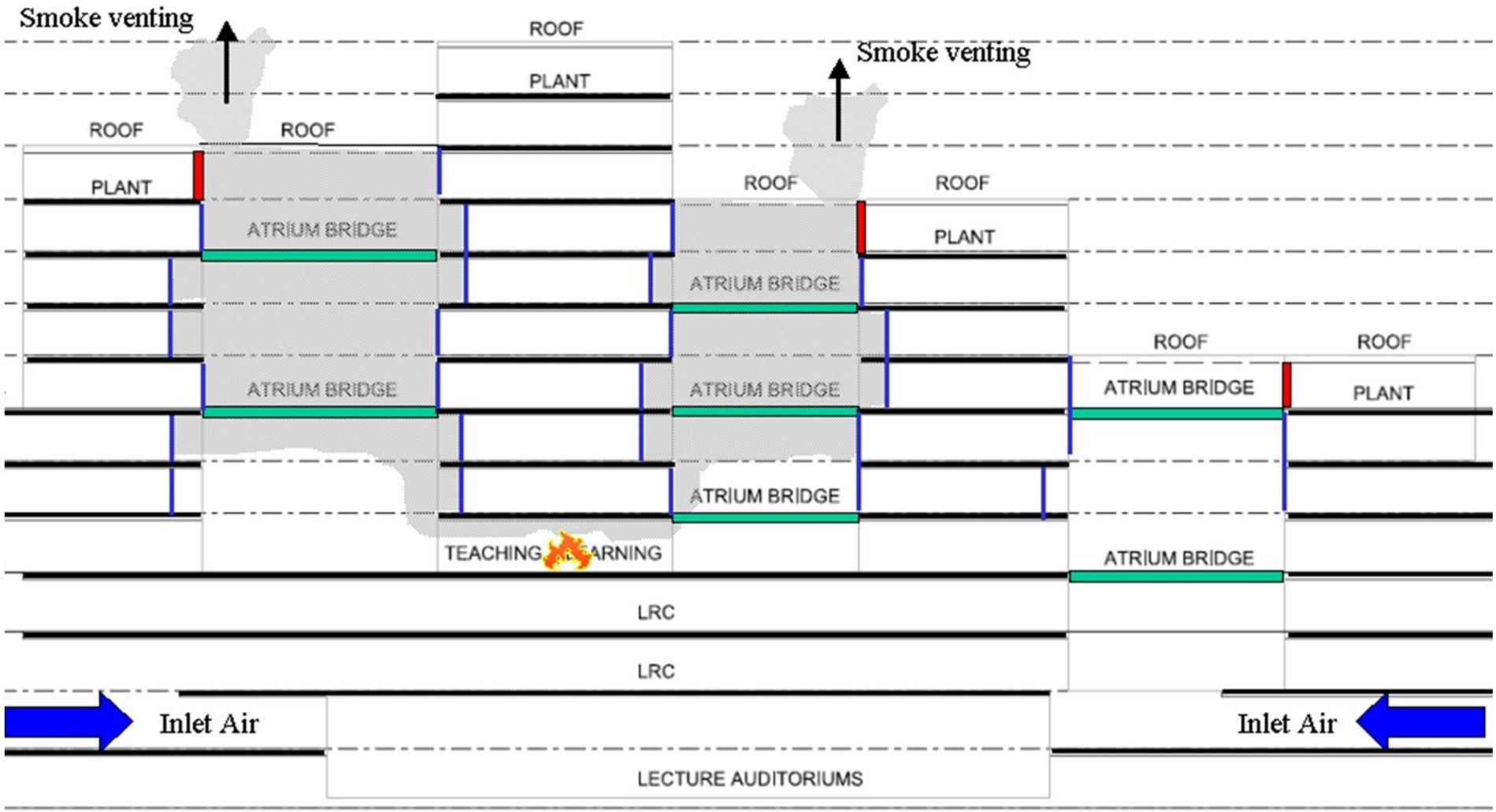
- Atria height >30m
- Option 1: Open accommodation
  - Storey extract each level
- Option 2: Accommodation fully enclosed from atria
  - Temperature Control
- Limitations on fire loading in atria base common for both
- Proposed combination of open accommodation on lower levels & substantially enclosed at high levels
  - Outside guidance scope
  - Fire engineering solution required.

Initial Advice – Before JGA Appointment



- Mechanical extract
- Maintain a clear layer above open storeys
- Without horizontal compartmentation significant increase in extraction rates.

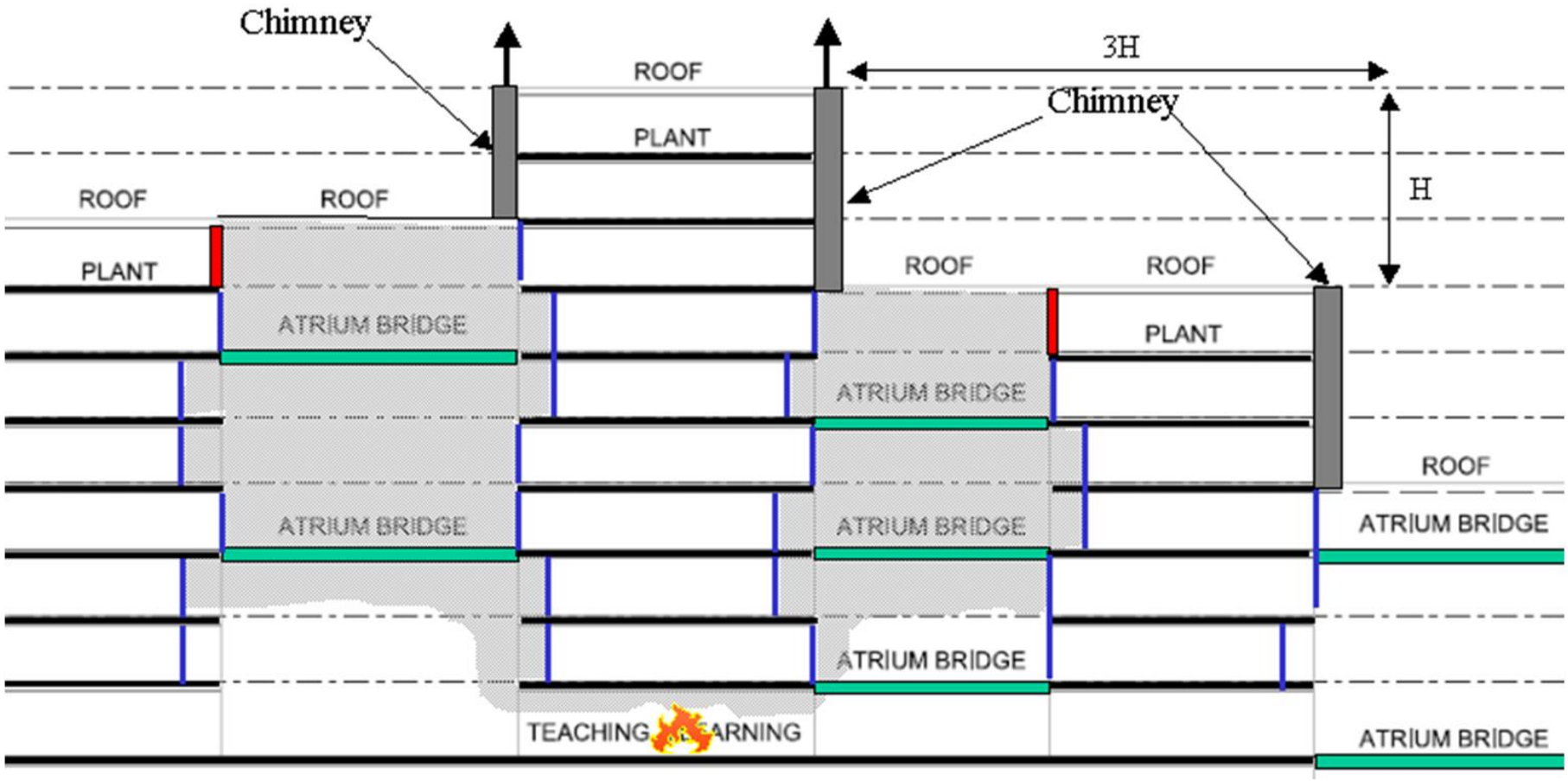
Atrium Solution



Plant rooms separated from atrium by fire resisting construction

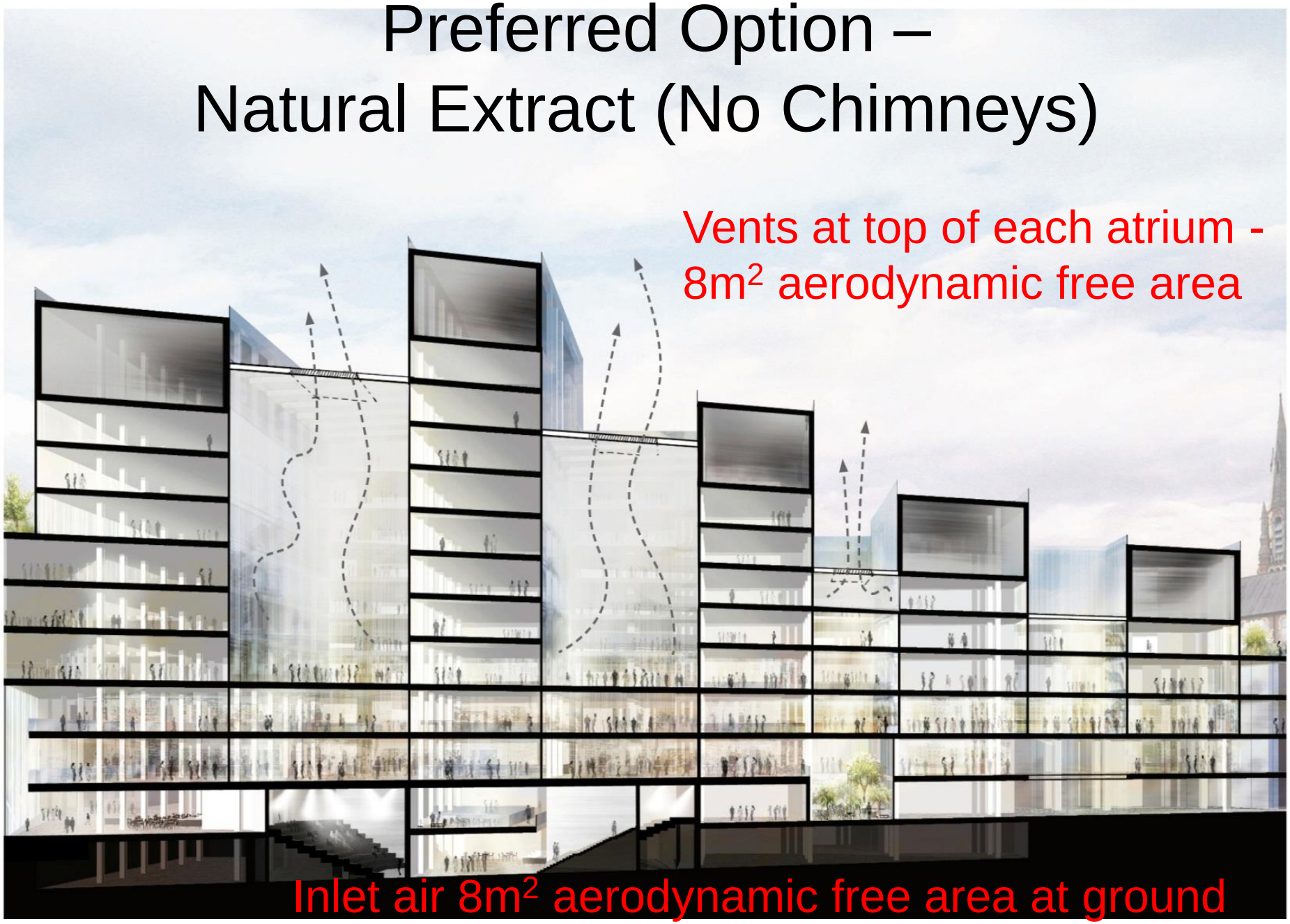
Accommodation above level +3 separated from atrium by smoke retarding construction.

Atrium Venting Options



- Natural vents preferred option
  - Chimneys / smoke shafts can ensure efficiency of natural system
  - External CFD study – impact of wind overpressures.

Preferred Option – Natural Extract (No Chimneys)

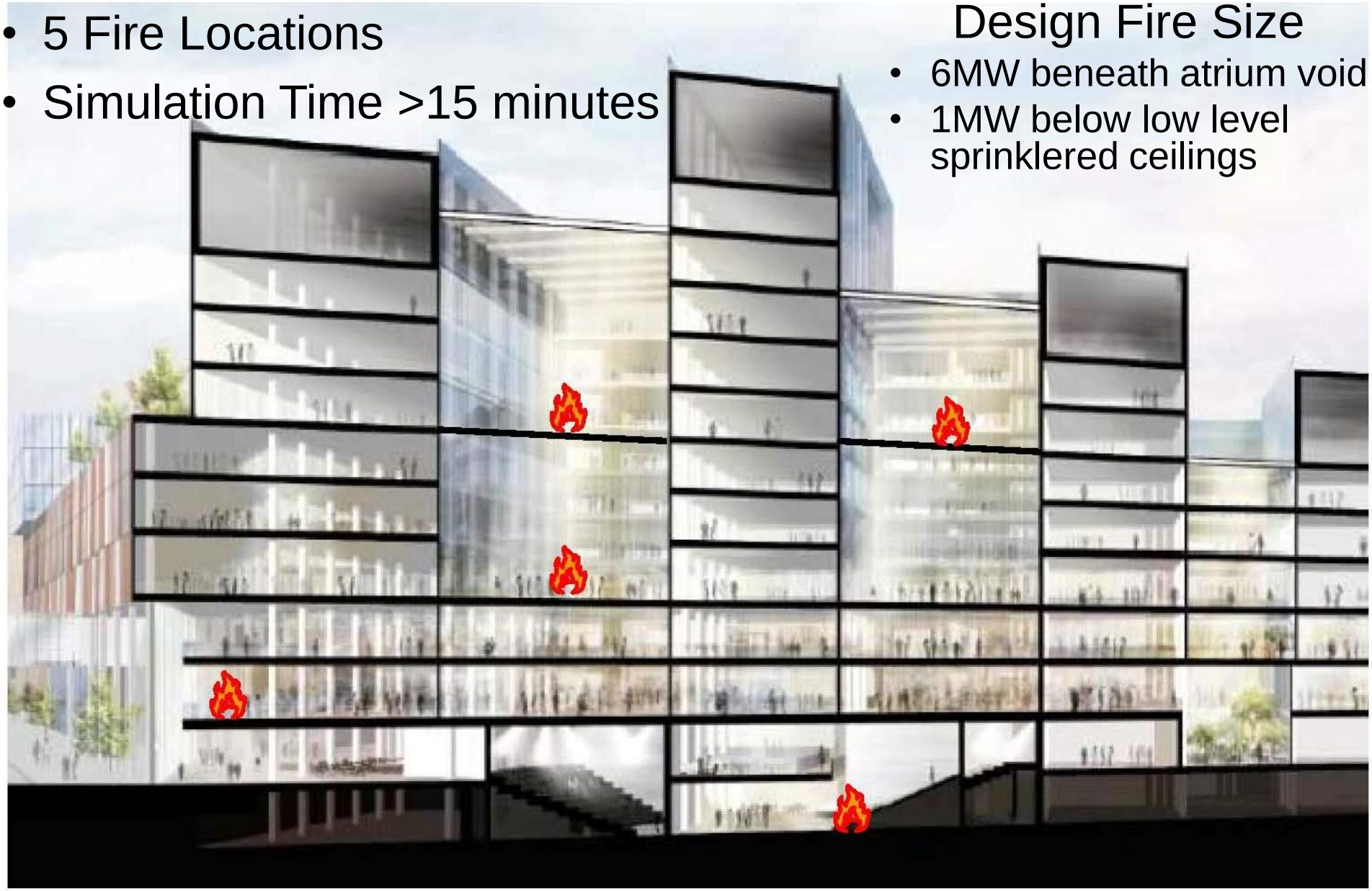


CFD - Fire Scenarios

- 5 Fire Locations
- Simulation Time >15 minutes

Design Fire Size

- 6MW beneath atrium void
- 1MW below low level sprinklered ceilings



Internal CFD Results – Natural Extract

- Tenability criteria
  - Temperature
  - Toxicity
  - Visibility
- Simulations > 16.5 minutes
- Tenability limits generally not reached
  - Visibility limit reached worse case 13 minutes - basement
    - Onerous assumptions – high soot yield use & Fire Size
- ASET v RSET.

Level +06 Fire: No Wind

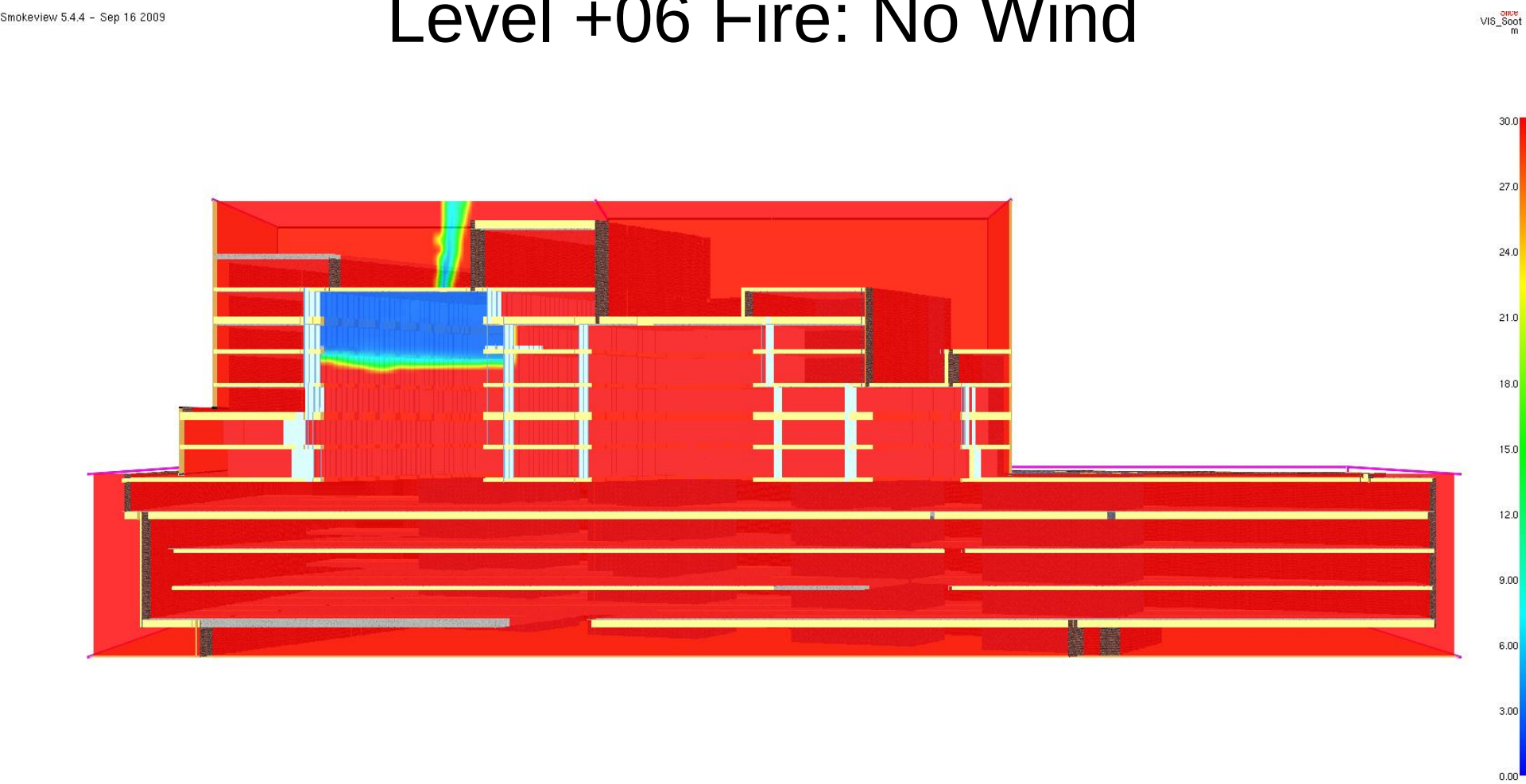
Growing fire 6th floor bridge within atrium at 1000s
Temperature: Scale 20°C – 100°C

Level +06 Fire: No Wind

Growing fire 6th floor bridge within atrium at 1000s

Carbon Monoxide: Scale 0ppm – 125ppm

Level +06 Fire: No Wind



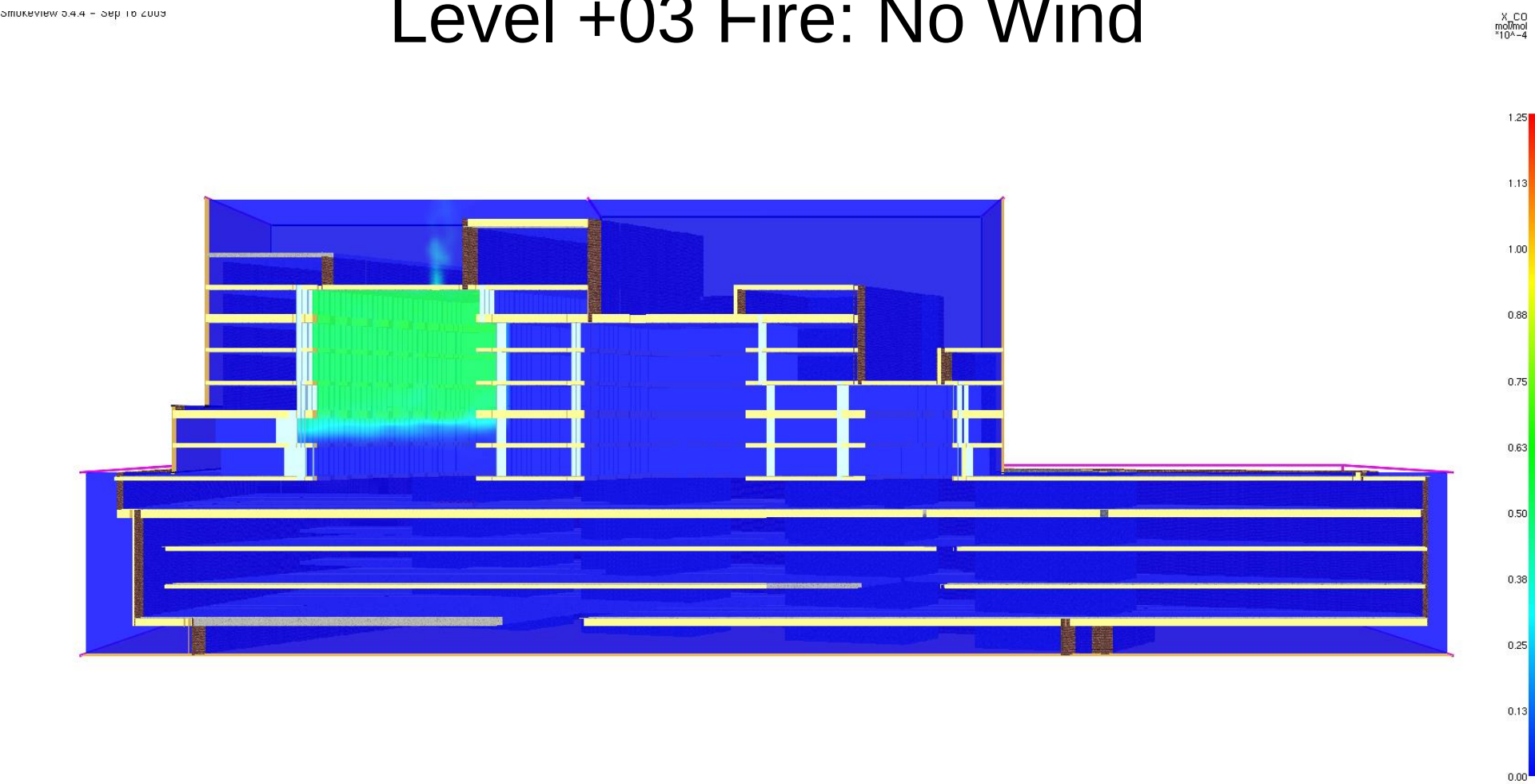
Growing fire 6th floor bridge within atrium at 1000s

Visibility: Scale 0m – 30m

Level +03 Fire: No Wind

Growing fire 3rd floor under void at 1000s
Temperature: Scale 20°C – 100°C

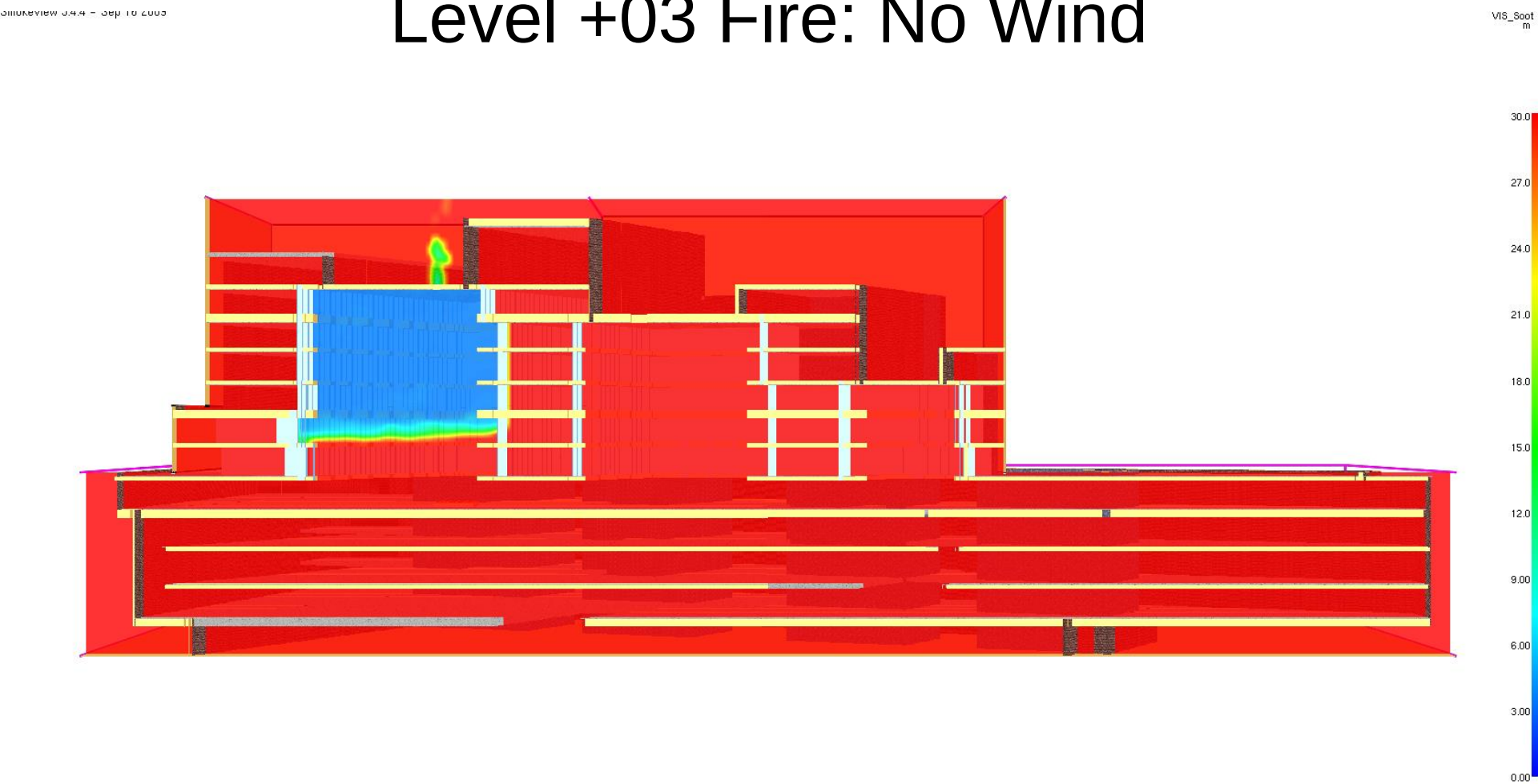
Level +03 Fire: No Wind



Growing fire 3rd floor under void at 1000s

Carbon Monoxide: Scale 0ppm – 125ppm

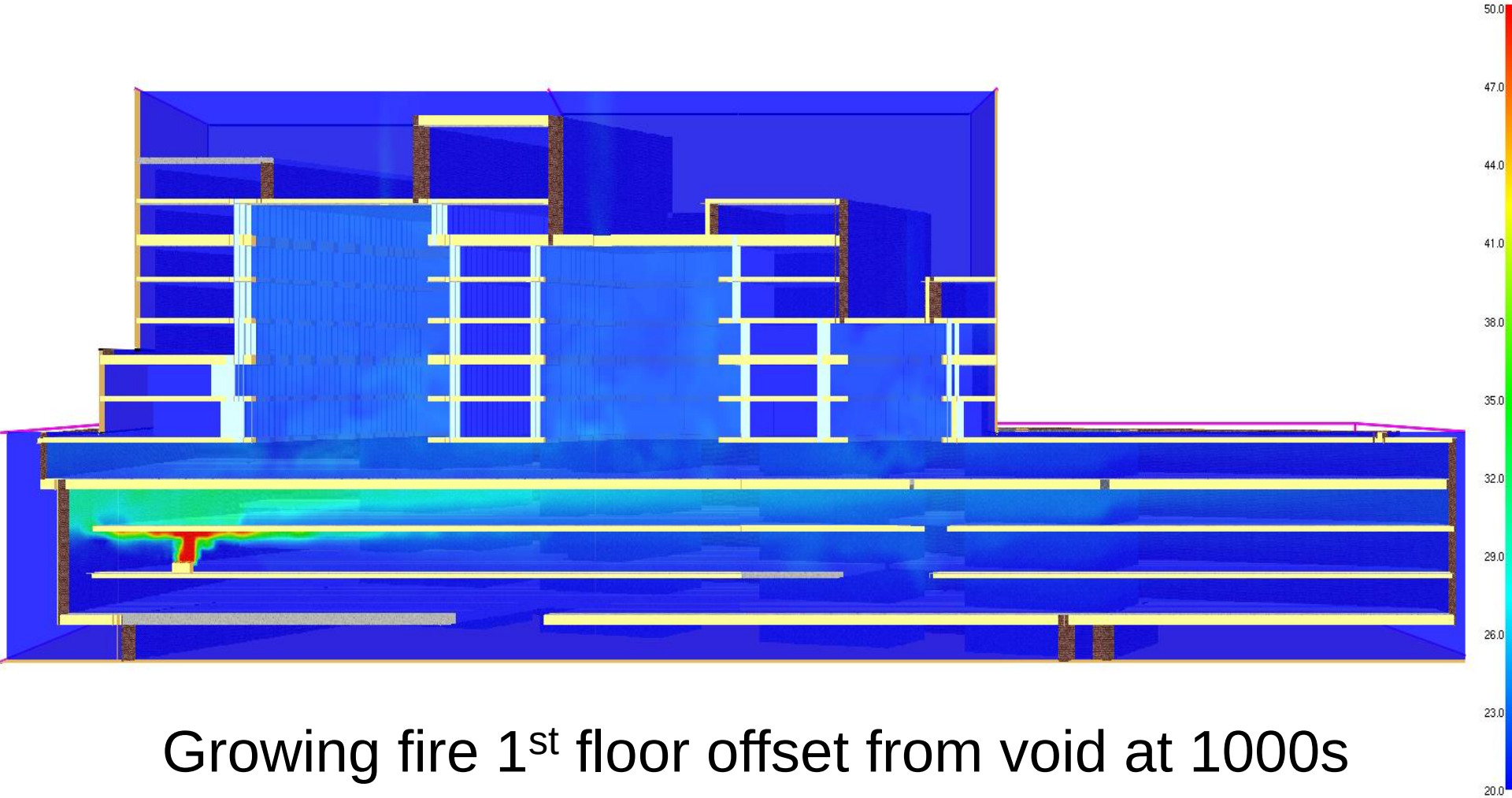
Level +03 Fire: No Wind



Growing fire 3rd floor under void at 1000s

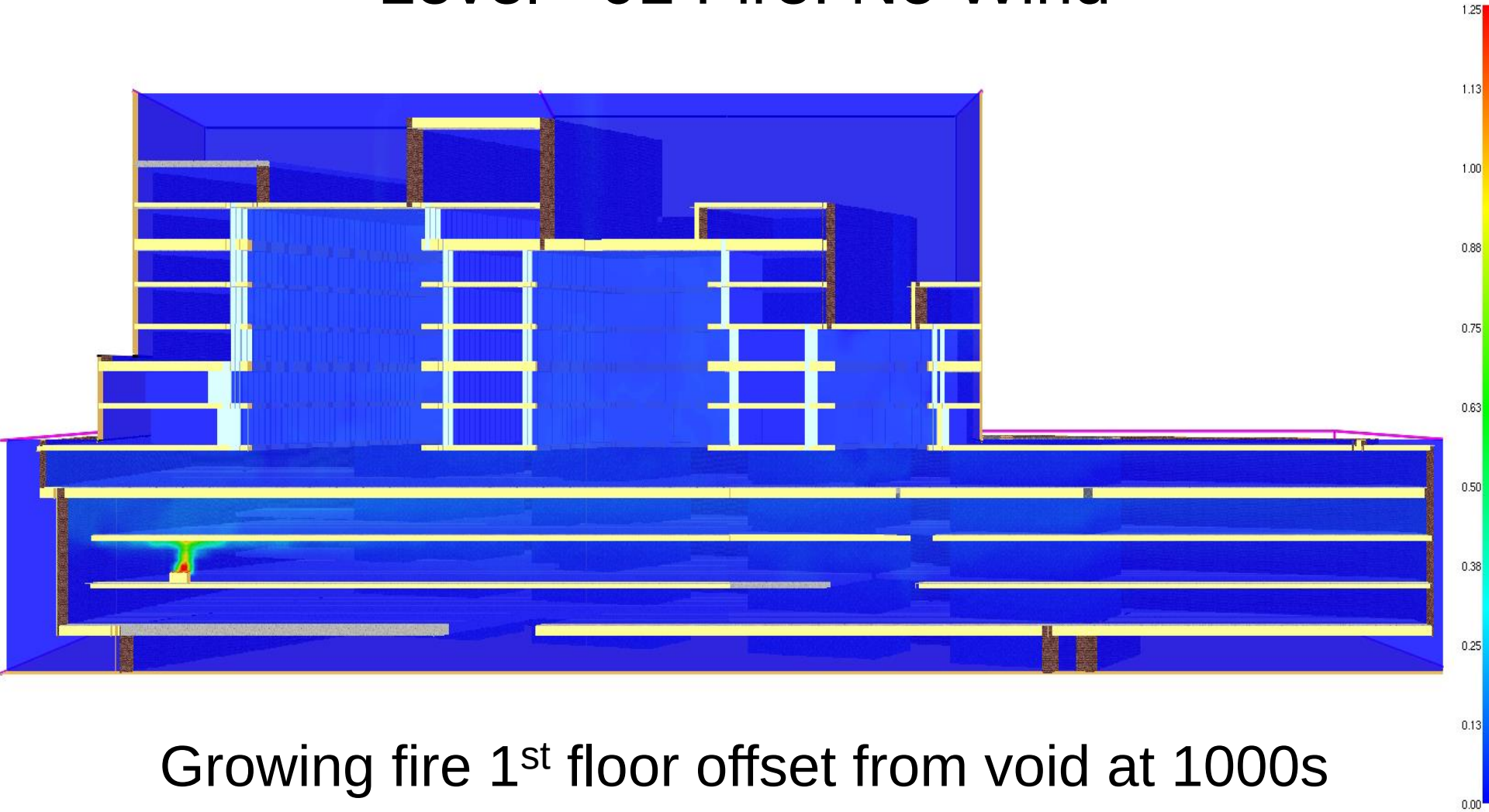
Visibility: Scale 0m – 30m

Level +01 Fire: No Wind



Growing fire 1st floor offset from void at 1000s
Temperature: Scale 20°C – 50°C

Level +01 Fire: No Wind



Growing fire 1st floor offset from void at 1000s
Carbon Monoxide: Scale 0ppm – 125ppm

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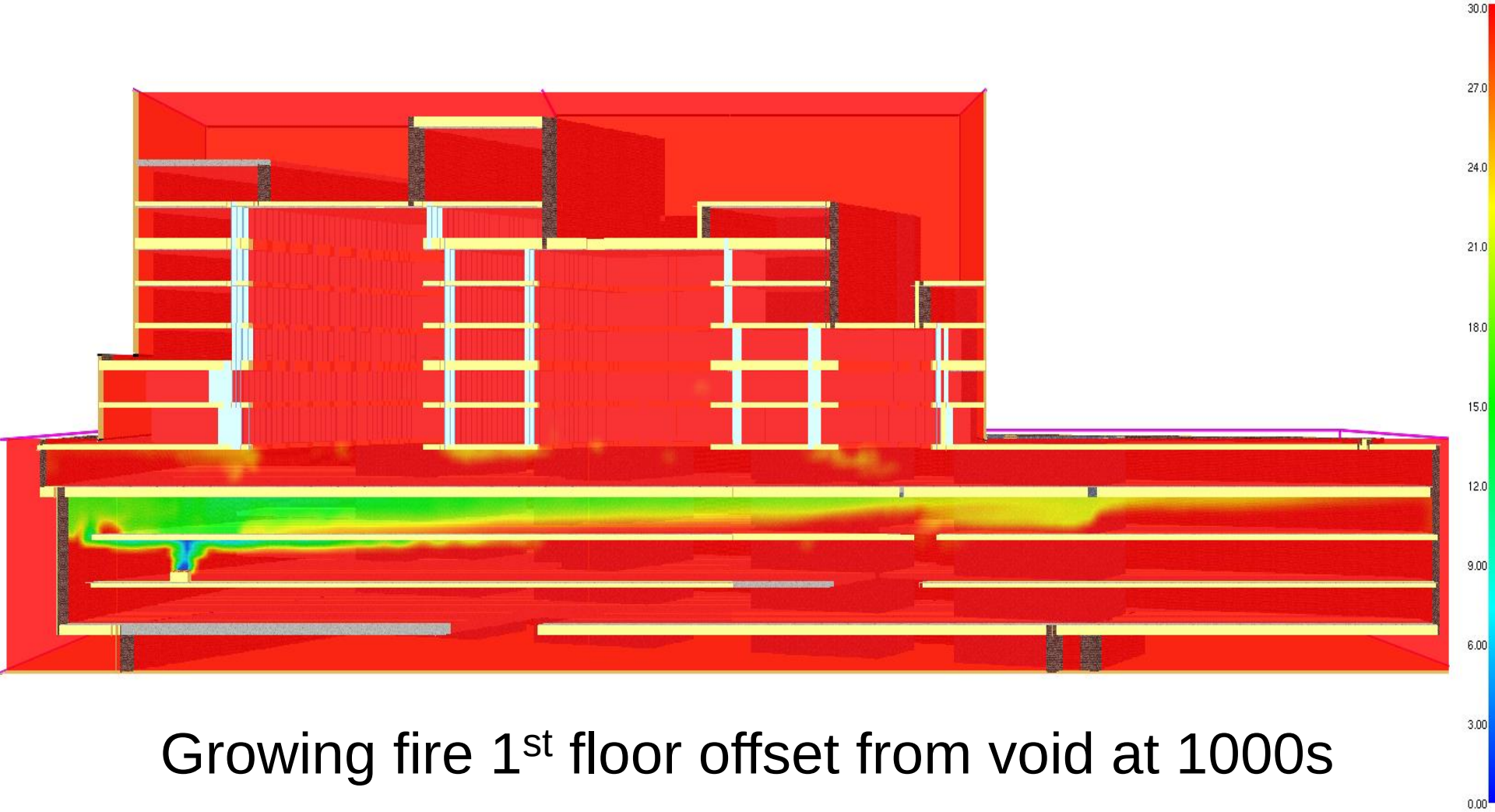
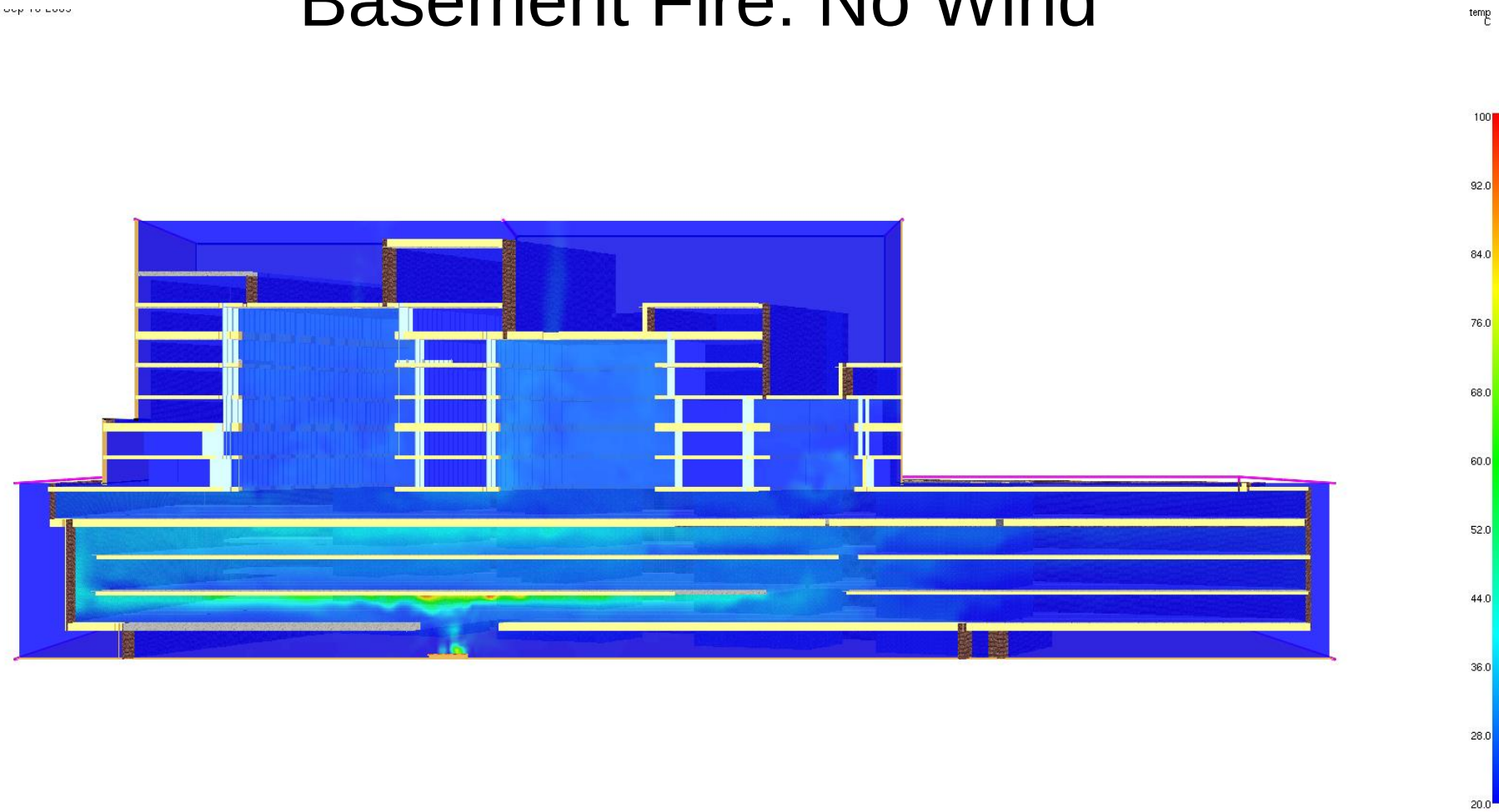
Level +01 Fire: No Wind



Growing fire 1st floor offset from void at 1000s

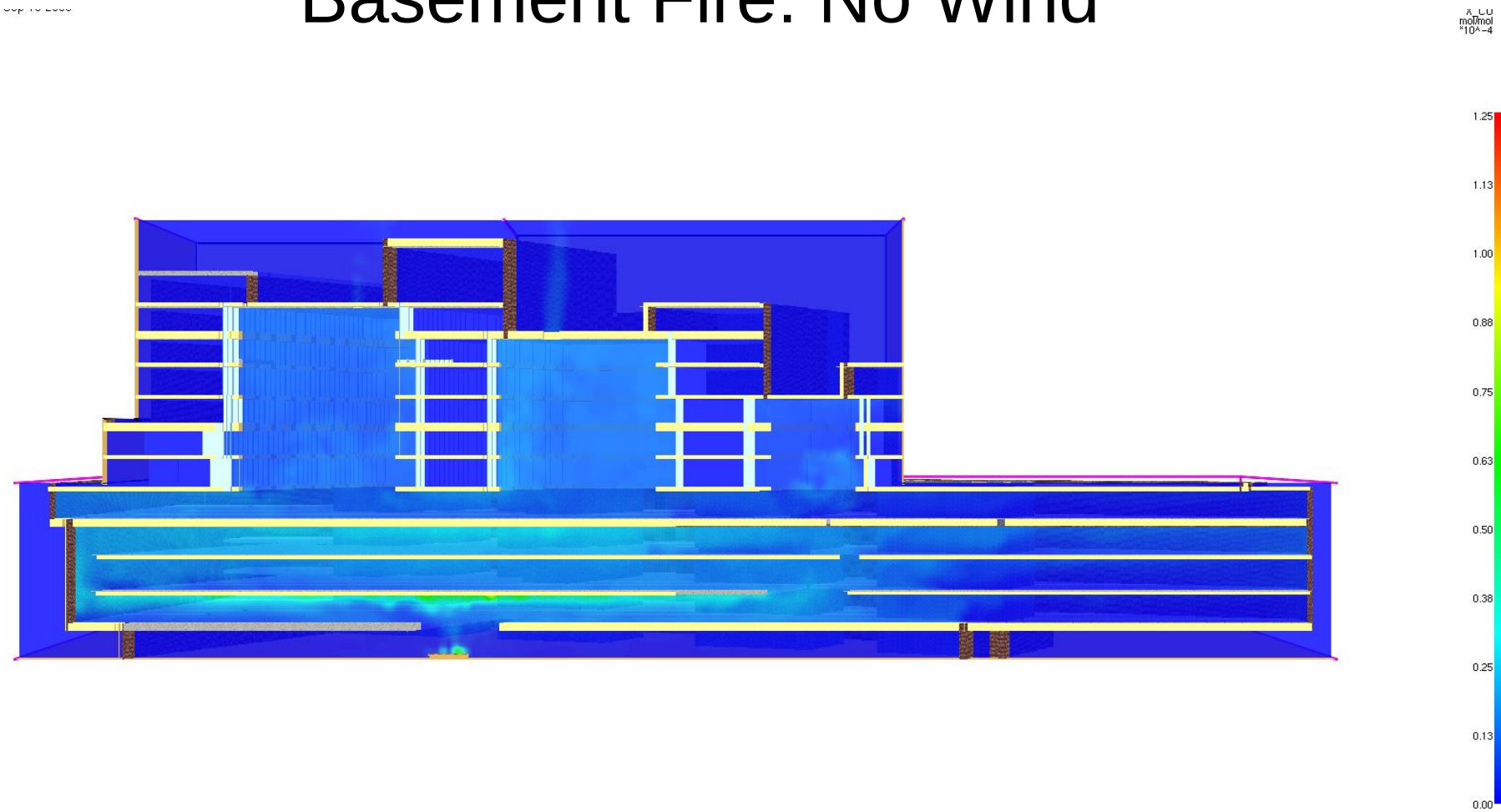
Visibility: Scale 0m – 30m

Basement Fire: No Wind



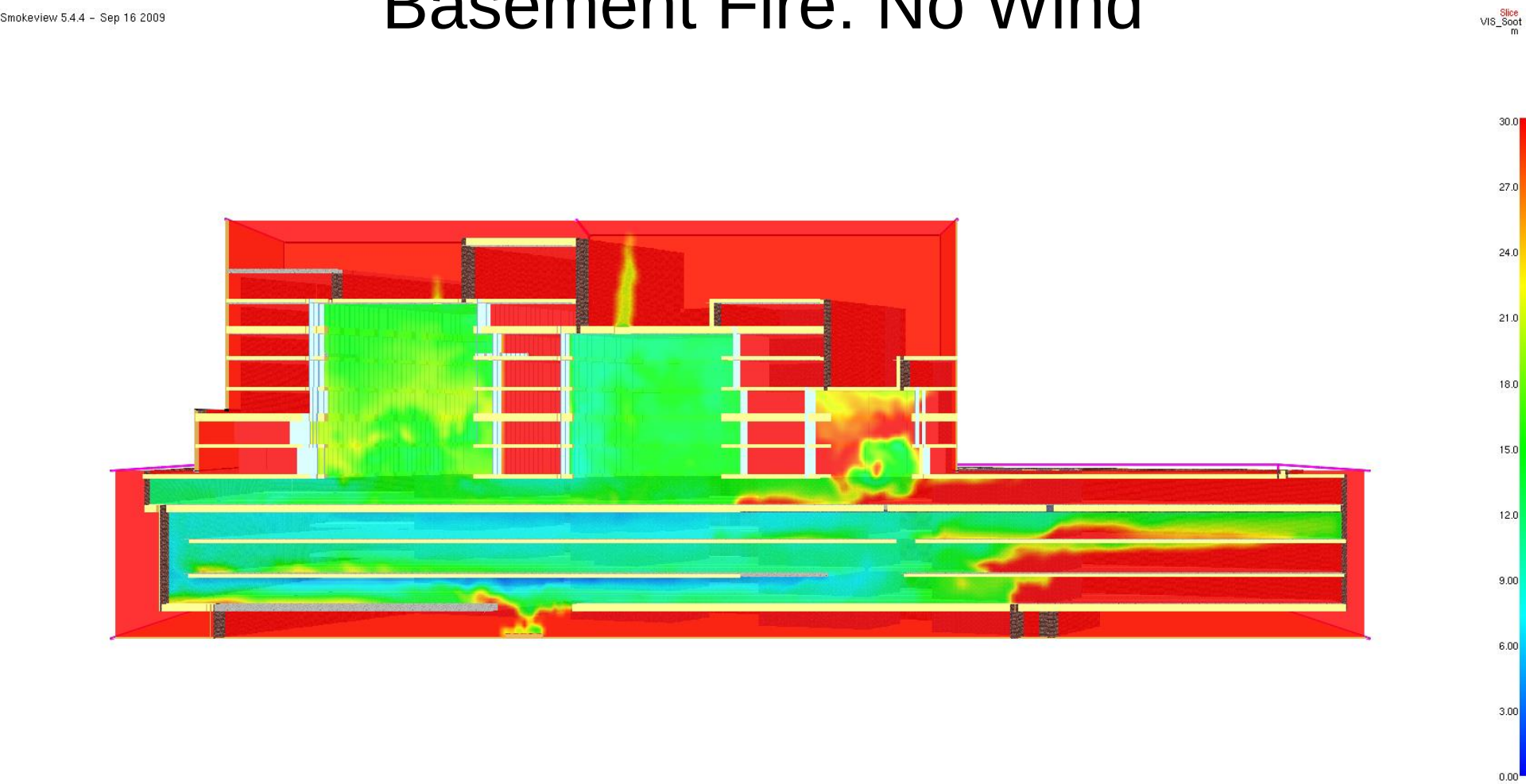
Growing fire at basement under void at 1000s
Temperature: Scale 20°C – 100°C

Basement Fire: No Wind



Growing fire at basement under void at 1000s
Carbon Monoxide: Scale 0ppm – 125ppm

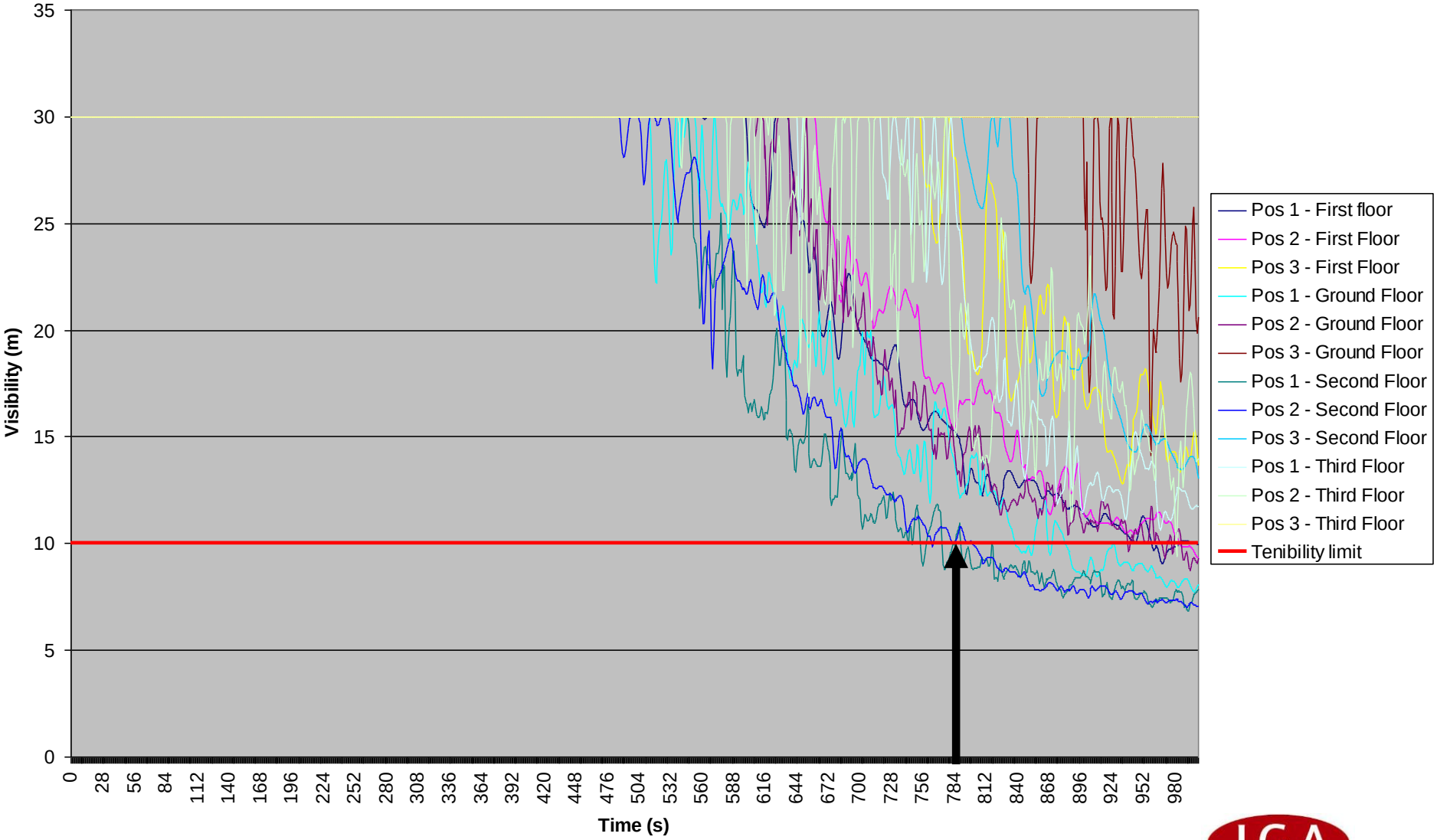
Basement Fire: No Wind



Growing fire at basement under void at 1000s

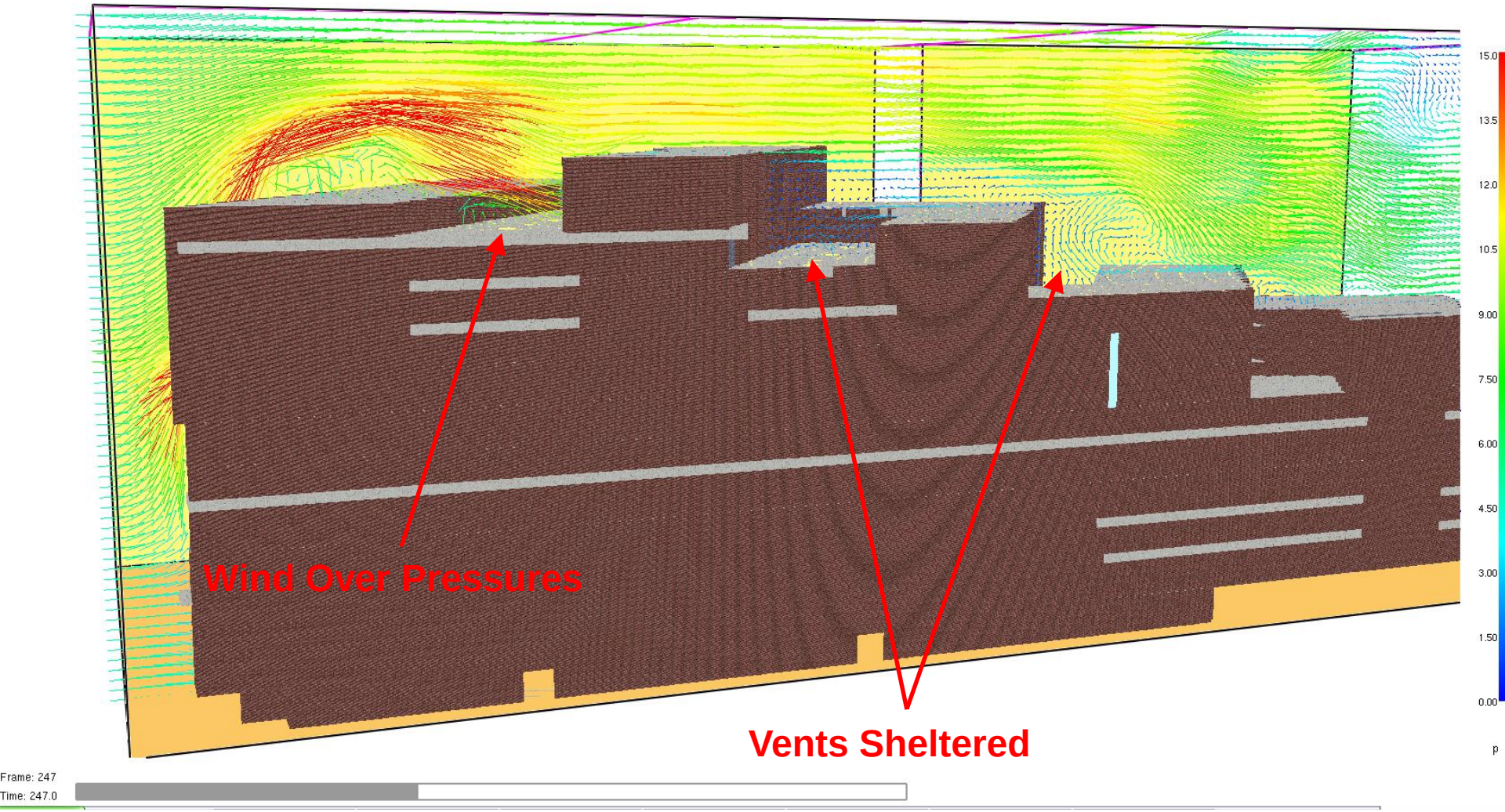
Visibility: Scale 0m – 30m

Visibility – Basement Fire



> 13 minutes (Onerous assumptions for soot yield & fire size)

External CFD Study – SE Wind



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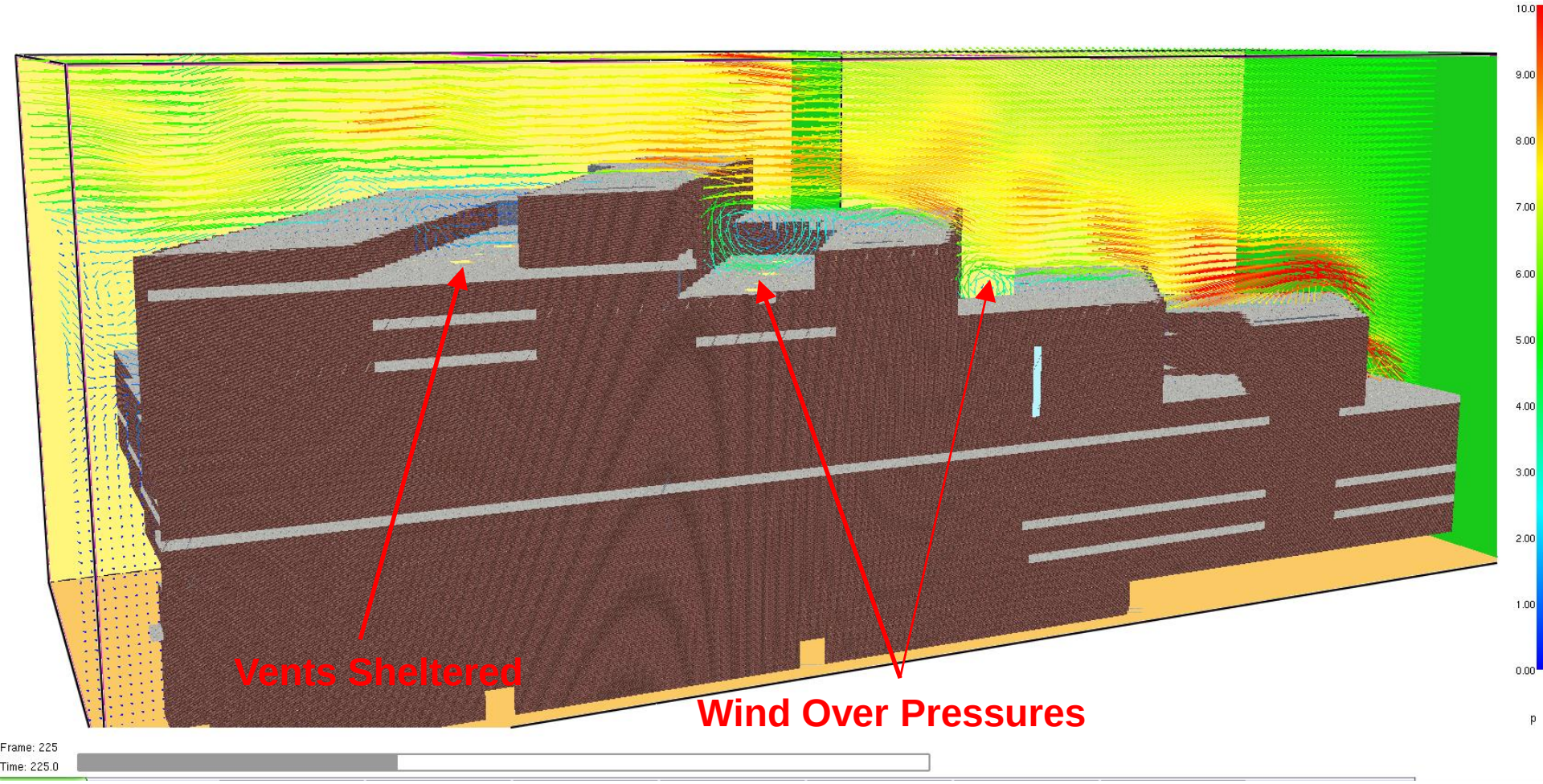
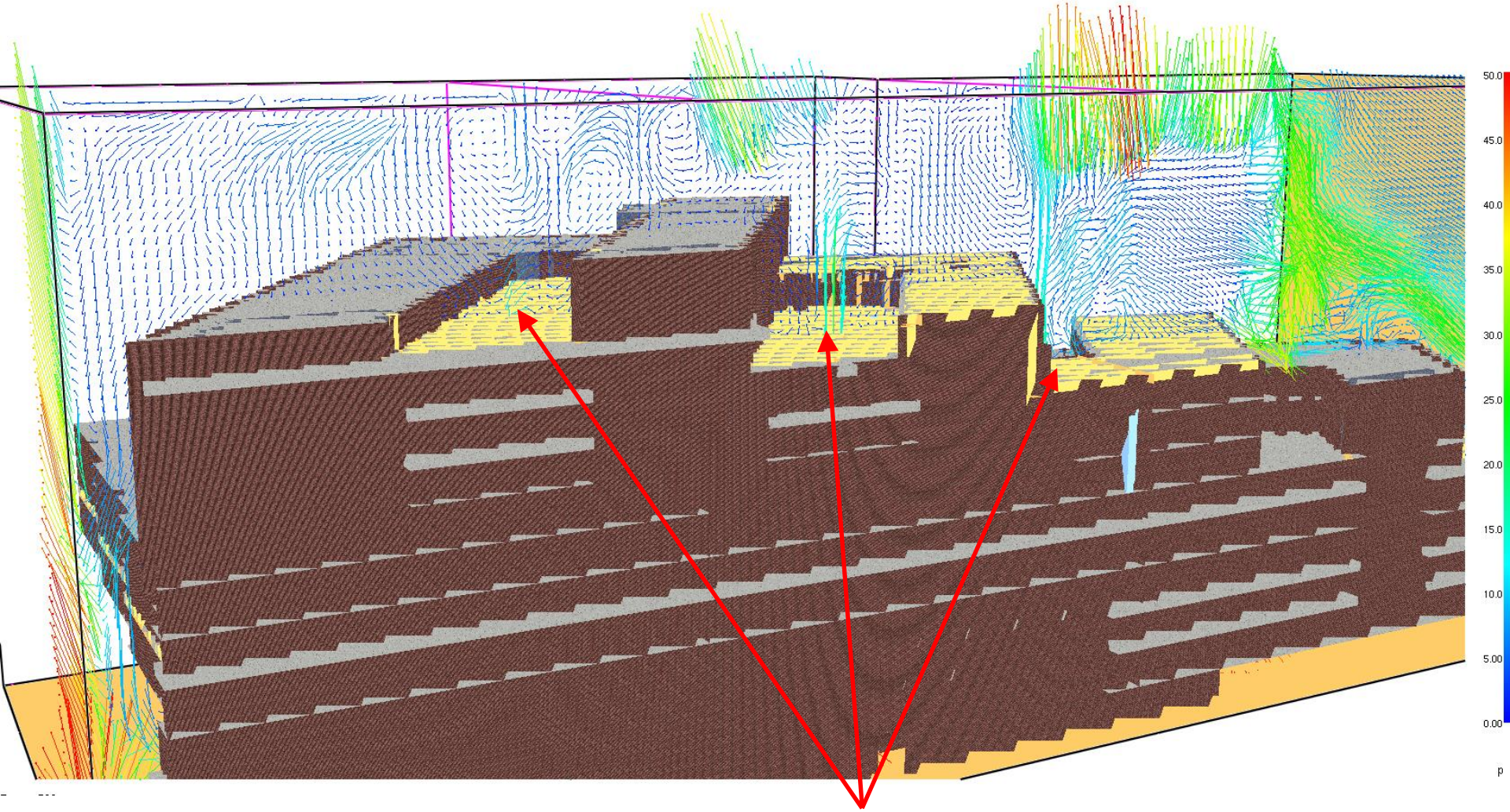
External CFD Study – NW Wind



External CFD Study – NE Wind

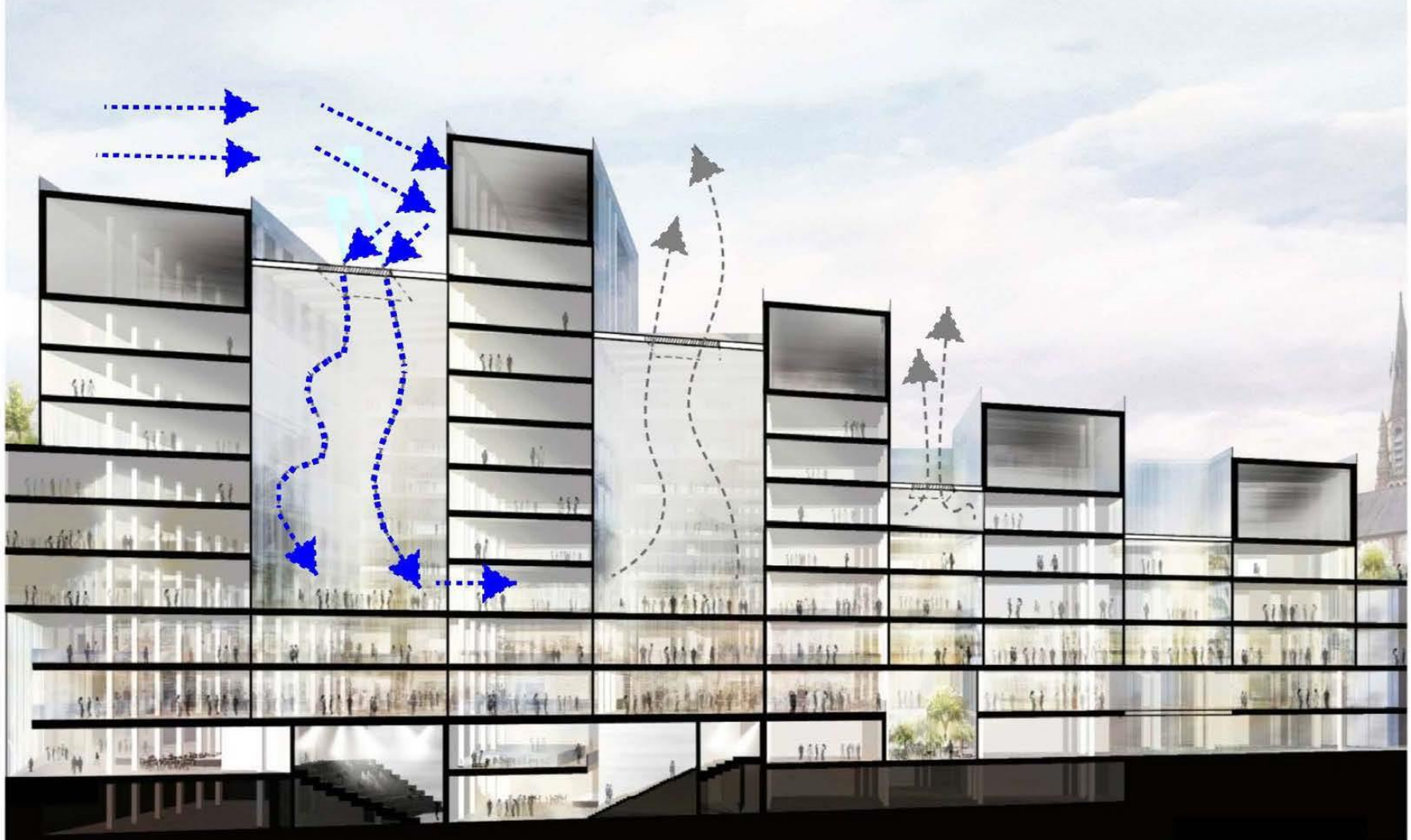


Velocity vectors demonstrate smoke venting out of vents - No over pressures.

Impact of Wind – 5m/s

Impact of SE Wind – 10m/s

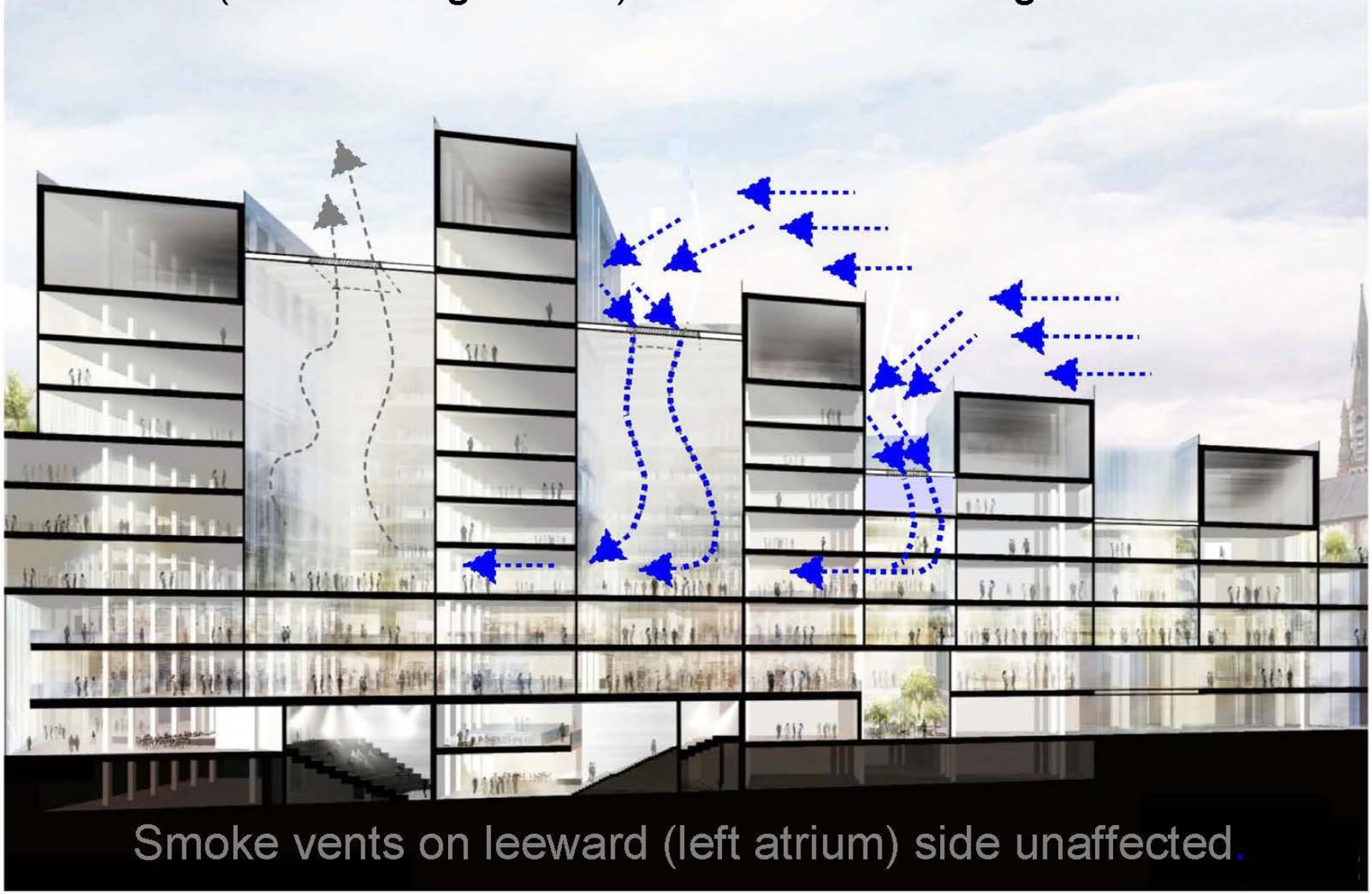
Over pressures prevent smoke venting through atrium roofs on windward (left atrium) side of the building – creates inlet air route.



Smoke vents on leeward (centre & right atria) unaffected.

Impact of NW Wind – 10m/s

Over pressures prevent smoke venting through atrium roofs on windward (centre & right atria) side of the building – inlet air route.



Smoke vents on leeward (left atrium) side unaffected.

CFD Result – Summary Table

Fire Location	Relevant Tenability Limits		Time To Reach Tenability Limits (ASET) (Time in minutes)		
			No Wind	5m/s Wind	10m/s Wind
Level +06 Bridge link LHS Atrium	**Level 04 & Above**	Temperature: 200°C	**>16.5**	**>16.5**	**>16.5**
	Level 03 & Below	Temperature: 100°C			
		CO: 125ppm			
		Visibility: ≥ 10m			
Level +06 Bridge Link Central Atrium	**Level 04 & Above**	Temperature: 200°C	**>16.5**	**>16.5**	**>16.5**
	Level 03 & Below	Temperature: 100°C			
		CO: 125ppm			
		Visibility: ≥ 10m			
Level +03 Beneath Atrium Void	**Level 04 & Above**	Temperature: 200°C	**>16.5**	**>16.5**	**>16.5**
	Level 03 & Below	Temperature: 100°C			
		CO: 125ppm			
		Visibility: ≥ 10m			

CFD Result – Summary Table

Fire Location	Relevant Tenability Limits		Time To Reach Tenability Limits (ASET) (Time in minutes)		
			No Wind	5m/s Wind	10m/s Wind
Level +01 Offset from Atrium Void	**Level 04 & Above**	Temperature: 200°C	**>16.5**	**Not modelled**	**Not modelled**
	Level 03 & Below	Temperature: 100°C			
		CO: 125ppm			
		Visibility: ≥ 10m			
Level -01 Beneath Atrium Void	**Level 04 & Above**	Temperature: 200°C	**>16.5**	**>16.5**	**>16.5**
	Level 03 & Below	Temperature: 100°C			
		CO: 125ppm			
		Visibility: ≥ 10m	**>13**	**>12.5**	**>12.5**

ASET v RSET

- ASET > 12.5 minutes
- RSET
  - Time to Detection
  - Alarm Time
  - Pre-movement
  - Travel Time
  - Flow Time
- RSET for Educational Building – 7 minutes
- RSET for Public Assembly Building – 8 minutes
- ASET v RSET Margin of Safety
  - Approx 4 – 5 minutes.

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Structure

- Each blocks standalone
  - Independent for structural fire resistance & sprinklers
    - Avoid overdesign of Blocks BB & BD
    - Also facilitates independent Means of Escape design
- Block BC – top storey >30m
  - TBE - 2 hours structural fire resistance & sprinklers
  - Detailed fire engineering study – 90 minutes sufficient
- Blocks BB & BD – top storey <30m
  - 90 minutes structural fire resistance
    - No sprinklers
- FF Shafts – 2 hours
- Insurers requirements.

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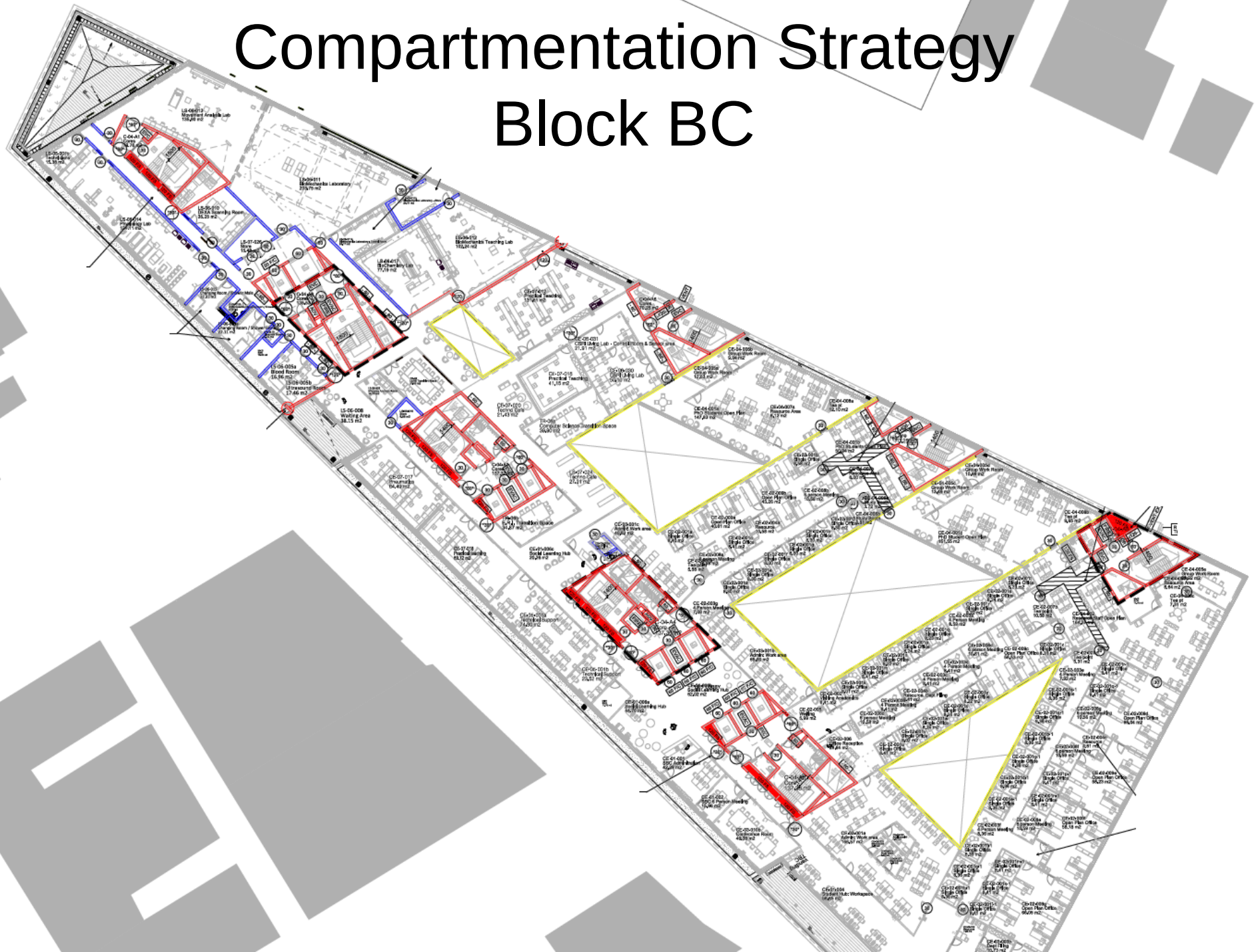
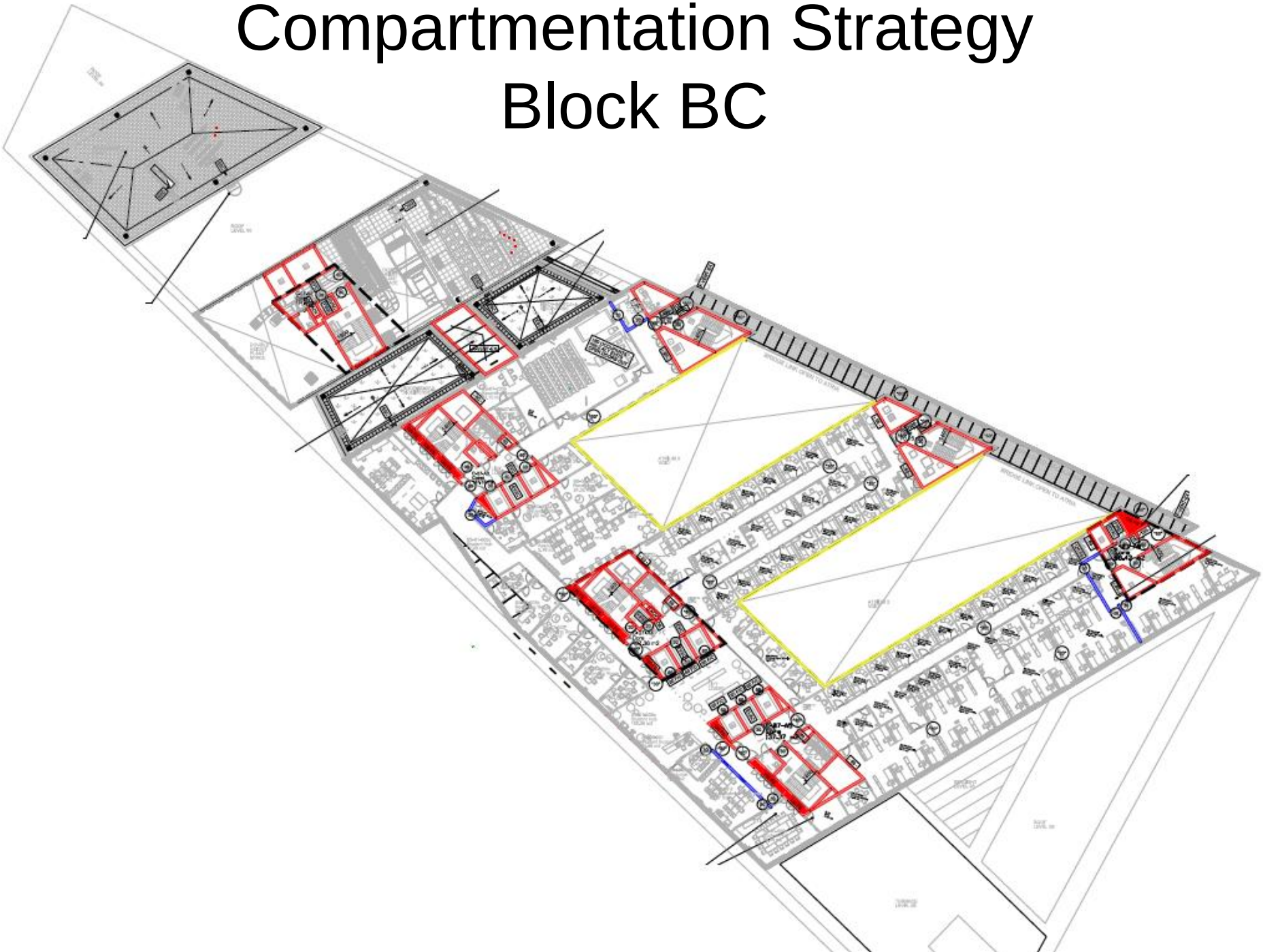
Compartmentation Strategy
Block BC



Compartmentation Strategy
Block BC



Compartmentation Strategy
Block BD

Elevations

- Block BC
  - Atrium building – sprinklered
    - Elevations can be fully unprotected
- Blocks BD
  - Compartment floors
    - Proximity issues at rear elevation
      - limits unprotected areas
    - No issues on primary elevations.

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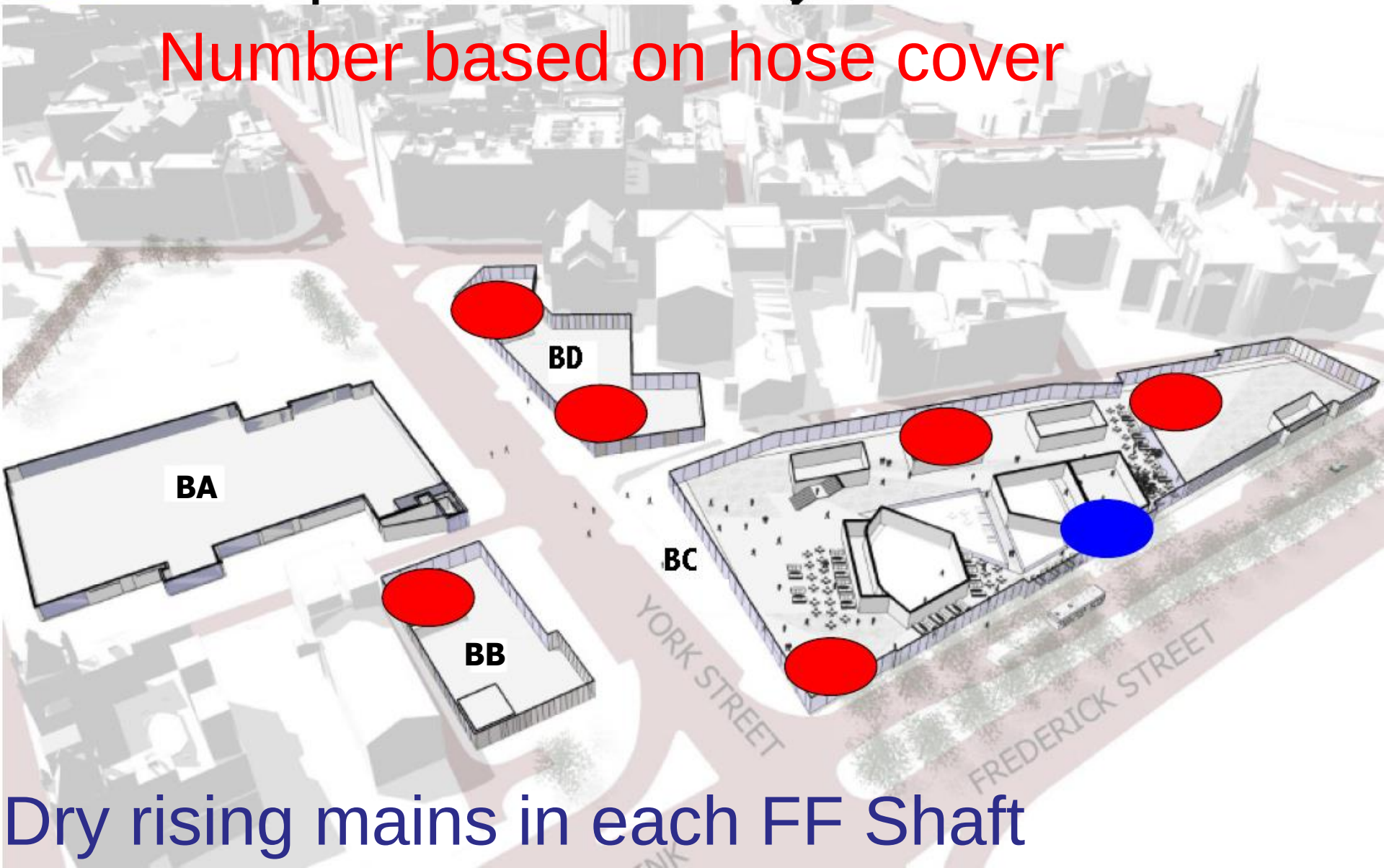
Fire Fighting Vehicle Access

Fire Fighting Shafts

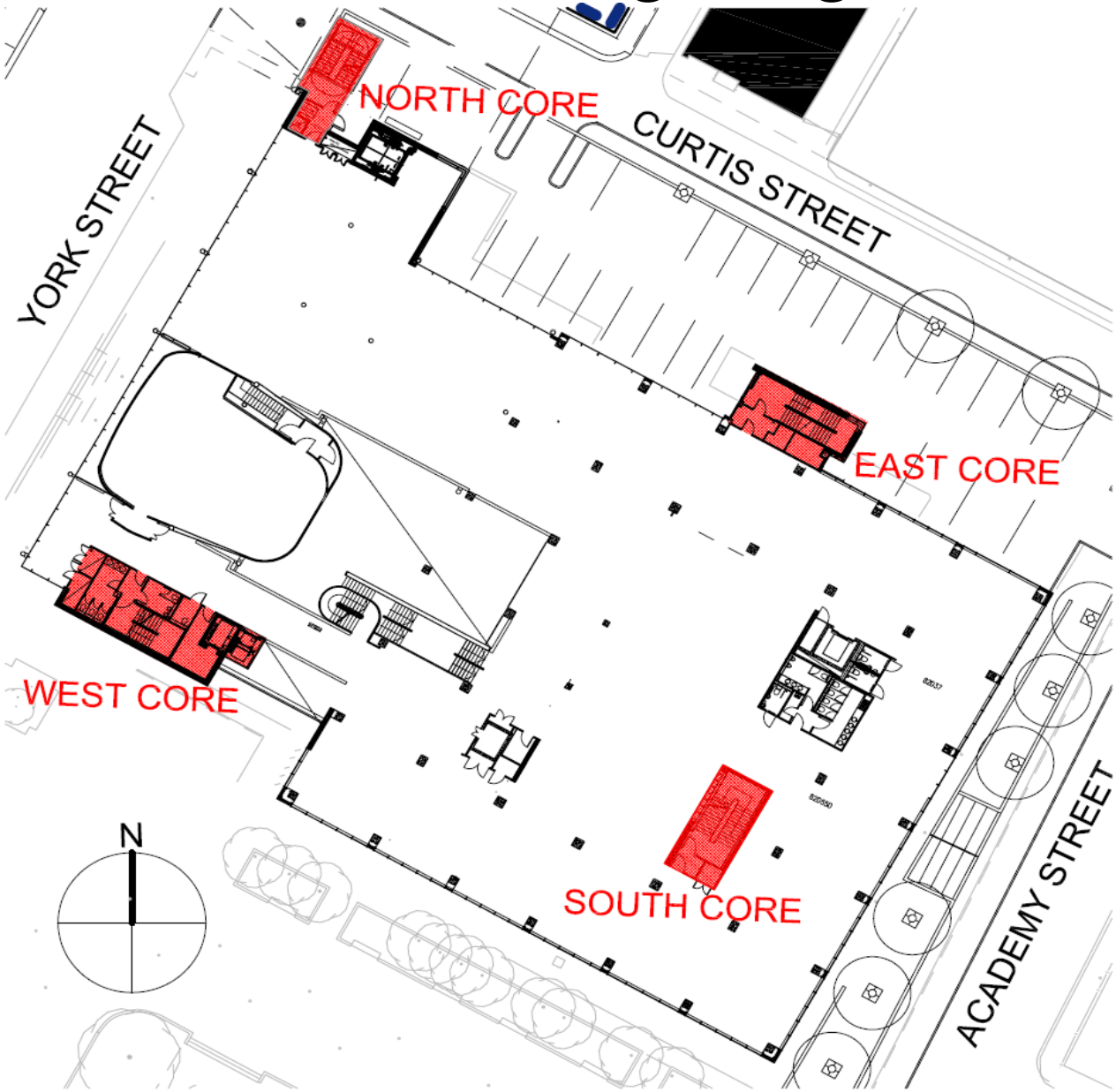
Escape Core with Dry Riser

Number based on hose cover

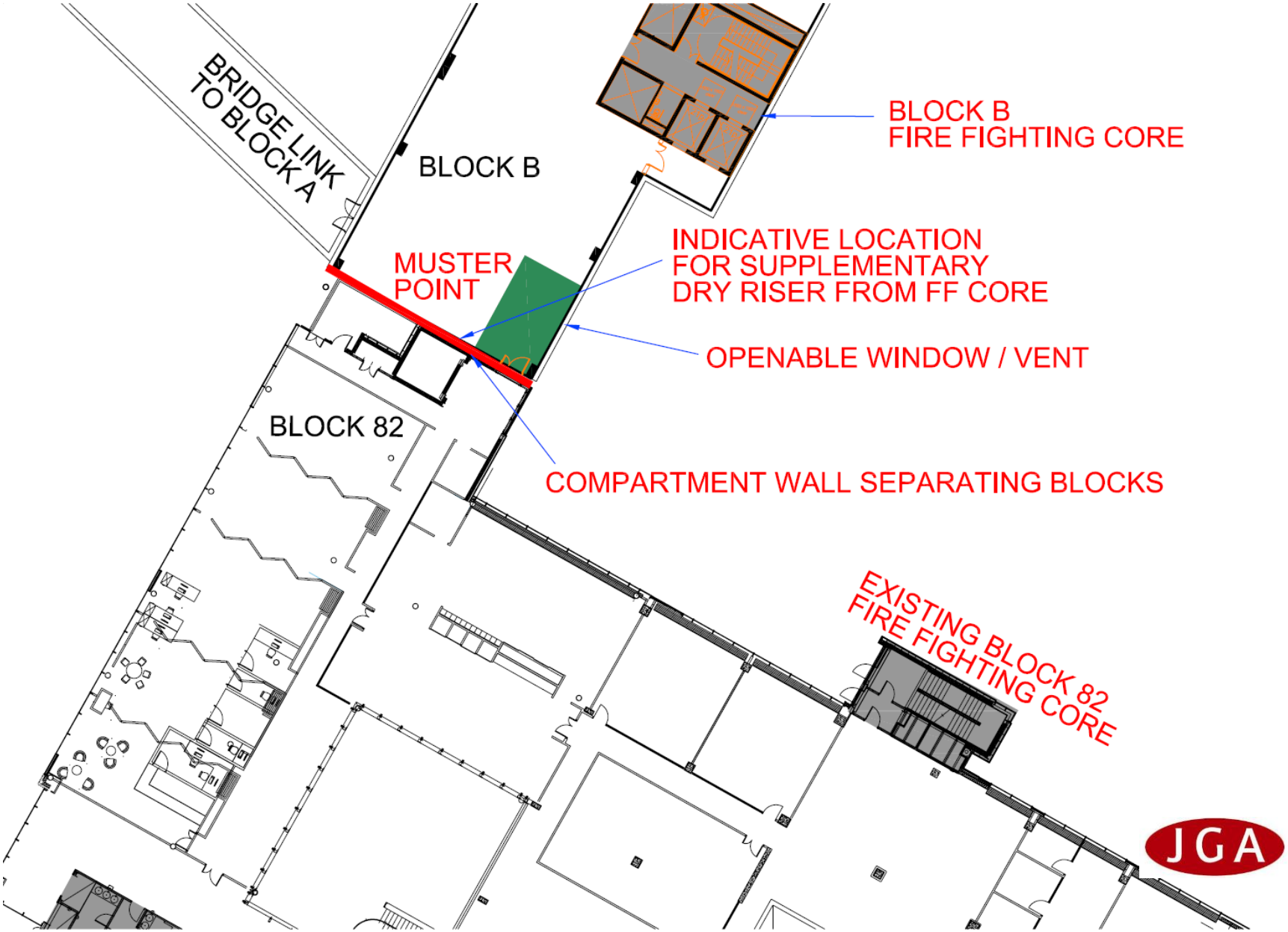


Dry rising mains in each FF Shaft

Block BA Fire Fighting Cores



Block BA Solution



Fire Fighting Venting Provisions

- Fire Fighting Shafts
  - FF Lobby Venting
    - $1m^2$ openable windows where adjacent elevations
    - Vertical smoke shaft if inboard
      - Mechanical extract proposed
  - FF Stairs
    - $1.5m^2$ automatically opening vent at top
- Basement
  - University Accommodation – Vent to Atrium
  - Plant – mechanical smoke extract.

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Questions?

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Jeremy Gardner Associates

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