ARUP

Memorandum

To	Conor Farrell
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Subject	Site Wide Population Capacity Assessment, 2026 update

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1. Introduction

This Memo presents an updated emergency evacuation assessment for a Forecourt Concert event at the Sydney Opera House (SOH), of which the primary objective is to understand emergency evacuation performance given an increased forecourt population. The assessment has been undertaken to support DA 445-10-2003 MOD 5 proposing a capacity increase to the permitted forecourt event occupancy.

This memo is a summary of a detailed assessment, and it supports the proposal to update Condition 6a of the consent, which currently limits the SOH to a maximum of 6,000 people per event. This assessment supplements and should be read in context with previous Arup studies.

This study considers:

- Modifications to Forecourt event layout, crowd control barrier configuration, population distribution, exit availability, and crowd management strategies,
- A forecourt-only evacuation, to understand evacuation parameters of a single large-scale outdoor concert event, and
- A forecourt plus Opera House evacuation, as a comparison to previous population assessments.

Performance metrics considered include:

- Areas of crowd congestion and queueing,
- Density experienced,
- Time spent at high densities,
- Exit utilisation and related time to exit.

The assessment comprises a series of agent-based evacuation simulations undertaken using MassMotion crowd modelling software.

2. Scenarios

Numerous scenarios were tested by Arup to understand the potential for increased audience capacity. Two scenarios are considered further in this memo:

1. Forecourt occupancy of 7,043 with all exits available including a managed Gate 4 scenario.
2. A site-wide scenario with 7,043 people on the forecourt combined with the SOH building occupants and all exits available including a managed Gate 4.

3. Industry Guidance and Performance Indicators

The following key documents (among others) have been considered as relevant guidance:

- Guide to Safety at Sports Grounds (Green Guide) 6th Edition, Department for Culture, Media and Sport, 2018, UK
- Guidelines for concerts, events and organised gatherings, Government of Western Australia, Department of Health, December 2009
- Crowd Dynamics, Prof. Dr. G. Keith Still, 2020, UK
- Pedestrian Planning and Design, Fruin, Metropolitan Association of Urban Designers and Environmental Planners, 1971.

Our work does not demonstrate compliance with the documentation listed. Instead, the documents listed have been used to inform the modelling performance metrics and indictors.

3.1 Crowd Density

Relevant industry guidance identifies the following performance metrics and thresholds:

- A density of 4 persons/m² is commonly cited as the preferred maximum density for standing spectators and people queuing at bars/toilets/counters. This density may be exceeded for limited periods during ingress and egress.
- Densities above 5 to 6 persons/m² are associated with loss of control and increased risk.
- The Western Australian Guidelines indicate that patrons should not be held at densities above 4 persons/m² for longer than approximately 6 minutes.

3.2 Queueing and Travel Time

Guidance also indicates that:

- Extended periods of queueing or lack of movement can lead to crowd frustration and agitation.
- Best practice guidance suggests occupants should ideally reach a free-flowing exit route within approximately 8 minutes, noting that longer durations may occur but should not be relied upon as acceptable performance.

3.3 Assessment Indicators

Based on this guidance, the following performance indicators were used to assess each scenario:

Table 1: Evacuation Modelling Assessment Indicators

Metric	Description	Threshold	Source
Average Non-Zero Density (area-based)	Identifies where density occurs in an occupied area	Up to 5ppl/m^2	WA guidance
Time Spent Above Density (area-based)	Identifies how long density is experienced within an occupied area	Time spent above 4ppl/m^2	WA guidance
Time Spent Above Density (agent-based)	Identifies individual exposure to density	Time spent above 4ppl/m^2	WA guidance Green Guide
Time Spent Queueing (agent-based)	Identifies duration of low-speed movement (less than 0.5 m/s), used as a proxy for queueing	Up to 8 minutes	WA guidance Green Guide

4. Modelling assumptions and clarifications

The modelling has been undertaken with numerous assumptions, which should be considered when interpreting the results:

- Occupants are modelled as individual people, with group behaviour effects not explicitly simulated.
- A simultaneous evacuation of the Forecourt, Broadwalk, and Opera Bar areas is assumed.
- The assessment does not consider a dynamic or moving threat scenario.
- Modelling reflects the specific concert infrastructure layout provided at the time of analysis. The modelling also reflects specific uses of exit utilisation.
- Crowd movements beyond the event precinct into Circular Quay, Macquarie Street, or the Royal Botanic Gardens (RBG) are not modelled.
- The results presented in this memo assume that:
    - the Royal Botanic Gardens access gates can be opened as required, and
    - Sufficient staff are available to actively direct patrons towards this exit, including against preferred or familiar routes.
- The performance indicators adopted are informed by industry guidance and are intended to provide high-level insights, rather than definitive safety criteria.

5. Findings and Recommendations

The modelling highlights crowd movements and related performance indicators under the assumptions set out in this assessment.

Comparing the previous studies and the 2026 update (scenario 7c):

- Increased Forecourt occupancy (7,000 as compared with 6,000) yields higher densities during evacuation, and more time spent in high density. However, these higher densities do not exceed the threshold of 5 people per square metre. Thus, the studies are comparable in this sense.

- During an evacuation, time spent queueing in high densities is less than 8 minutes in the previous studies and current scenario testing.
- Time to clear the precinct is 17:06 in scenario 7c and 15:51 in the previous study, though given the >170m distance from bottom of the monumental steps to the model exit, this time is dictated by the travel speed of the slowest agent. The time to substantially egress the precinct (no queueing, free flow movements) is comparable across the two scenarios.

Gate 4 Management:

- Modelling shows that a separate, managed route through Gate 4 supports improved exit utilisation from the Monumental Steps. New localised high densities and queuing appear because of the changed movement pattern, but the overall effect reduces density and queuing outcomes in other areas, particularly at the forecourt concert area.

Botanic Gardens Exit Management:

- Most patrons enter the SOH precinct from Circular Quay or Macquarie Street. The best performing evacuation models utilise these two exits as well as the Botanic Gardens as an emergency evacuation route. Based on patron exit familiarity, active management will be required to guide occupants towards the RBG exit in an evacuation.

Active Crowd Management:

- An aim of the modelling is to help understand how infrastructure, physical barriers and fixed exits influence evacuation crowd dynamics, and thus, how crowd management can improve and optimise crowd flows and evacuation time. As such, active crowd observation and crowd management is needed to direct crowds around pockets of high density and to exits to help optimise exit utilisation.

The specific recommendations listed above should be adopted in addition to previous Arup recommendations, noting that:

- Performance metrics are based on best practice guidance and are intended as high-level indicators of emergency egress capacity and conditions. It is recognised that real emergency scenarios rely on a combination of infrastructure, management systems, and response, and that actual human behaviour will vary from the modelling outcomes. Nevertheless, the results remain useful to illustrate the capacity and constraints of the precinct infrastructure to inform evacuation planning.