



TECHNICAL NOTE 1

DATE:	15 November 2023	CONFIDENTIALITY:	Confidential
SUBJECT:	Interim Escape capacity for 5,000 persons in the warehouse		
PROJECT:	The Factory	AUTHOR:	Andrew Gilchrist
CHECKED:	James Thouless	APPROVED:	Jason Oldham

Introduction

WSP Fire has been requested by Manchester City Council to assess the maximum occupant capacity for the ongoing use of the Factory during the design and construction of external stairs from the South of the warehouse. This is required in order to ease the number of occupants required to evacuate along Victoria Street.

To date WSP have been conducting pedestrian modelling from the final exits to the South of the venue along the entire length of Victoria Street ("The Factory Evacuation Modelling", September 2023) and a Fire Strategy for the building (MF-WSP-XX-XX-RP-YD-03-0004) these reports should be read alongside this Technical Note. The current results for the modelling for the maximum anticipated occupancy for the venue of 7,000 persons shows that the occupant density and length of queuing has the potential for a crushing scenario.

It is proposed that in the interim period the occupancy of the warehouse is limited to 5,000 persons (including staff) with no concurrent events in the theatre.

This Technical Note calculates the escape capacity by following the methodology in PD 7974-6 and comparing the Available Safe Escape Time (ASET) with the Required Safe Escape Time (RSET). Additionally, the results of the evacuation modelling for this event have been used.

This Technical Note only considers the escape from Level 2 of the warehouse and theatre spaces. All other fire strategy elements during the interim period are to be in accordance with the end condition fire strategy report.

Fire Safety Management

The Fire Risk Assessment for any interim events in the factory warehouse should be updated to reflect the current occupancy limit for the venue and what procedures are to be implemented to control the occupancy numbers.

The position of the stage for the event should not be in front of and/or restrict the width of any of the emergency exits in the venue, so that all of the exits are available for use. The materials on the stage should be risk assessed and remain within the limitations of the fire strategy, industry standards / best practice and fire safety management document for the event.

Available Safe Escape Time

As per the WSP Fire Strategy for the building, the ASET for the use of the warehouse in an unseparated configuration is 1200 seconds (20-minutes). This is based on a CFD study for the building which can be found in the most recent fire strategy. The fire size of 5MW used in this study should be adhered to in any event planned for the venue.

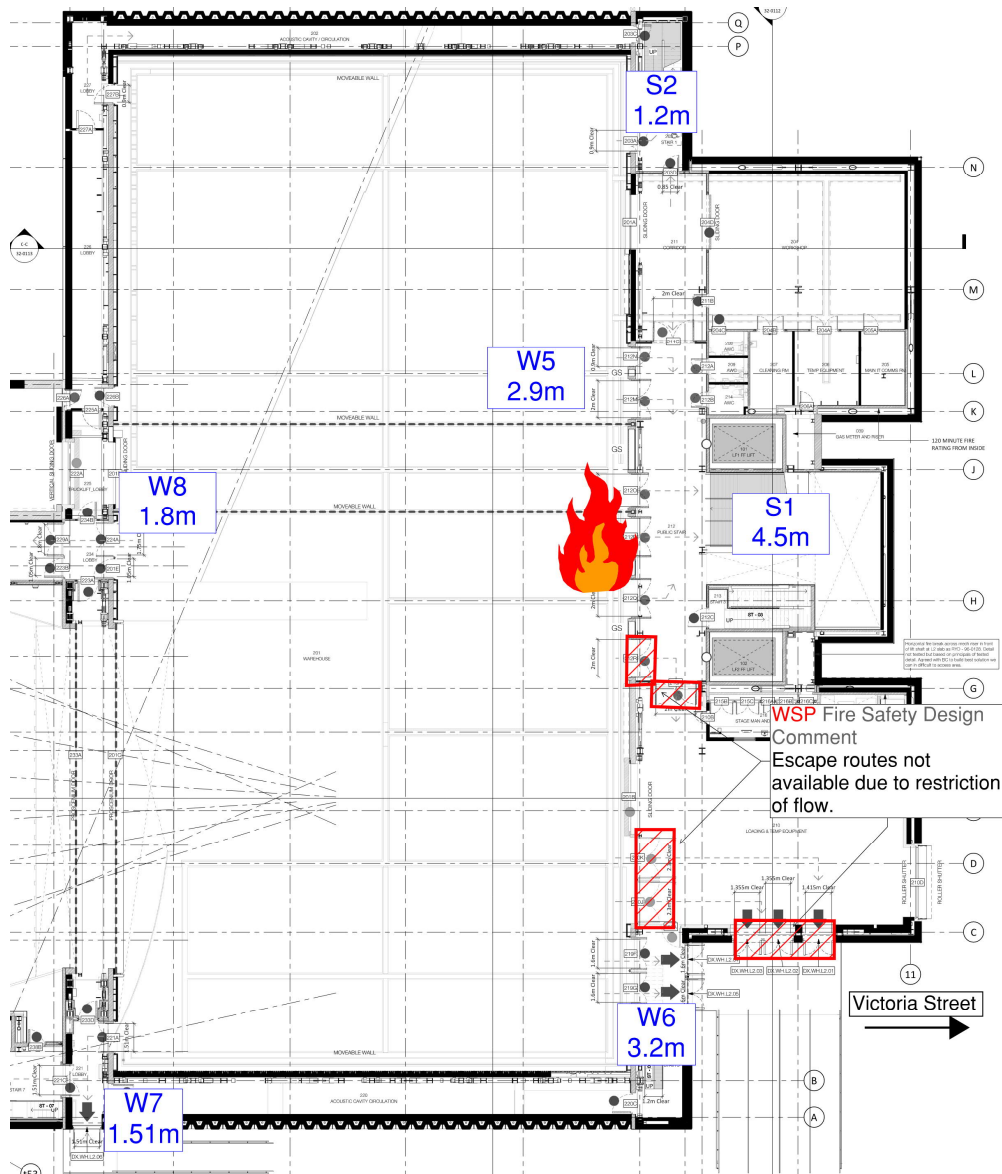
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Required Safe Escape Time

The means of escape is based on 5 exits from the warehouse, as shown in Figure 1. It should be noted that exits W6 and W7 discharge towards Victoria Street. The number of occupants and the flow of these occupants has been used as an input into the external escape model to determine if the flow of people along this route is acceptable.

Figure 1 - Means of escape from the warehouse.



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The internal egress modelling has been undertaken using Pathfinder developed by Thunderhead Engineering. Version 2021, Revision 2021.2.0525 has been used for this analysis. The configuration of the warehouse that has been included is the warehouse is undivided.

The occupancy is based on 5,000 occupants to determine a RSET for the space with this occupancy. This has included the removal of the exits into the loading bay as shown in the figure above. This is to reduce the flow of occupants along Victoria Street and ensure that occupant density on this route remains at a safe level.

Additionally, it has been assumed that a fire could block the largest exits which are three directly opposite the central stair (6m), which has left 2.9m of clear width into the central stair.

The evacuation model shows that it takes 492 seconds for occupants to exit the warehouse. In addition to this the time it takes for occupants to begin moving has been agreed with Building Control to be 60 seconds (premovement time). Therefore, the total RSET is 551 seconds. As the ASET is 1200 seconds occupants are provided with sufficient time to escape, these results are summarised in Table 1.

Table 1 - Summary of results.

Areas	ASET (sec)	ASET (mins)	RSET (sec)	RSET (mins)	Factor of Safety
Warehouse Area	1200 seconds	20 minutes	551 seconds	9.2 minutes	2.2
The whole building	N/A	N/A	621 Seconds	10.35 minutes	-
Victoria Street – last occupant to discharge at the end of the street	N/A	N/A	904	15.1 minutes	-

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Figure 2 - $t = 0$, where 5,000 occupants are in the warehouse.

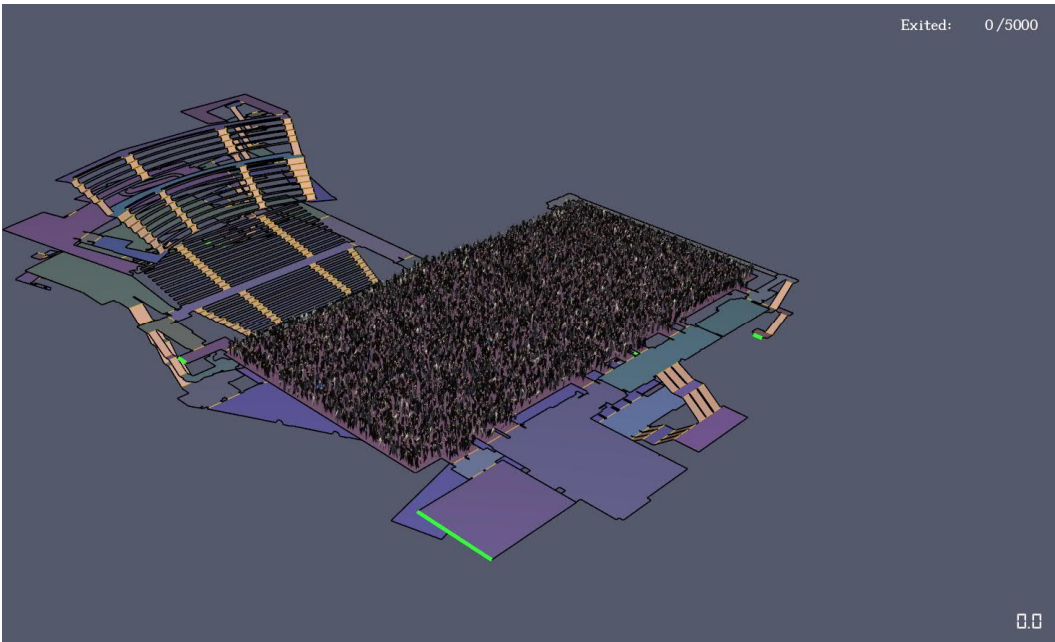
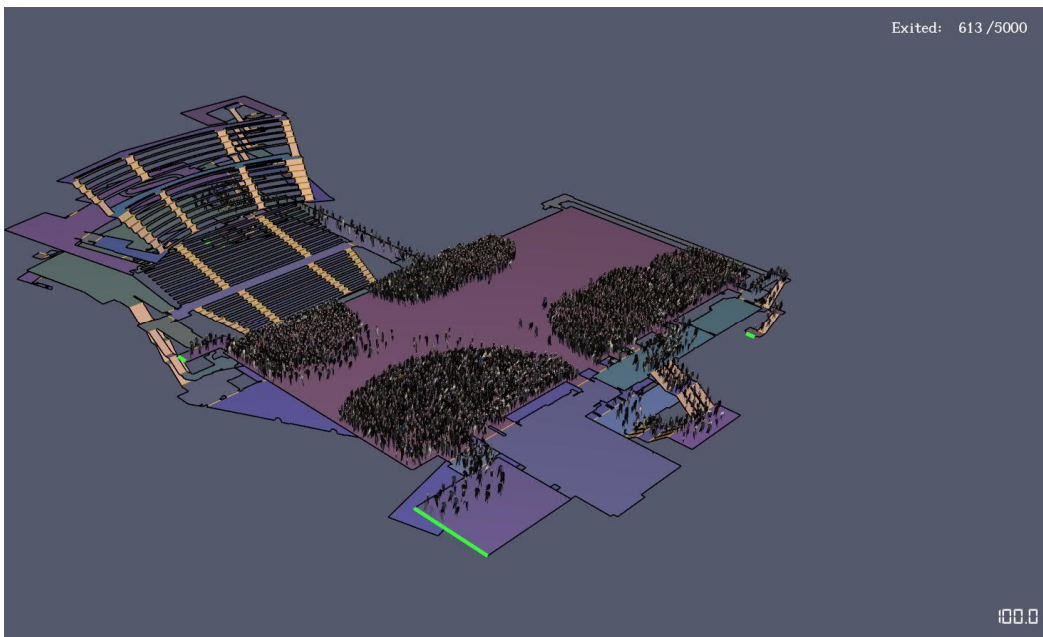


Figure 3 - $t = 100$ seconds, where 613 people have exited the building.



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Figure 4 - $t = 300$ seconds, where 2,662 occupants have left the building.

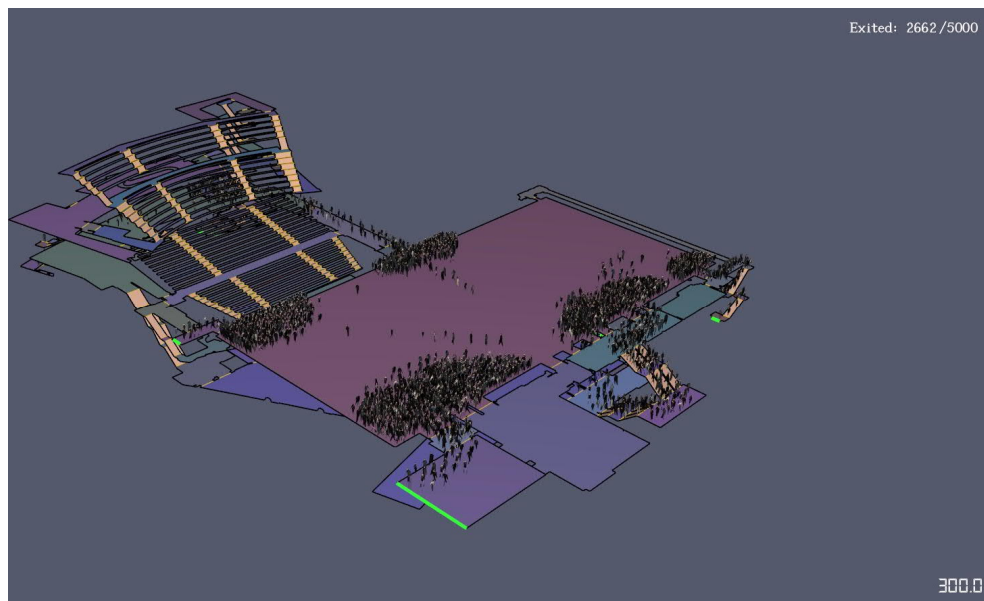
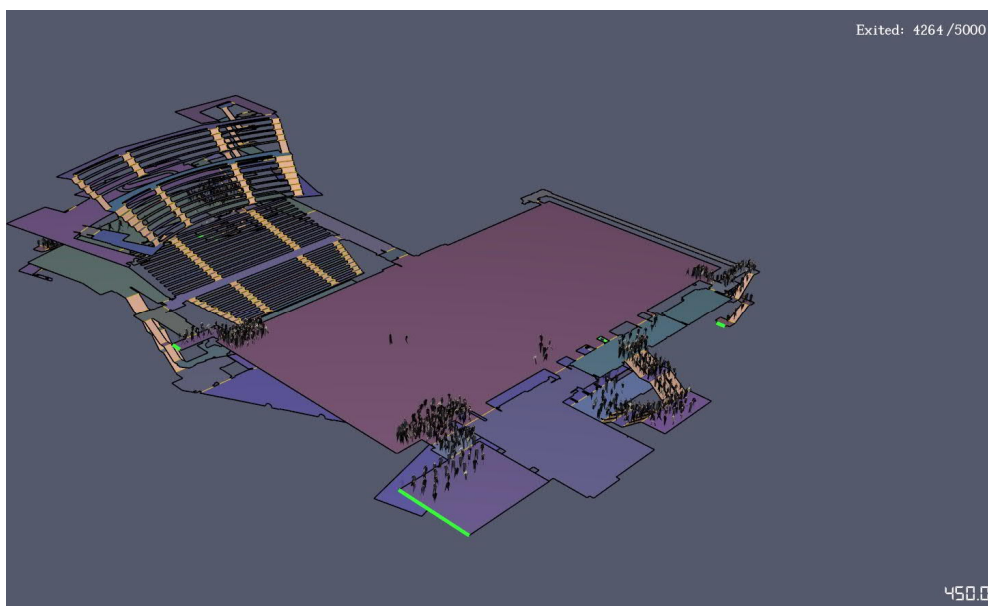


Figure 5 - $t = 450$ seconds, where 4,264 people have left the building.



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Figure 6 – $t = 492$ seconds, where all occupants have left the warehouse.

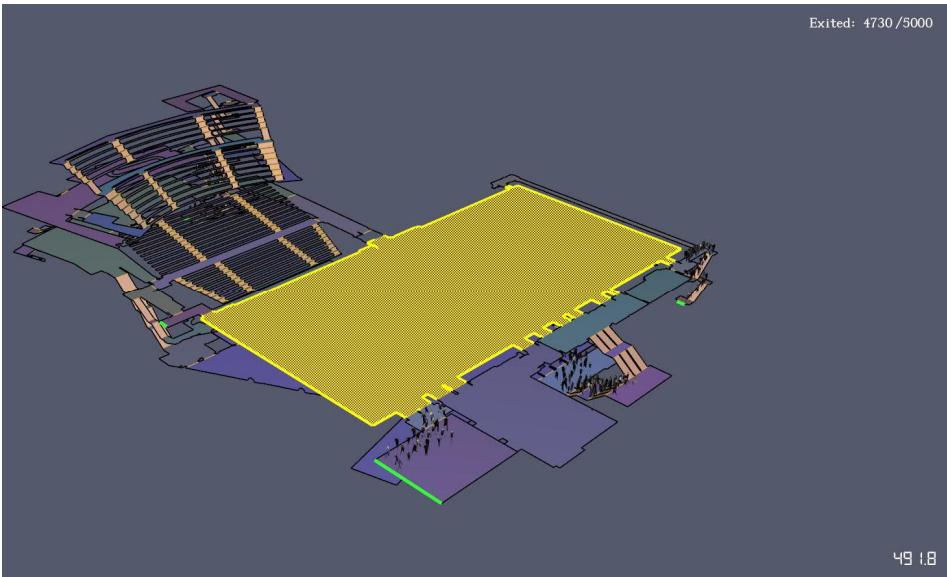
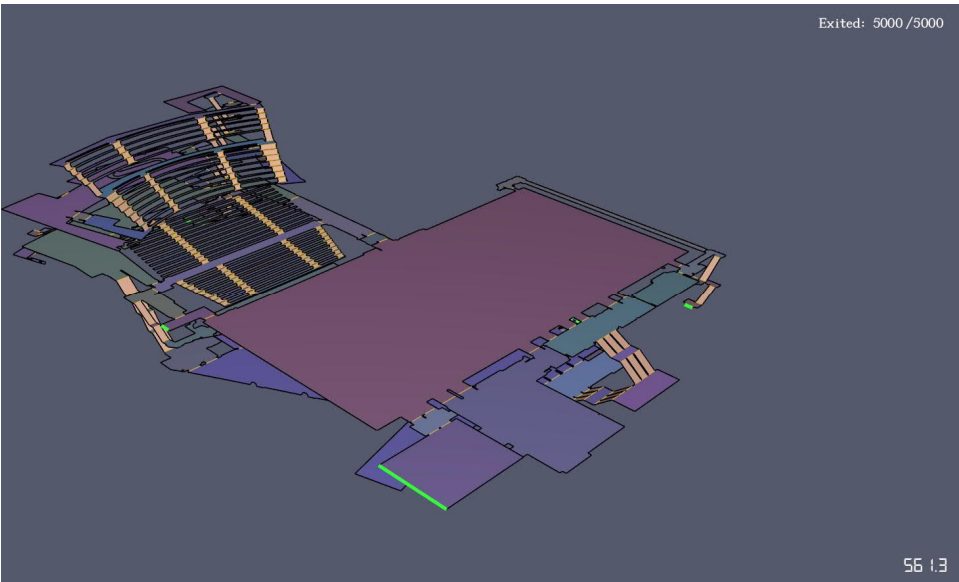


Figure 7 – $t = 561$ seconds, where all occupants have left the building.



External Evacuation Modelling

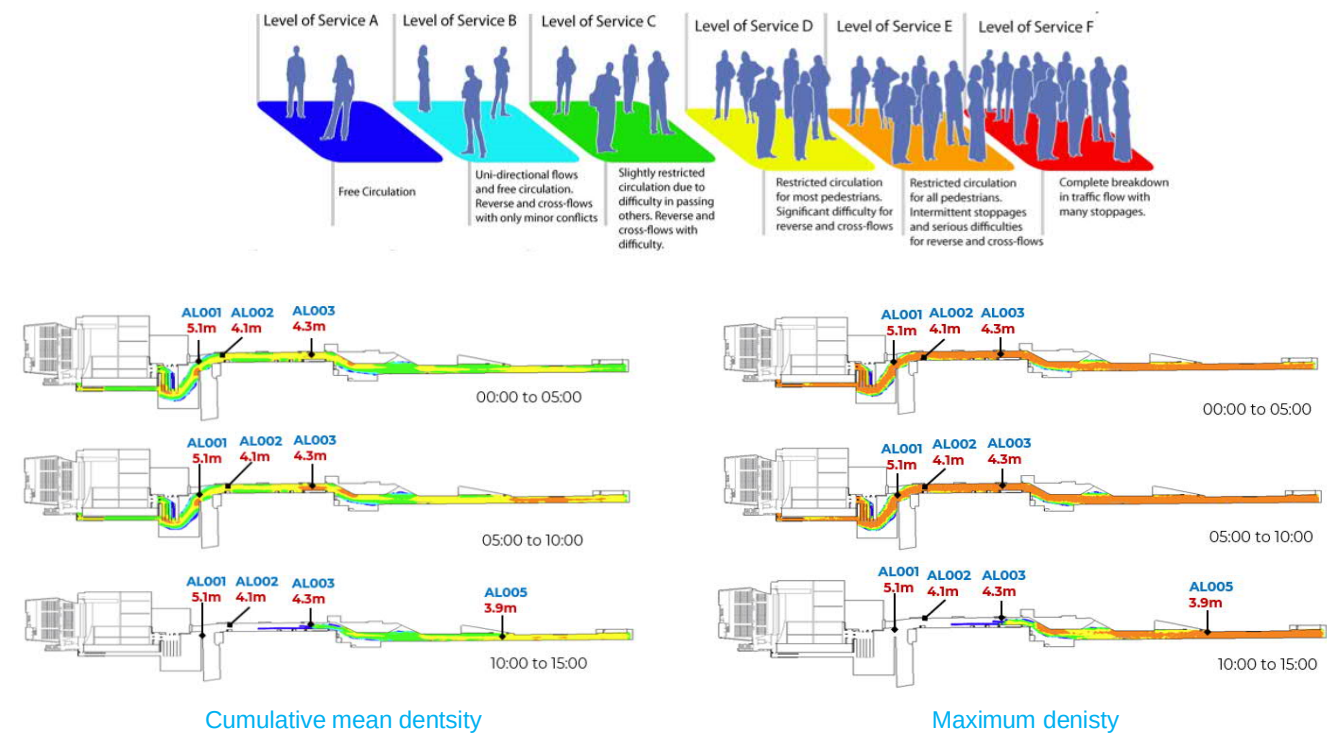
The external evacuation modelling provides positive results for this event, with the RSET not being impacted by a buildup of occupants in Victoria Street. The cumulative mean density and maximum density are at an acceptable level as shown in Figure 8. Therefore, it can be concluded from the external

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evacuation model that the means of escape is suitable for 5,000 occupants from the warehouse. The external evacuation model is appended in full at the back of this Technical Note.

Figure 8 – Evacuation modelling density results.



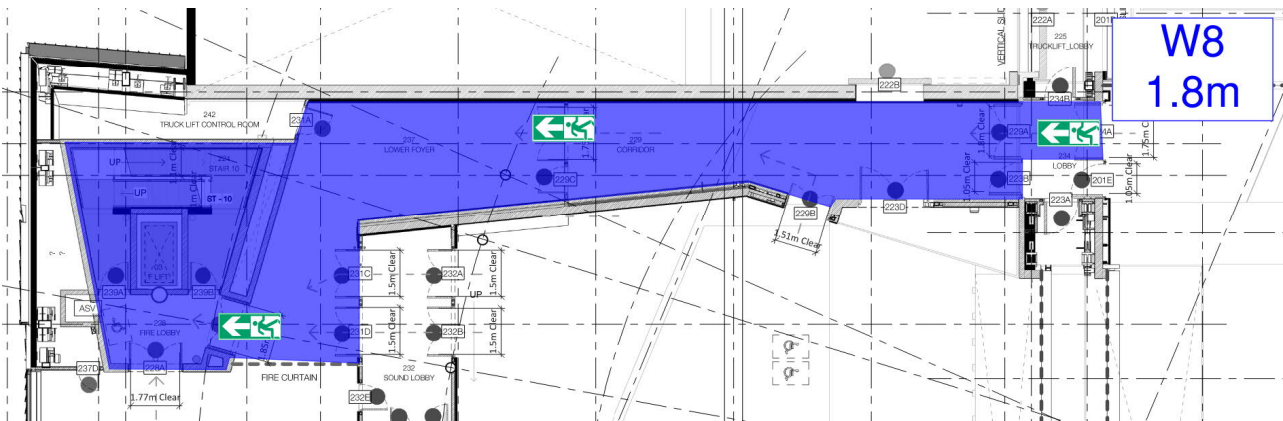
Site Works Required

This Technical Note has been prepared on the basis that occupants can escape through the double doors to the West of the building into the corridor adjacent to the theatre and down the escape stair in this area, highlighted in Figure 9 below. It should be ensured that for the interim events with 5,000 people in the warehouse that this exit is available in the event of a fire. Temporary exit signage may be required and this should be installed ahead of any event.

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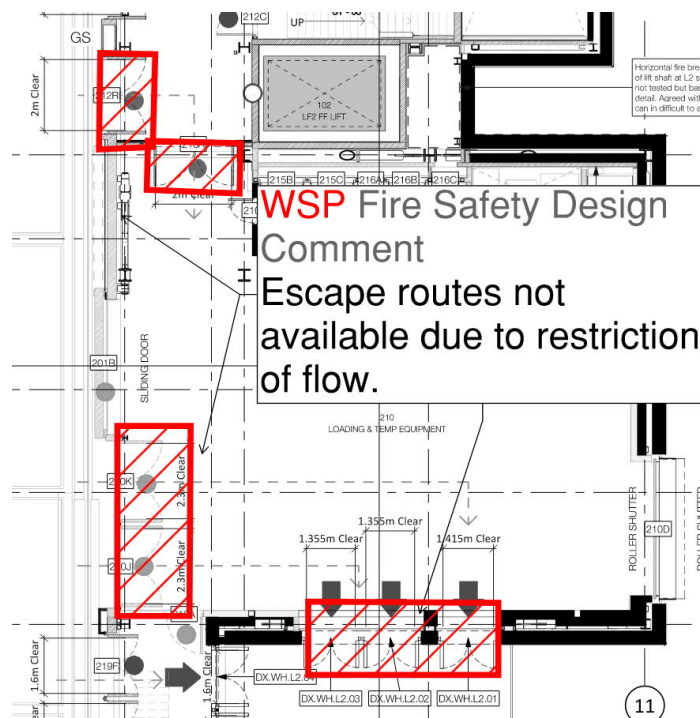
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Figure 9 - Illustration of the required exit route into the theatre from the warehouse.



This Technical Note also relies on the flow of occupants towards Victoria Street being restricted within the Factory Building. To achieve this the doors 212R, 210A, 210K, 210J, DX.WH.L2.03, DX.WH.L2.02 and DX.WH.L2.01 should not be used for escape, these are highlighted in Figure 10. In the interim period the signage should be adapted and the doors should be managed so that spectators at any events do not attempt to use these doors for escape.

Figure 10 - Exits which should not be used during the interim events.



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It is recommended that Victoria Street is stewarded during events, with the appropriate lighting provided to ensure that there are no slips, trips or falls during an evacuation.

Conclusion

This Technical Note demonstrates that there is sufficient exit capacity in The Factory for 5,000 occupants in the warehouse when there is not also an event taking place in the theatre at the same time. This provides an interim exit capacity figure whilst a solution is developed for the external means of escape from the South of the building.

All other passive and active fire safety systems should be in line with the fire strategy which has been prepared to date.



The Factory

Evacuation Modelling

November 2023

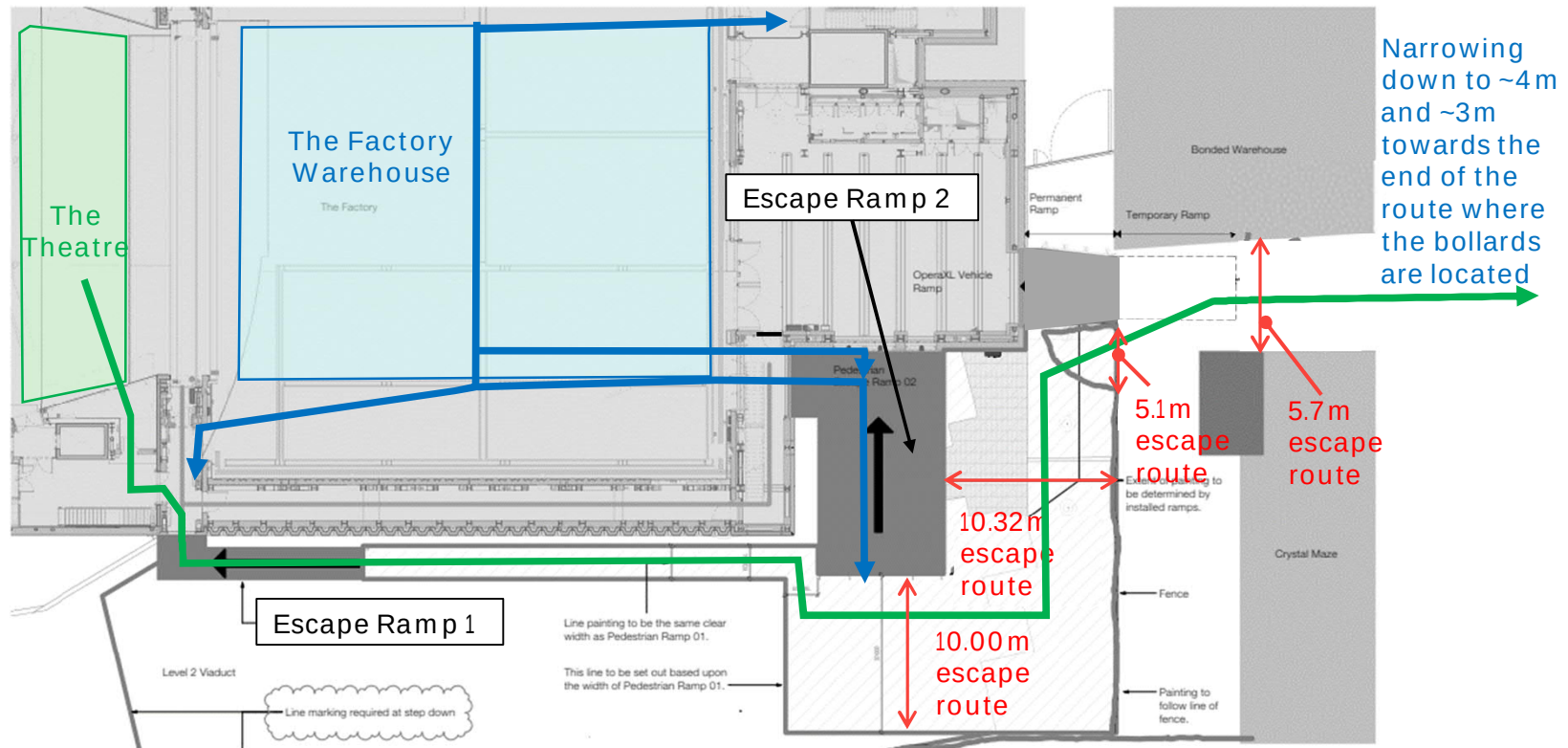
UK People Movement



1

Scenario 5 Inputs

Evacuation Scenario 5



- Scenario 5 is based on a fire occurring in the warehouse blocking the three largest exits into the central stair. This represents a large fire developing in the vicinity of the stair doors in the warehouse.
- This fire scenario is considered a conservative assumption as this is the main entrance and exit for the warehouse. Therefore, the stage which has the main potential for a fire should be located sufficiently away from the stair entrances.
- Three fewer doors to Escape Ramp 2 are available in order to reduce flow rates outside that otherwise would lead to congestion in the alley

Internal Dynamic Modelling - The number of people leaving the factory at each door was derived from the internal dynamic model. Initial results from the modelling indicate that people may take up to 500 seconds to leave the building using each exit door.

The diagram is a site plan of the Warehouse Theatre, showing the layout of the building and its surrounding areas. The main building is labeled 'The Warehouse' and contains 'The Theatre'. The plan shows the location of 'AL Door1', 'AL Door2', 'AL Ramp1', and 'AL Ramp2'. A red dashed line indicates the evacuation route from the theatre through the doors and ramps to the assembly points. The assembly points are marked with red dots and labeled 'AL 001' and 'AL 002'. The plan also shows the location of the 'TOTAL No. of people = 1552' assembly point. Dimensions are provided for various areas: 5.7m, 4.1m, 5.13m, 10.32m, and 10m- from provided pdf. A note indicates that the area is 'equal to the ramp'.

The Theatre

No. of people = 924

The Warehouse

No. of people = 804

No. of people = 748

AL Door1

AL Ramp1

AL Door2

AL Ramp2

AL 001

AL 002

TOTAL No. of people = 1552

5.7m

4.1m

5.13m

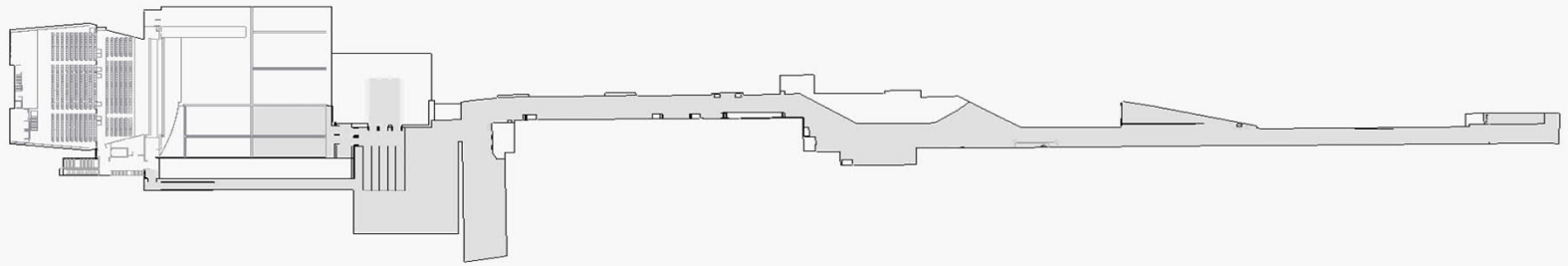
10.32m

10m- from provided pdf

equal to the ramp

2

Scenario 5 Dynamic Modelling Results

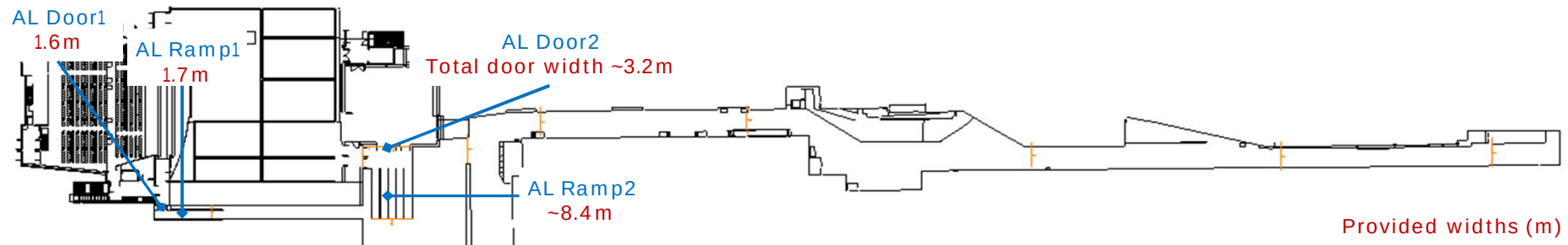


Video (available on request)

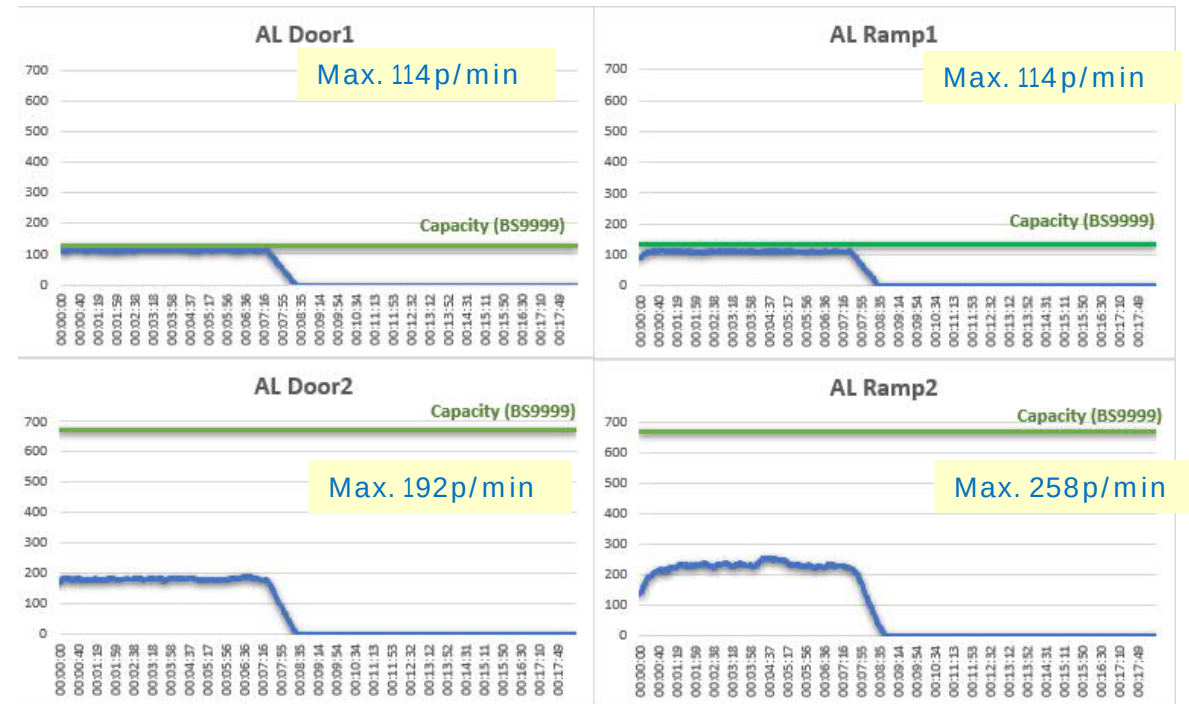
Population of 2,476

00:00:00

Scenario 5 – Capacity Performance Immediate escapes

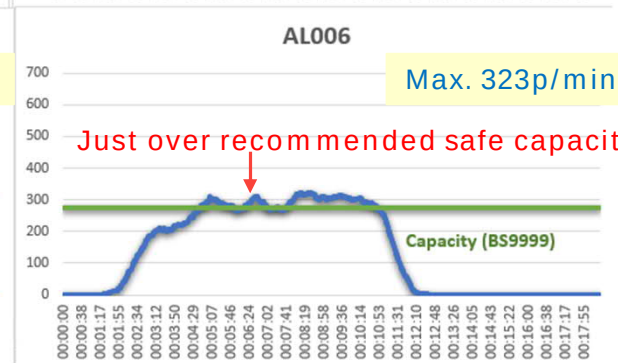
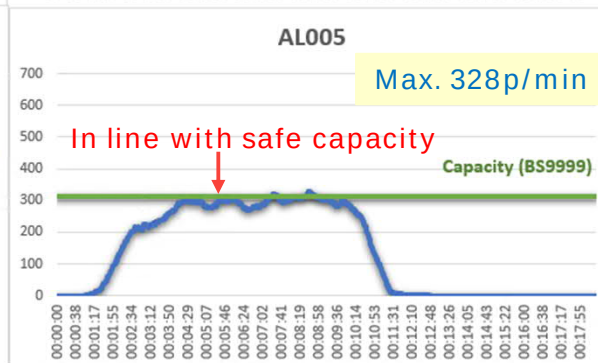
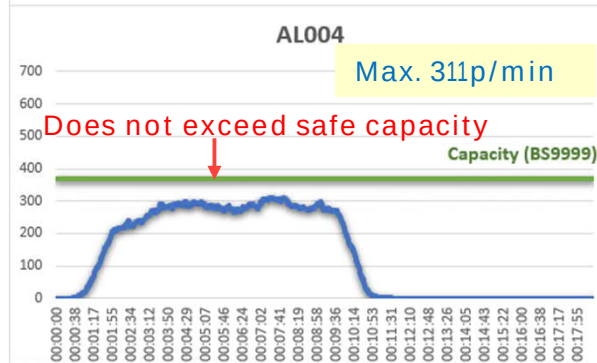
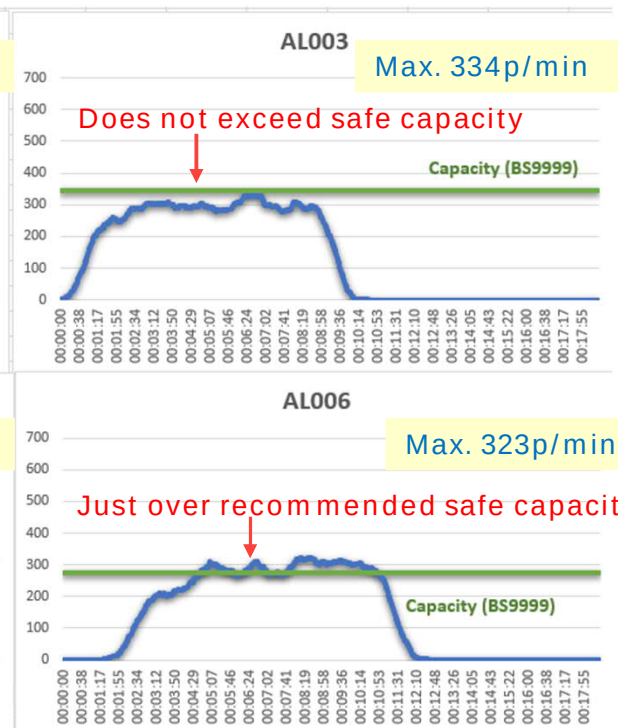
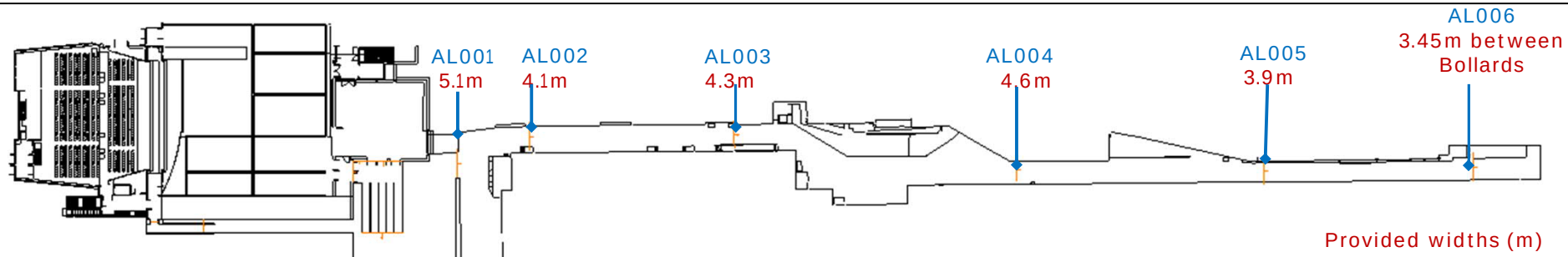


- The capacity performance has been extracted from the dynamic model of Scenario 5.
- The immediate escape routes and circulation elements from the Building (Doors and Ramps) are correctly sized to accommodate the maximum throughputs during an evacuation, as shown by the graphs on this slide.
- On the next slide, the graphs show that the external route capacity also meets the requirements in most areas (and just exceeds recommended flow rates at AL006).



— External route capacity performance during emergency evacuation
 — Capacity requirement during evacuation based on BS9999

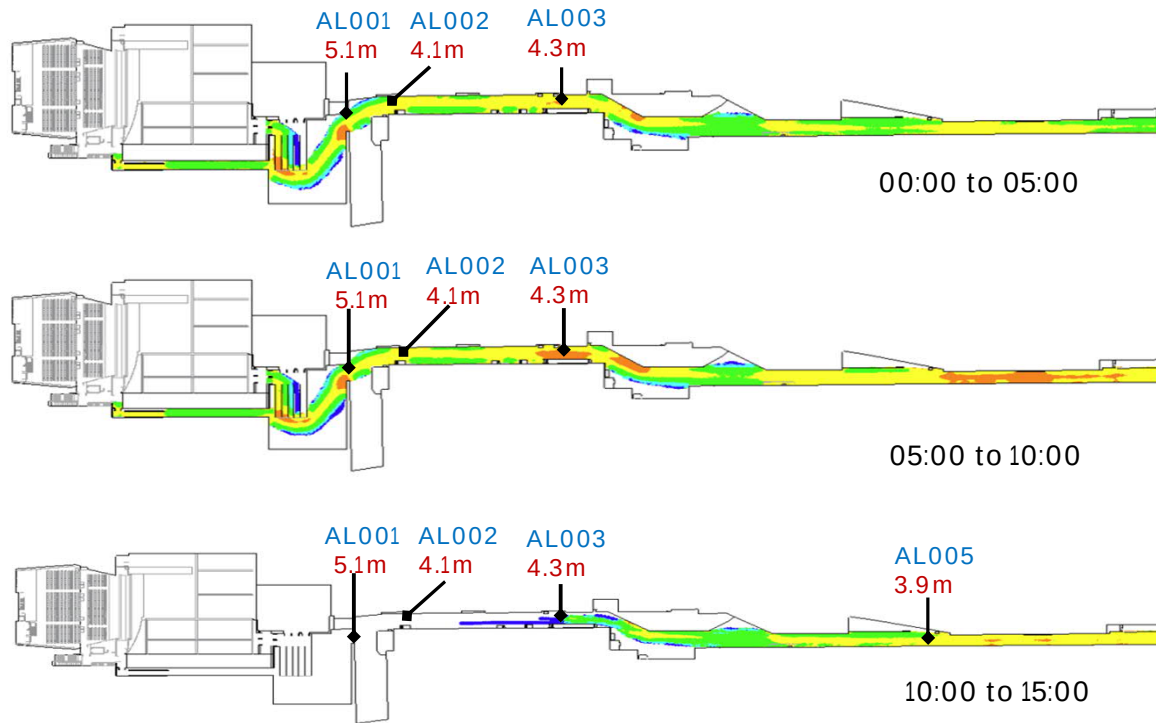
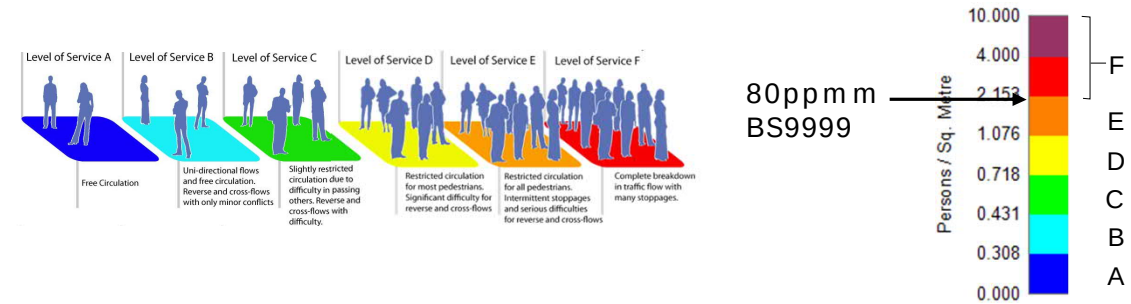
Scenario 5 – Capacity Performance External escape route



— External route capacity performance during emergency evacuation
— Capacity requirement during evacuation based on BS9999

Cumulative Mean Density – Fruin Walkways (S5)

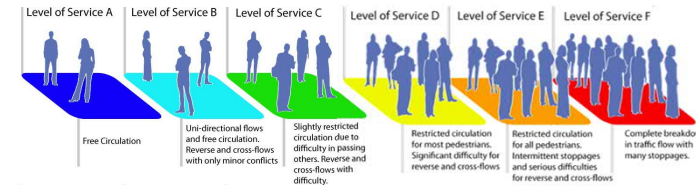
Walkway Level of Service (LoS) F: >2.15 people/m²



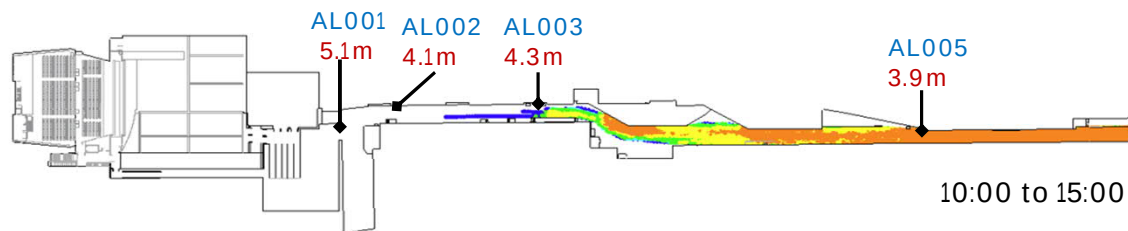
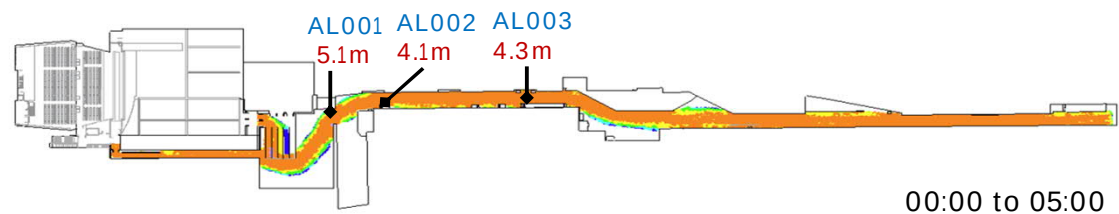
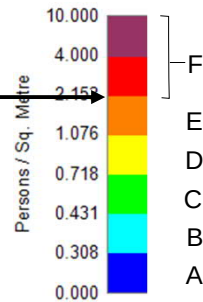
- These Cumulative Density Maps show the Walkway Mean (average) densities every 5 minutes of the simulation time.
- These results show a significant reduction in density levels compared with previous scenarios, with no LoS F and much smaller areas at LoS E (which one would expect in an evacuation).

Maximum Density – Fruin Walkways (S5)

Walkway Level of Service (LoS) F: >2.15 people/m²

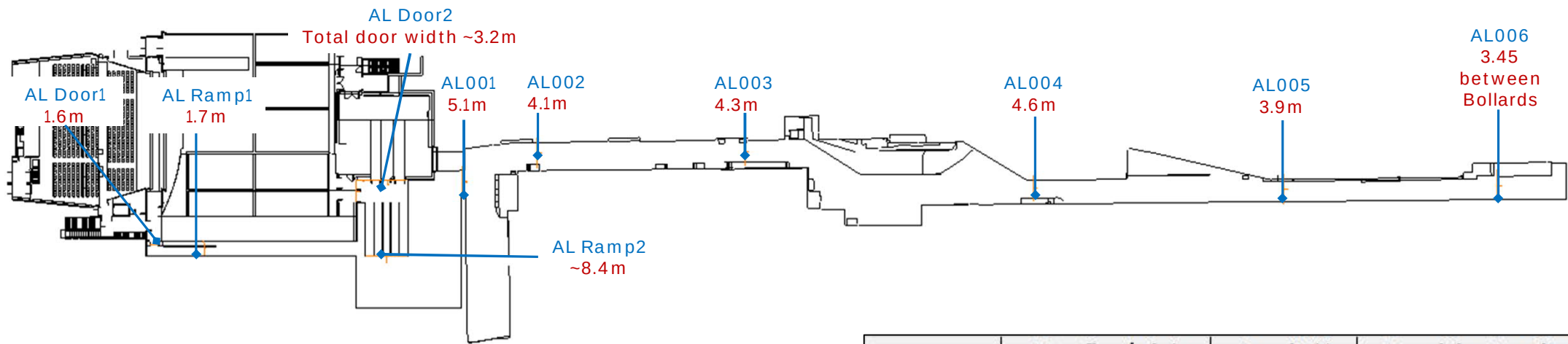


80pp m m
BS9999



- These Cumulative Density Maps show the Walkway Maximum densities every 5 minutes of the simulation time.
- These results show that the maximum densities are lower than 2.15 person/sqm (LoS E) along the entire length of the escape route.
- There should not be any unusual risks of slips, trips and falls or crushing at these density levels – where in previous scenarios density levels had been >4 persons/sqm and was a safety concern.

External Route Capacity Performance - Flow Rate (S5)



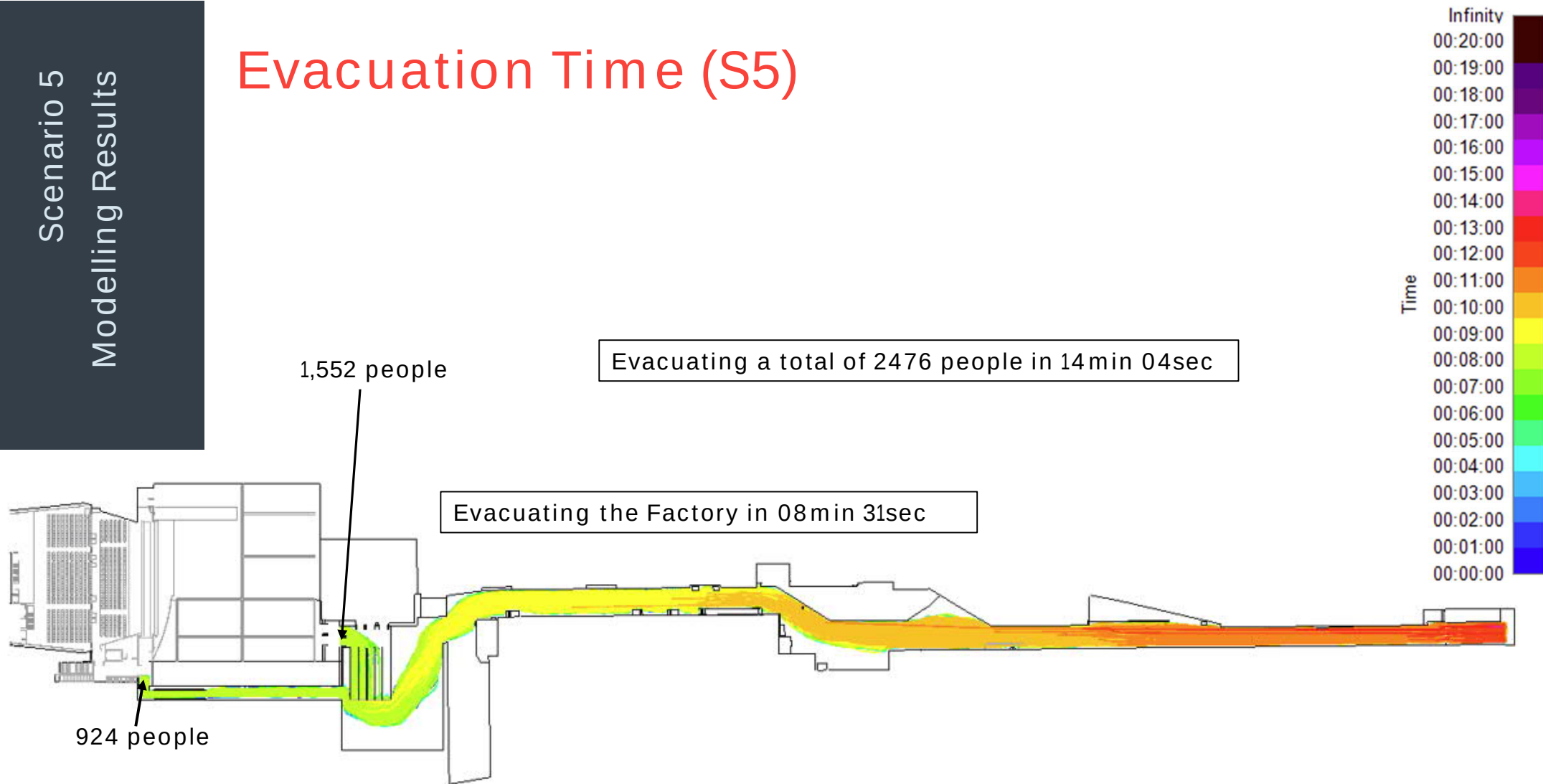
The model results indicate that due to the reduced flow rate coming from the building, flows in the alley are now much more closely aligned to recommended flow rates, and does not lead to dangerous levels of congestion.

	Max. flow/min*	Capacity**	Remaining Capacity
AL001	298	410	27%
AL002	334	328	-2%
AL003	334	344	3%
AL004	311	368	15%
AL005	328	312	-5%
AL006	323	276	-17%
AL Door1	114	128	11%
AL Door2	192	672	71%
AL Ramp1	114	136	16%
AL Ramp2	258	672	62%

* Max. flow/min at each location was extracted from LEGION model

** Recommended capacity: flow/min based on BS9999

Evacuation Time (S5)



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Findings and Recommendations

Findings & Recommendations

Findings from Dynamic Modelling

- Reducing number of available doors from the Warehouse reduces the flow rate onto Escape Ramp 2 and in turn into the alley.
- As a result, people exiting via the alley no longer exceed available capacity and so congestion levels do not build to dangerous levels as had been observed in previous scenarios tested.
- In addition, congestion and delays do not occur on Ramp 2 which had been seen in previous scenarios, and so flows are not impeded and no queuing in these areas occur.
- Safety levels have been significantly increased within the alley escape route outside the building compared to previous scenarios.

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