ARUP

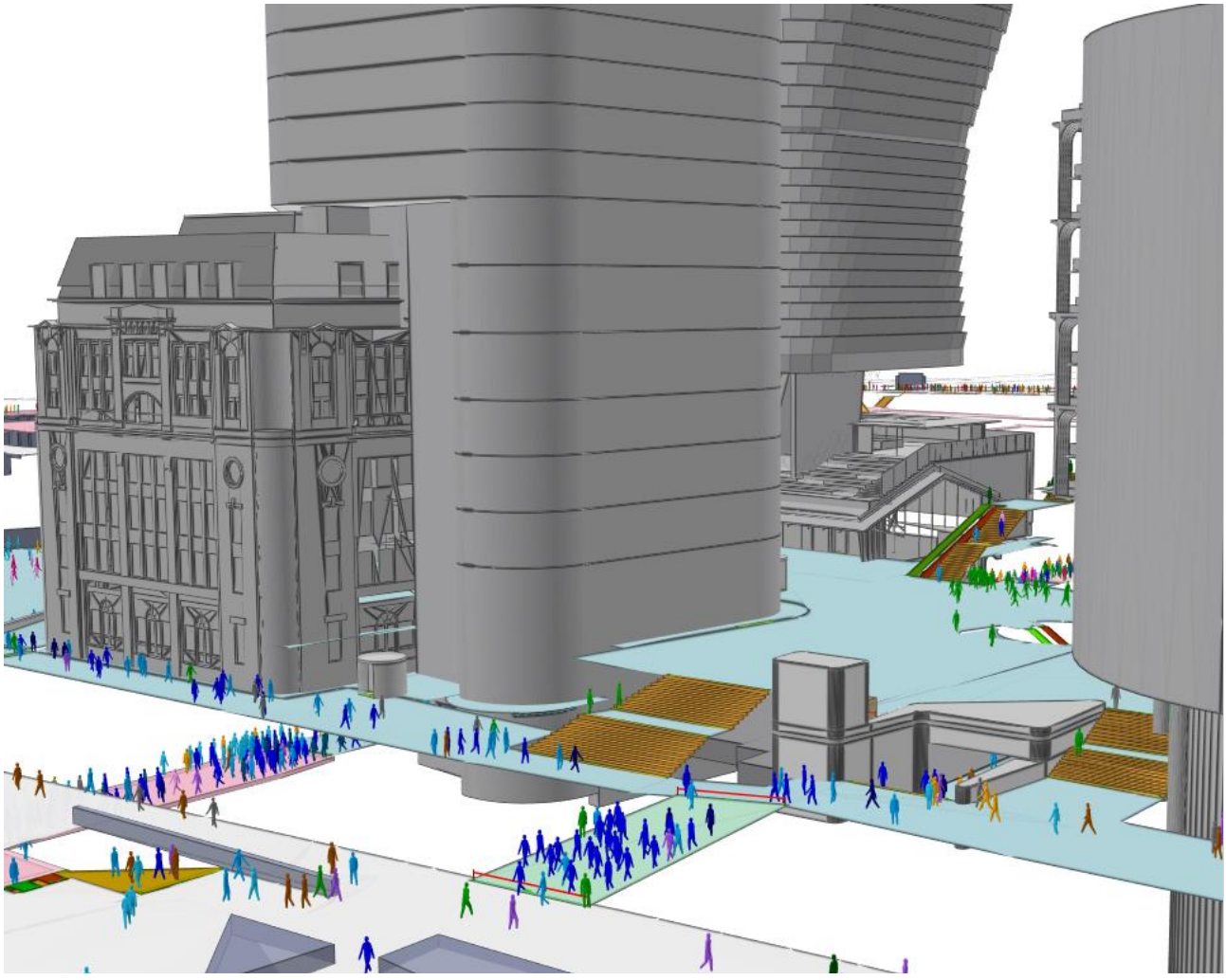
TOGA Development & Construction

TOGA Central

SSD DA - Pedestrian Modelling Analysis

Reference: TBAS

Version A | 28 July 2022



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1. Executive Summary

This Pedestrian Modelling Analysis Report has been prepared by Arup Australia Pty Ltd to accompany a detailed State significant development (SSD) development application (DA) for the mixed-use redevelopment proposal at TOGA Central, located at 2 & 8A Lee Street, Haymarket (the site). The site is legally described as Lot 30 in Deposited Plan 880518, Lot 13 in Deposited Plan 1062447 and part of Lot 14 in Deposited Plan 1062447. The site is also described as 'Site C' within the Western Gateway sub-precinct at the Central Precinct.

This report has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) issued for the SSD DA (SSD 33258337).

This report concludes that the proposed mixed-use redevelopment is suitable and warrants approval subject to the implementation of the following mitigation measures:

- Consideration of design interventions to help resolve pedestrian movement conflicts observed within the lower ground "node" at the junction of the Link Zone, Devonshire Street Tunnel, Henry Deane Plaza, and Lee Street Tunnel. The non-compliance at this node was identified to TfNSW in previous studies and TOGA's proposal had made this localized point of congestion no worse.
- A stair connection at the northern end of the Link Zone within the Third Square or Atlassian development (near the NE corner of the TOGA development) can help eliminate congestion within the node by pulling some pedestrian demand from Lower Ground to Upper Ground, thereby reducing congestion in the node at Lower Ground. TfNSW has identified that a stair in this location could be beneficial to pedestrian flows but the stair location and design has not been confirmed/committed.
- Further consideration of pedestrian movements for scenarios not captured in the pedestrian modelling studies which could include retail ins and outs, or consideration of wet weather scenarios which might drive routing assumptions different to those tested in this study.

Following the implementation of the above mitigation measures, the remaining impacts are appropriate.

2. Introduction

This report has been prepared to accompany an SSD DA for the for the mixed-use redevelopment proposal at TOGA Central, located at 2 & 8A Lee Street, Haymarket.

The Minister for Planning, or their delegate, is the consent authority for the SSD DA and this application is lodged with the NSW Department of Planning and Environment (DPE) for assessment.

The purpose of the SSD DA is to complete the restoration of the heritage-listed building on the site, delivery of new commercial floorspace and public realm improvements that will contribute to the realisation of the Government's vision for an iconic technology precinct and transport gateway. The application seeks consent for the conservation, refurbishment and adaptive re-use of the Adina Hotel building (also referred to as the former Parcel Post building (fPPb)), construction of a 45-storey tower above and adjacent to the existing building and delivery of significant public domain improvements at street level, lower ground level and within Henry Deane Plaza. Specifically, the SSD DA seeks development consent for:

- Site establishment and removal of landscaping within Henry Deane Plaza.
- Demolition of contemporary additions to the fPPb and public domain elements within Henry Deane Plaza.
- Conservation work and alterations to the fPPb for retail premises, commercial premises, and hotel and motel accommodation. The adaptive reuse of the building will seek to accommodate:
  - Commercial lobby and hotel concierge facilities,
  - Retail tenancies including food and drink tenancies and convenience retail with back of house areas,
  - 4 levels of co-working space,
  - Function and conference area with access to level 7 outdoor rooftop space, and
  - Reinstatement of the original fPPb roof pitch form in a contemporary terracotta materiality.
- Provision of retail floor space including a supermarket tenancy, smaller retail tenancies, and back of house areas below Henry Deane Plaza (at basement level 1 (RL12.10) and lower ground (RL 16)).
- Construction of a 45-storey hotel and commercial office tower above and adjacent to the fPPb. The tower will have a maximum building height of RL 202.28m, and comprise:
  - 10 levels of hotel facilities between level 10 – level 19 of the tower including 204 hotel keys and 2 levels of amenities including a pool, gymnasium and day spa to operate ancillary to the hotel premises. A glazed atrium and hotel arrival is accommodated adjacent to the fPPb, accessible from Lee Street.
  - 22 levels of commercial office space between level 23 – level 44 of the tower accommodated within a connected floor plate with a consolidated side core.
  - Rooftop plant, lift overrun, servicing and BMU.
- Provision of vehicular access into the site via a shared basement, with connection points provided to both Block A (at RL 5) and Block B (at RL5.5) basements. Primary access will be accommodated from the adjacent Atlassian site at 8-10 Lee Street, Haymarket, into 4 basement levels in a split-level arrangement. The basement will accommodate:
  - Car parking for 106 vehicles, 4 car share spaces and 5 loading bays.
  - Hotel, commercial and retail and waste storage areas.
  - Plant, utilities and servicing.
- Provision of end of trip facilities and 165 employee bicycle spaces within the fPPb basement, and an additional 72 visitor bicycle spaces within the public realm.

- Delivery of a revitalised public realm across the site that is coordinated with adjacent development, including an improved public plaza linking Railway Square (Lee Street), and Block B (known as 'Central Place Sydney'). The proposal includes the delivery of a significant area of new publicly accessible open space at street level, lower ground level, and at Henry Deane Plaza, including the following proposed elements:
  - Provision of equitable access within Henry Deane Plaza including stairways and a publicly accessible lift.
  - Construction of raised planters and terraced seating within Henry Deane Plaza.
  - Landscaping works within Henry Deane Plaza.
- Utilities and service provision.
- Realignment of lot boundaries.

This report has been prepared in response to the requirements contained within the Secretary's Environmental Assessment Requirements (SEARs) dated 17 December 2021 and issued for the SSD DA. Specifically, this report has been prepared to respond to the SEARs requirement issued below.

Item	Description of requirement	Section reference (this report)
11. Traffic, Transport and Accessibility: Pedestrian Impact Statement	▪ Provide a transport and accessibility impact assessment, which includes: – analysis of the impacts of the proposed development (including justification for the methodology used), including predicted modal split, a forecast of additional daily and peak hour multimodal network flows as a result of the development (using industry standard modelling), identification of potential traffic impacts on road capacity, intersection performance and road safety (including pedestrian and cyclist conflict) and any cumulative impact from surrounding approved developments.	Section 5

It should be noted that this report focuses solely on pedestrian movements within public realm circulation spaces and related impact upon completion of the building. For modes other than pedestrians, please refer to Stantec's Transport Impact Assessment and for pedestrian impact during the construction, please refer to Stantec's Construction Traffic Management Plan.

The Site

The site is located within the City of Sydney Local Government Area (LGA). The site is situated 1.5km south of the Sydney CBD and 6.9km north-east of the Sydney International Airport within the suburb of Haymarket.

The site is located within the Western Gateway sub-precinct, an area of approximately 1.65ha that is located immediately west of Central Station within Haymarket on the southern fringe of the Sydney CBD. Immediately north of Central Station is Belmore Park, to the west is Haymarket (including the University of Technology, Sydney and Chinatown), to the south and east is rail lines and services and Prince Alfred Park and to the east is Elizabeth Street and Surry Hills.

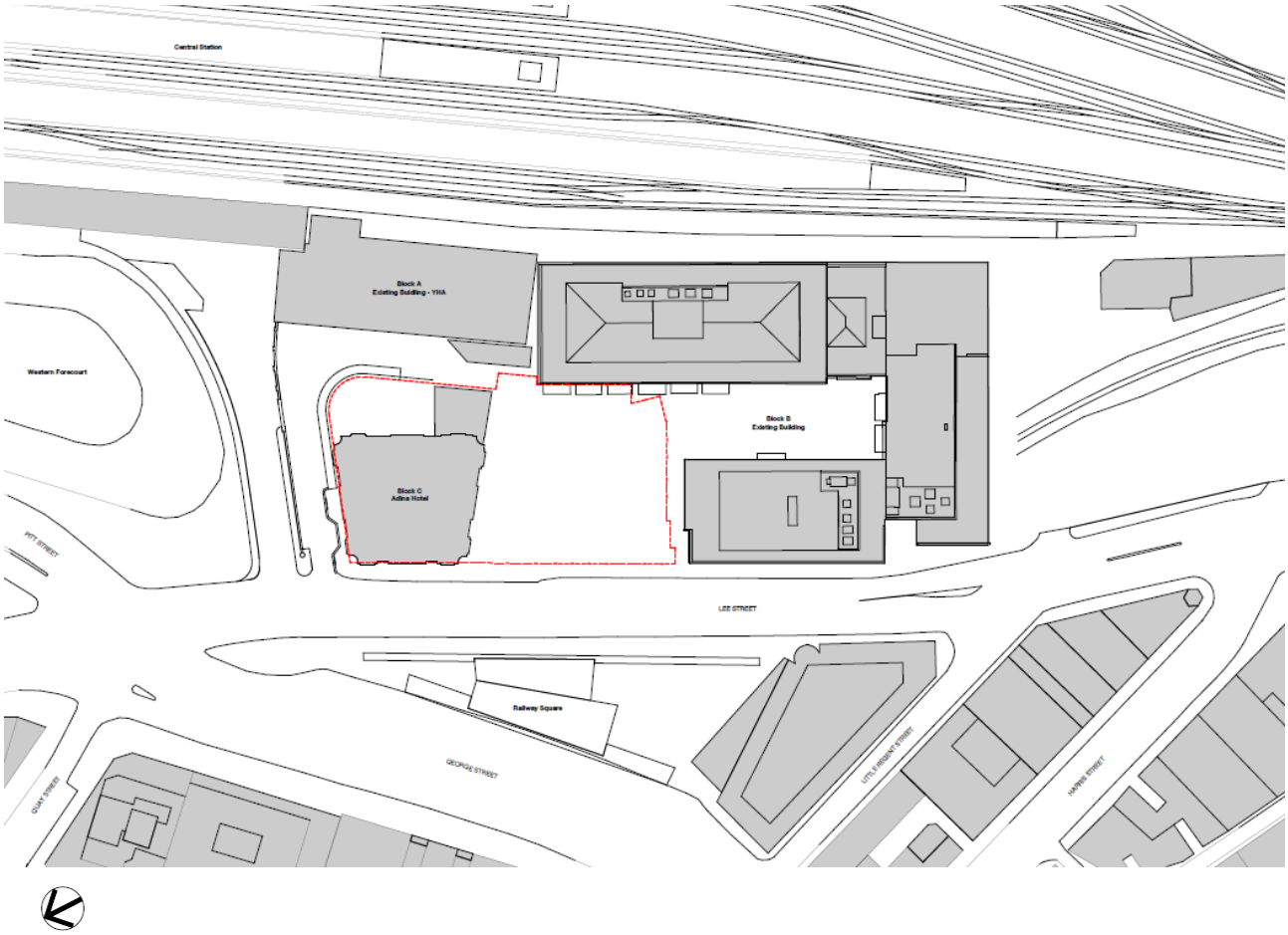
Central Station is a public landmark, heritage building, and the largest transport interchange in NSW. With regional and suburban train services, connections to light rail, bus networks and to Sydney Airport, the area around Central Station is one of the most-connected destinations in Australia.

The site is located at 2 & 8A Lee Street, Haymarket and is legally described as Lot 30 in Deposited Plan 880518, Lot 13 in Deposited Plan 1062447 and part of Lot 14 in Deposited Plan 1062447.

The land that comprises the site under the Proponent's control (either wholly or limited in either height or depth) comprises a total area of approximately 4,159sqm.

The location of the TOGA Central site is illustrated in Figure 1.

Figure 1: Site Identification Plan



Source: Bates Smart

Development blocks A and B are shown in Figure 2.

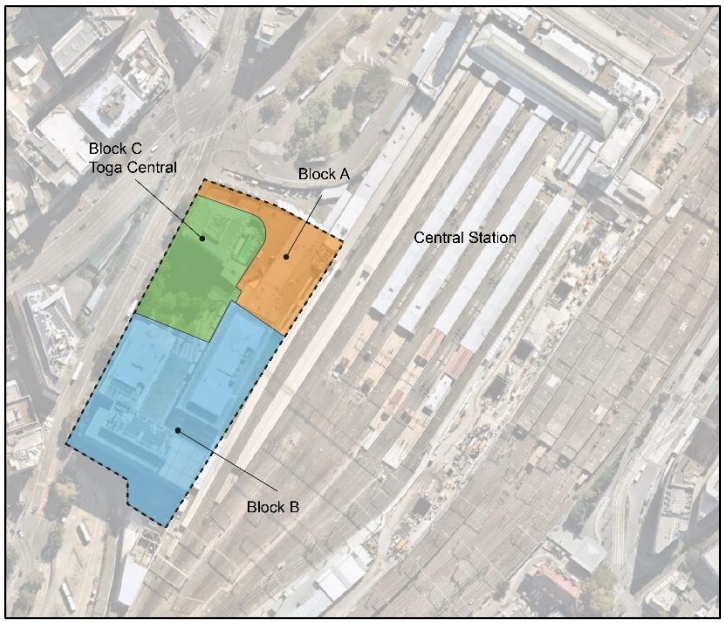


Figure 2: Development blocks Western Gateway

The site currently comprises the following existing development:

- Lot 30 in Deposited Plan 880518 (Adina Hotel building): the north-western lot within the Western Gateway sub-precinct accommodates a heritage-listed building which was originally developed as the Parcels Post Office building. The building has been adaptively re-used and is currently occupied by the Adina Hotel Sydney Central. The eight-storey building provides 98 short-stay visitor apartments and studio rooms with ancillary facilities including a swimming pool and outdoor seating at the rear of the site.
- Lot 13 in Deposited Plan 1062447 and part of Lot 14 in Deposited Plan 1062447 (Henry Deane Plaza): the central lot within the Western Gateway sub-precinct adjoins Lot 30 to the south. It accommodates 22 specialty food and beverage, convenience retail and commercial service tenancies. The lot also includes publicly accessible space which is used for pop-up events and a pedestrian thoroughfare from Central Station via the Devonshire Street Tunnel. At the entrance to Devonshire Street Tunnel is a large public sculpture and a glazed structure covers the walkway leading into Railway Square. This area forms part of the busy pedestrian connection from Central Station to Railway Square and on to George and Pitt Streets, and pedestrian subways.

The site is listed as an item of local significance under Schedule 5 of the *Sydney Local Environmental Plan 2012* 'Former Parcels Post Office including retaining wall, early lamp post and building interior', Item 855.

The site is also included within the Central Railway Station State heritage listing. This is listed on the State Heritage Register 'Sydney Terminal and Central Railway Station Group', Item SHR 01255, and in Schedule 5 of the *Sydney Local Environmental Plan 2012* 'Central Railway Station group including buildings, station yard, viaducts and building interiors' Item 824.

The site is not however listed independently on the State Heritage Register. There is an array of built forms that constitute Central Station, however the Main Terminal Building (particularly the western frontage) and associated clocktower constitute key components in the visual setting of the Parcel Post building.

3. Pedestrian Movement Assessment Methodology

Arup has been commissioned by TOGA to provide pedestrian planning advice to support the development of TOGA Central. A MassMotion pedestrian modelling exercise was undertaken by Arup on behalf of TOGA to:

- Help understand the potential future movement patterns through the Western Gateway Precinct;
- Assess the performance of the public realm around the TOGA development with respect to pedestrian movement;
- Respond to the Transport for New South Wales (TfNSW) requirement to meet level of service C in precinct circulation spaces; and
- Assess the potential performance of doors and access points to the TOGA hotel and commercial lobby (as per drawings provided by TOGA on the 24th June 2022 and updated NLA with a population density of 1 persons per 10m2).

3.1 TfNSW Requirements

TfNSW set the Transport and Customer Requirements for the Western Gateway sub-precinct, including the following key requirement relating to pedestrian movement:

1.1 The proposal must ensure that:

1.1.1 The pedestrian routes and circulation spaces are to accommodate morning peak hour at 2056 +15% pedestrian demand achieving Fruin Level of Service C."

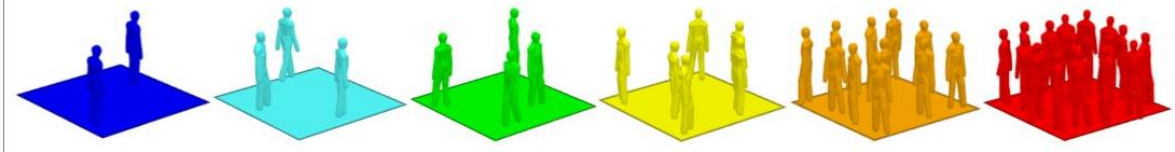
We interpret this requirement to mean:

- Pedestrian movements through public realm circulation spaces are to be assessed using a dynamic pedestrian simulation tool,
- Pedestrian demands are to be based on the Future Transport forecast year of 2056 with an additional 15% surplus added to demand (except for precinct developments including TOGA, Atlassian, Central Place Sydney, Over Station Development, and the Bus Layover Site, which are assumed to be at full occupancy).
- A 2056 forecast year represents a "Day 3" combined full buildout of all precinct developments.
- Fruin Level of Service is reported for the peak 15-minutes of the AM peak hour.

3.1.1 Pedestrian Density Assessment - Fruin Level of Service

Pedestrian densities and experiences are assessed using Fruin's Level of Service (LoS). Figure 3 below explains the different flowrate targets and experiences for LoS Walkways.

Fruin Level of Service– Walkways



	LoS A	LoS B	LoS C	LoS D	LoS E	LoS F
Description	LoS A – Free circulation	LoS B – Uni-directional flows and free circulation. Minor conflicts if reverse direction or cross flows	LoS C – Slightly restricted circulation and passing. High probability of conflict on reverse and cross flow movements	LoS D – Restricted circulation for majority. Severely restricted reverse and cross flow movement	LoS E – Restricted circulation for all. Extreme difficulty for reverse and cross flow movements	LoS F – Complete breakdown in flow
Flowrate (people per minute)	0 - 23	23- 33	33 - 49	49 - 66	66 - 82	> 83

Figure 3: Fruin Level of Service – Walkways

Fruin describes LoS C as follows:

> Freedom to select individual walking speed and freely pass other pedestrians is restricted. Where pedestrian cross movements and reverse flows exist, there is a high probability of conflict requiring frequent adjustment of speed and direction to avoid contact. Designs consistent with this LOS would represent reasonably fluid flow; however, considerable friction and interaction between pedestrians is likely to occur, particularly in multi-directional flow situations. Examples of this type of design would be heavily used transportation terminals, public buildings, or open spaces where severe peaking, combined with space restrictions, limit design flexibility.

Transit agencies, owners and operators around the world have adopted Fruin thresholds to help describe the performance of transit stations. These agencies often target the middle of LoS C, or the breakpoint between LoS C and LoS D as the typical design density for the planning and design of transport interchanges as it provides a balance between congestion, design, and infrastructure. For this assessment, we assume that a result in the LoS C range (or better) as an average across the peak 15-minutes, is acceptable and LoS D (yellow) or worse is to be avoided.

3.2 Simulation Model Development

The precinct has been modelled using MassMotion pedestrian simulation software to understand how future pedestrian demands can be served through the Western Gateway sub-precinct. The original version of the MassMotion pedestrian model was created by Arup on behalf of Dexus-Frasers (DF) in support of their SSD DA for Central Place Sydney (CPS), and developed in coordination with Transport for NSW as a key stakeholder in the process.

In general, TfNSW supplied:

- The 2056 +15% future year demand forecast (from their Central Station STEPS model);
- Data that supported understanding of pedestrian trip origins and destinations between Central Station and surrounding travel zones (from the PTPM-SMW model);
- Bus and light rail movements (from the PTPM-SMW model);
- Discussion and agreement of the pedestrian route assumptions underpinning some of the trips that move between Central Walk West and University of Technology, Sydney (UTS);
- Layout of Henry Deane Plaza (HDP).

Dexus-Frasers provided:

- Layout for their development site,
- Estimations of tower use and NLA yields.

Following the CPS modelling for DF, versions of the model have been used to support:

- Atlassian, for the Atlassian Central SSD DA;
- TfNSW, to help understand demand and layout changes; and now
- TOGA, for the TOGA Central SSD DA.

For each subsequent effort, revised modelling utilised:

- Inputs and assumptions largely consistent with those developed during the original effort with DF and TfNSW;
- Building layout and associated public realm layouts provided by Atlassian, TfNSW and TOGA;
- Discrete changes to demand and routing per each development NLA yield and building access plans.

As such, the same tool has essentially been utilised to study each Development Application which supports consistency in analysis and reporting across the precinct.

3.3 Development of the TOGA MassMotion Model

The baseline TOGA MassMotion model aims to reflect:

- The 2056 + 15% AM peak hour pedestrian origin-destination matrix previously agreed with TfNSW and Arcadis (TfNSW's transport planning technical advisor for the precinct), as shown in Appendix 1;
- A revised set of future year demand projections to include demand to/from the TOGA site based on increased commercial NLA and hotel rooms;
- An updated design for the TOGA buildings; and
- A two-level public domain plan for Henry Deane Plaza.

4. Modelling Inputs and Assumptions

4.1 Day 3 Scenario

As summarised in Table 1, the Precinct model simulates a Day 3 Scenario which accounts for the opening of Atlassian, Dexus-Frasers, Central Walk West, Henry Deane Plaza (HDP), the Third Square, the Over Station Development (OSD), and the Bus Layover Site.

Table 1: Day 3 scenario assumptions for areas within the Western Gateway precinct

Precinct Area Status	Day 1	Day 2/3
TOGA Central development open and fully occupied	X	X
Central Place Sydney development open and fully occupied		X
Atlassian Central development open and fully occupied		X
Sydney Metro Central Station open		X
Central Walk West open		X
Henry Deane Plaza redeveloped		X
Third Square redeveloped		X
OSD operational (~200k GFA) and occupied		X
Bus Layover Site development open and fully occupied		X
Lee Street pedestrianised		

4.2 TOGA and HDP Updated Geometry

TOGA provided Arup with a set of updated drawings of the TOGA development (RL16 Lower Ground and RL21 Upper Ground) and a two-storey public domain for HDP. Figure 4 and Figure 5 show the geometry that was included into the TOGA Central dynamic model, with access points depicted by yellow arrows.

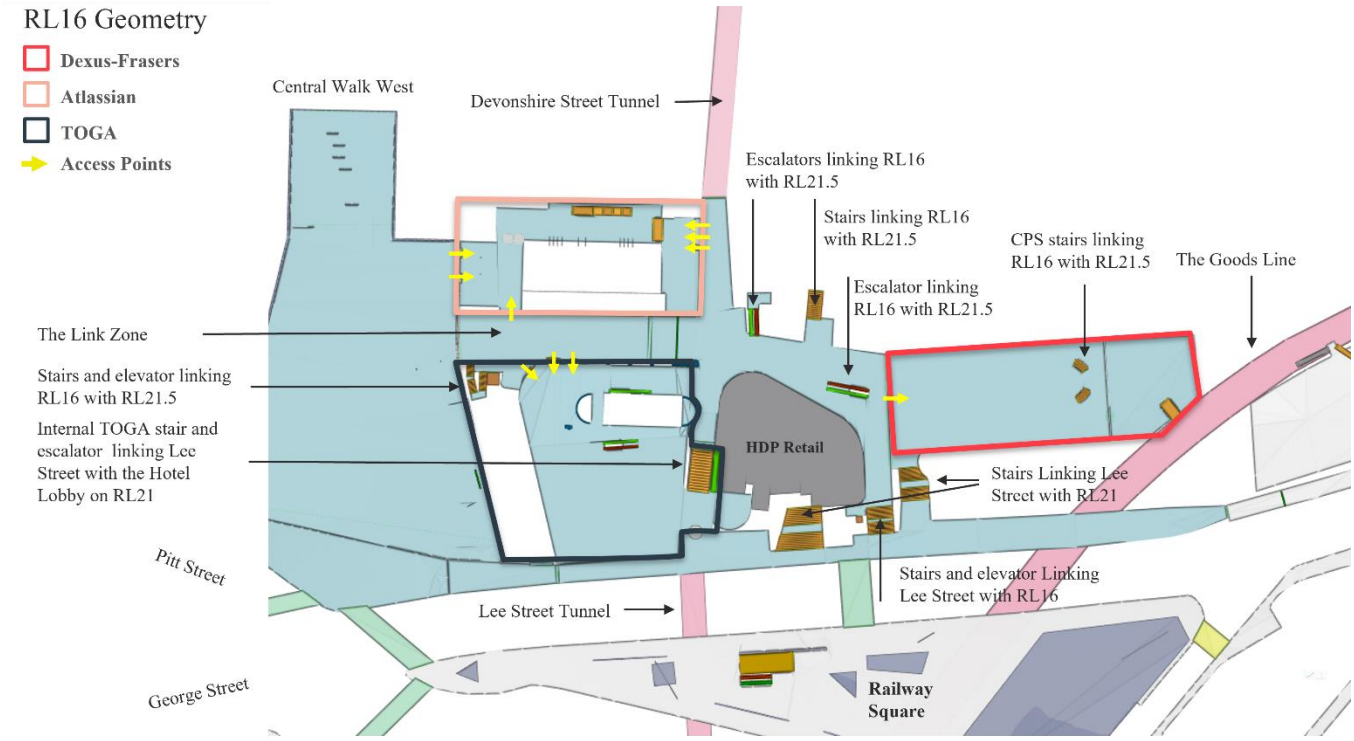


Figure 4: RL 16 Geometry included into TOGA Central model (Model source: 01_56_AM_TOGA)

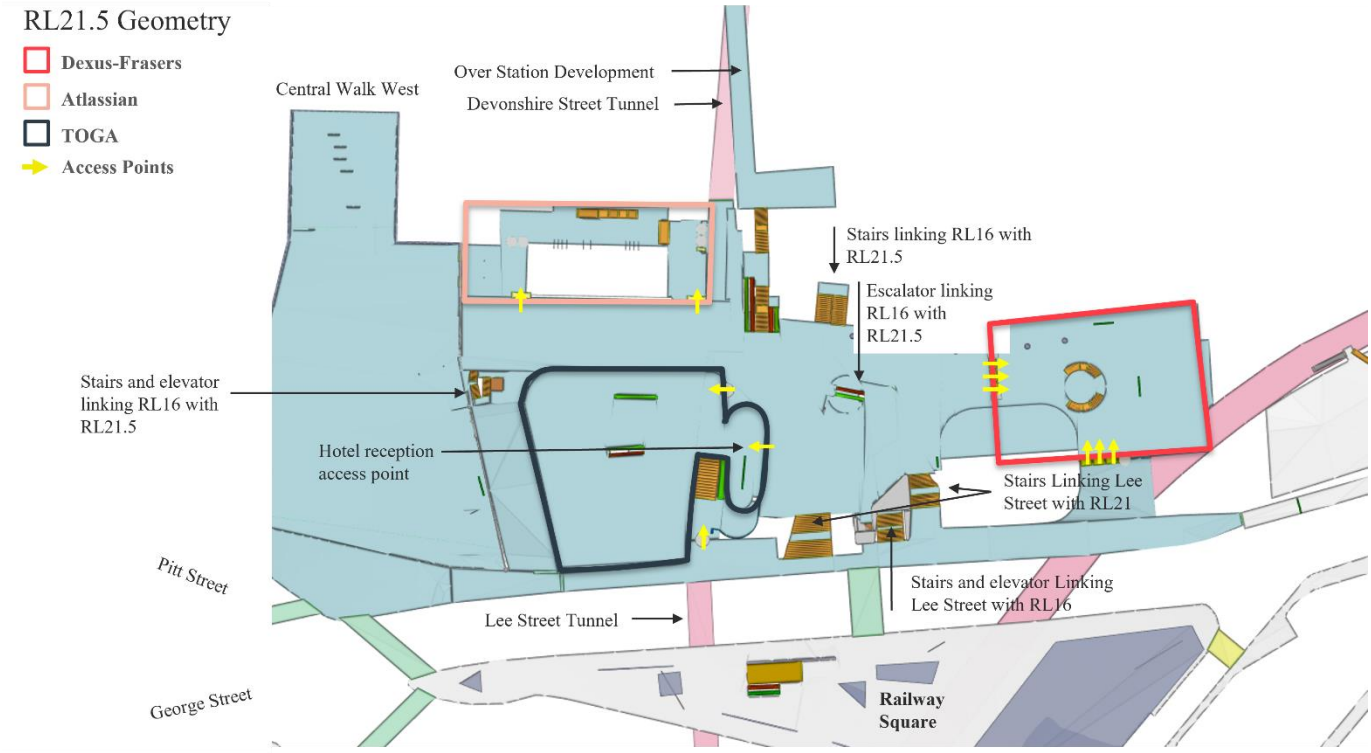


Figure 5: RL 21.5 Geometry included into TOGA Central model (Model source: 01_56_AM_TOGA)

4.2.1 TOGA Access Points

The TOGA development proposes multiple access and egress points at RL16 and RL21.5 which is summarised in Table 2.

Table 2: TOGA Central access and egress points

Level	Access and egress points
RL16 Lower Ground	• Three sets of doors joining with the Link Zone at the NE corner of the building
RL21.5 Upper Ground	• Revolving door access at the SE corner of the development • Separate set of doors accessing the hotel lobby • Revolving door access from Lee Street (approx. RL19), joining with an internal stair up to RL 21.5

4.2.2 Ambulance Avenue Heritage Wall and Link Zone vertical transport

The connection between Central Walk West and the Link Zone through the Ambulance Avenue Heritage Wall has been modelled as one large opening, as shown in Figure 6 below.

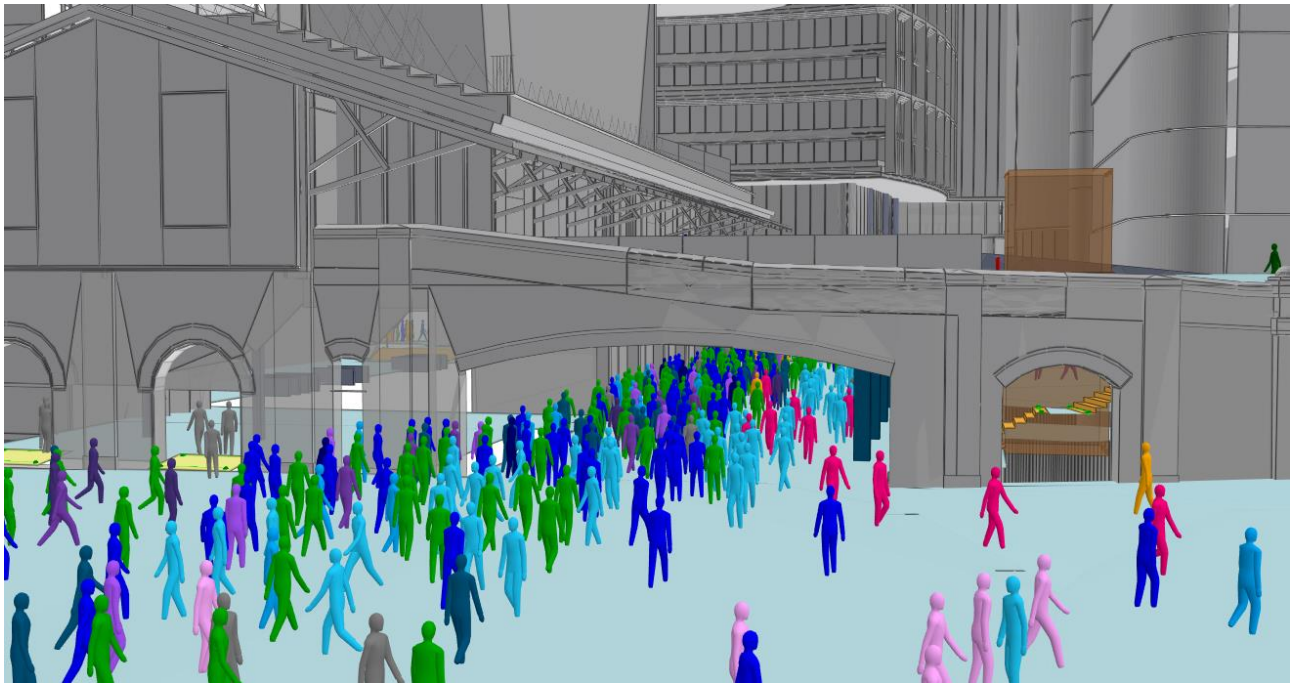


Figure 6: Modelled connection through the Ambulance Avenue Heritage Wall (Model source: 01_56_AM_TOGA)

4.3 TOGA Updated Demand and Route Splits

The TOGA development proposes three primary uses including commercial, retail and hotel uses; Table 3 shows GFA and NLA for the development based on land uses.

Table 3: TOGA Central building GFA and NLA

	NLA	GFA
Commercial	26,823m^2	29,253m^2
Hotel (210 rooms)	67m^2	9,429m^2
Retail	-	4,520m^2

The forecast demand for commercial user groups was developed based on the assumed population density of 1 person per 10m^2 NLA, and added to the trip distribution within the AM peak. The assumed trip arrival rate was derived from a survey undertaken for a commercial development within Sydney CBD, which suggests that approximately 60.8% of trips arrive and 1.5% depart within the AM peak (8-9AM). Table 4 shows the

resultant arrival and departure demand for TOGA commercial users.

Table 4: Commercial building users included in model

	Arrival	Departure	Total
Trips for commercial users within the AM peak	1,632	41	1,683

Hotel related demand was developed based on the number of rooms provided by the development, room occupancy % and trip distribution within the AM peak. The room occupancy % and trip distribution has been derived from a survey of a hotel within Sydney CBD. The survey showed that on a typical weekday, there is an 86% room occupancy rate with 4% of the demand arriving and 8% departing within the AM peak. Table 5 shows arrival and departure demand for hotel users.

Table 5: Hotel building users included in model

	Arrival	Departure	Total
Trips for hotel users within the AM peak	7	14	22

Noting that the TOGA development accounts for retail uses at the lower ground, the MassMotion model does not include retail demand or activity given the retail offering and related visitation, staffing profile, transaction times, etc. are unknown at this stage. It is expected that retail trips within the study area will largely be pass-by trips rather than destination retail. As such, the retail is not expected to generate additional trips beyond those already represented by AM peak hour movements.

Commercial and hotel trips to/from the TOGA development have been distributed based on the assumption that 79% of trips will arrive or depart through the heritage archway from Central Walk West, 16% through Devonshire Tunnel, 2% through Lee Street Tunnel and 2% through the revolving doors at Lee Street. Figure 7 shows the Origin-destination matrix developed for demand travelling to/from TOGA. Commercial demand has been split evenly between the Lower and Upper Ground floors within the TOGA Central building given the planned stacked/twin lift system. Figure 8 shows the departure and arrival splits to/from TOGA.

	Adina	Toga Commercial LG	Toga Commercial UG	Elizabeth St North	Elizabeth St South	Devonshire St	Devonshire St	Lee St West	Lee St East	Broadway South	Broadway North	Quay St West	Quay St East	George St West	George St East	Devonshire St exit	Western Concourse exit	Eddy Ave bus	**Total**
Adina																2	10	1	14
Toga Commercial LG						1	1									2	15	1	20
Toga Commercial UG						1	1									2	15	1	20
Elizabeth St North		13	13																
Elizabeth St South																			
Devonshire St		21	21																
Devonshire St		21	21																
Lee St West		6	6																
Lee St East		6	6																
Broadway South		9	9																
Broadway North		9	9																
Quay St West		3	3																
Quay St East		3	3																
George St West		5	5																
George St East		5	5																
Devonshire St exit	1	94	94																
Western Concourse exit	5	591	591																
Eddy Ave bus	0	30	30																
Total	7	816	816																

Figure 7: TOGA demand matrix (*Model source: 01_56_AM_TOGA*)

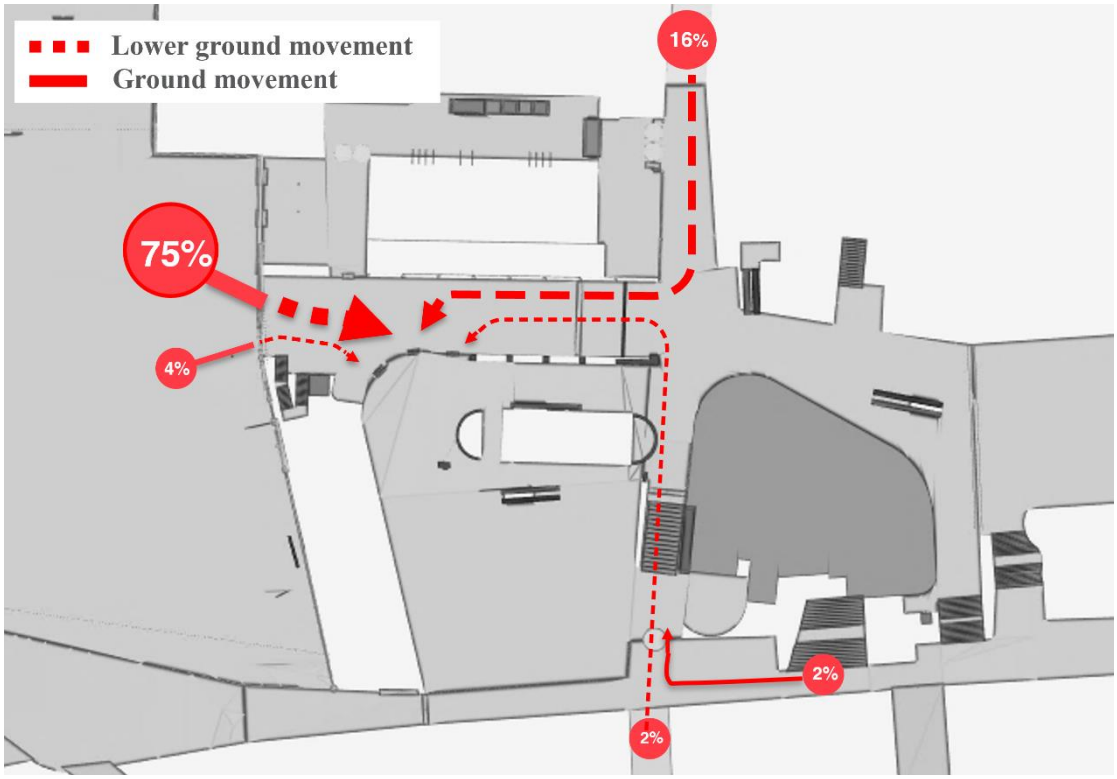


Figure 8: TOGA demand percentage splits

4.4 Precinct Route Splits

MassMotion agents choose shortest path to assigned destinations. The outcome of this behaviour within the model often produces a binary result (i.e. all agents choose the same path) which is not responsive to environment or amenity. To counteract this, Arup has previously imparted some route splits to redistribute people within the Precinct. It should be noted that these route splits were derived from iterative testing of the pedestrian network during the original work with DF and TfNSW. The iterative testing revealed that no one single route between Central Walk West and UTS has sufficient capacity to handle all movements and a diffused, distributed network is required to support movements. A such, the routing splits emerged from the prior work and are then enforced and fixed within the TOGA MassMotion modelling to recognise the capacity constraints within the wider pedestrian network, and to maintain consistency with previous pedestrian studies.

Figure 9 to Figure 12 summarise the assigned proportion of agents going to Broadway North, Broadway South, Bus Layover Site and CPS.

From: Central Walk West
Destination: Broadway South

Route description	Assigned percentage
Through Lee Street Tunnel	40%
Along Adina footpath	30%
Through HDP (Lower Ground)	30%

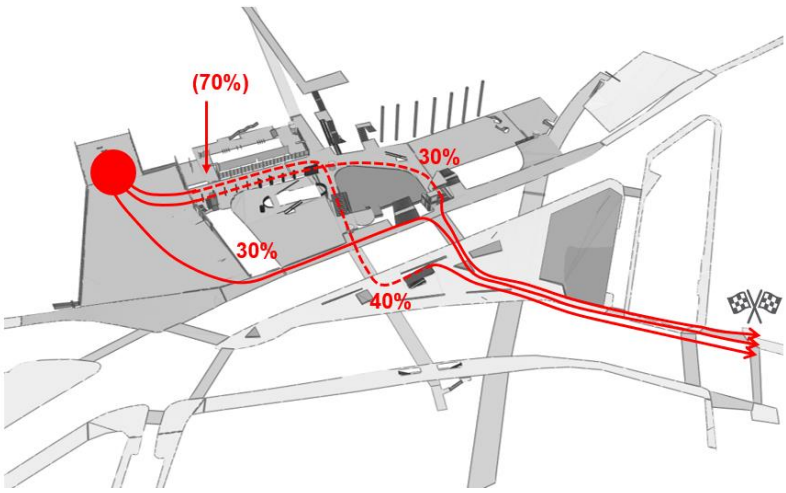


Figure 9: Route splits (Central Walk West to Broadway South)

From: Central Walk West
Destination: Broadway North

Route description	Assigned percentage
Through Lee Street Tunnel	54%
Along Adina footpath	18%
Through HDP (Lower Ground)	18%
The Goods Line	10%

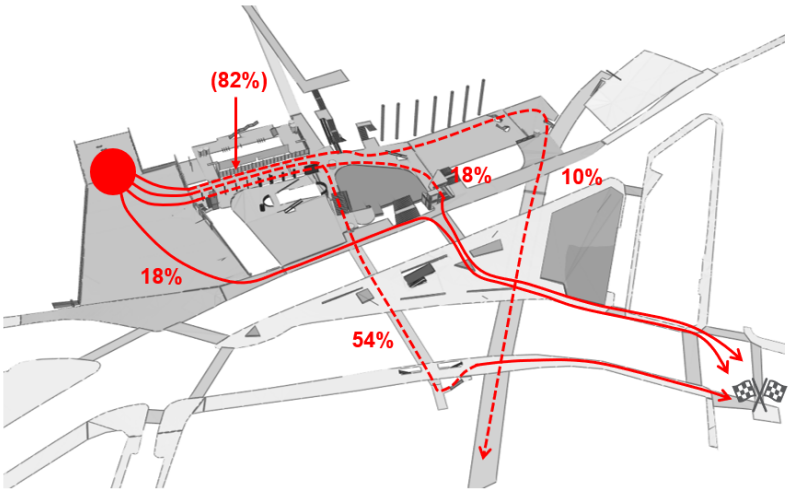


Figure 10: Route splits (Central Walk West to Broadway North)

From: Central Walk West
Destination: Bus Layover

Route description	Assigned percentage
Along Adina footpath	40%
Through HDP (Lower Ground)	60%

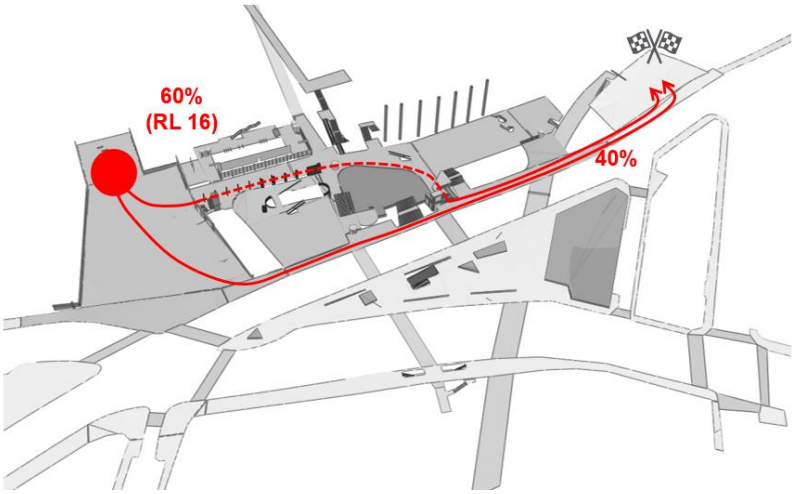


Figure 11: Route splits (Central Walk West to Bus Layover)

From: Central Walk West
Destination: Dexus-Frasers development

Route description	Assigned percentage
Via Ambulance Avenue staircase/lift to Upper Ground	100%

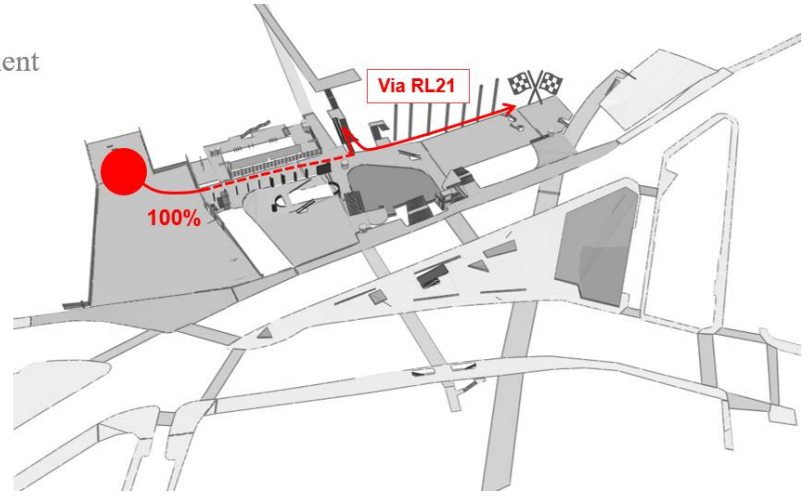


Figure 12: Route splits (Central Walk West to Dexus-fraser developments)

4.5 Traffic Signal Phasing

To facilitate pedestrian crossings in the vicinity of the Western Gateway precinct, signal phases have been adjusted to ensure all agents arrive at their assigned destination outside the Precinct area at Broadway/Harris/Regent Street and Pitt/George Street. The locations where signal phases have been adjusted are shown in Figure 13.

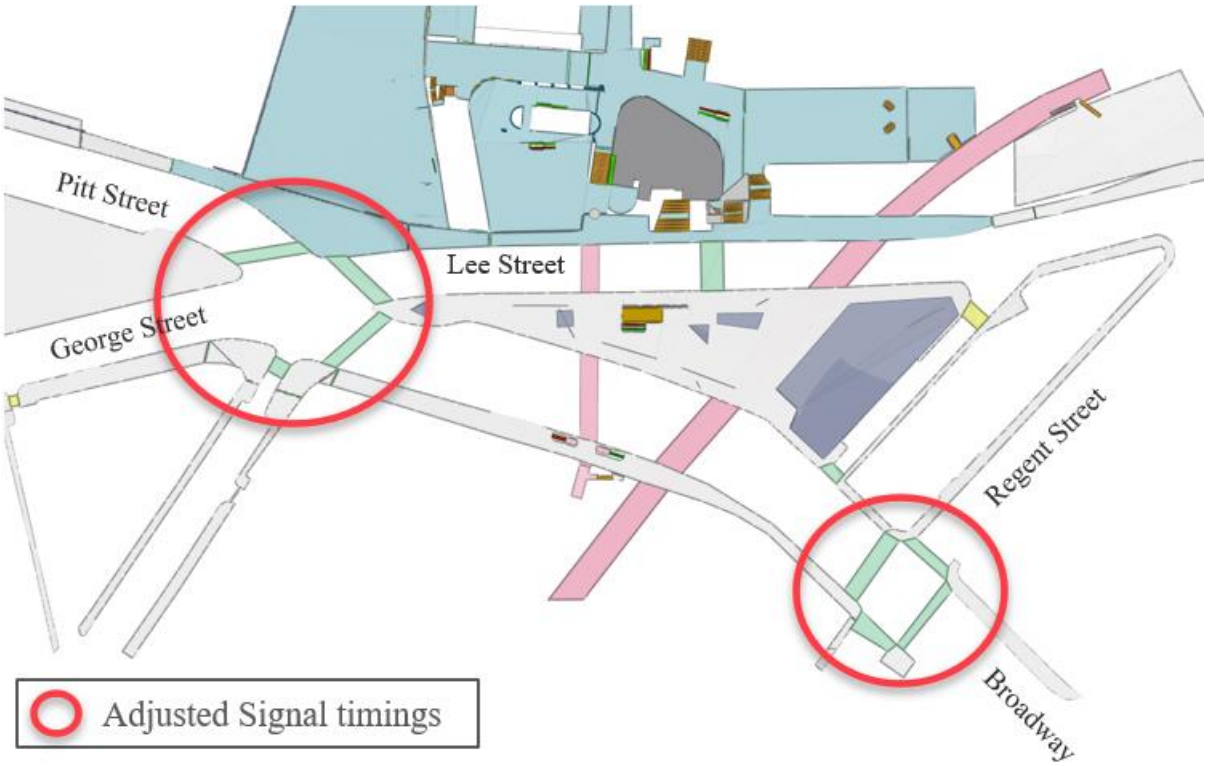


Figure 13: Adjusted signal timing locations (Model source: 01_56_AM_TOGA)

4.6 Over Station Development

The model assumes that there are direct connections between the station platforms at Central and the OSD. As such, while the model includes customers travelling from Central Station to the OSD, they do not appear within the Western Gateway precinct.

5. Assessment and Findings

5.1 Previous MassMotion Model Assessment

Figure 14 shows Fruin level of service walkways results of the most recent scenario studied on behalf of TfNSW. This scenario omits the Link Zone stair in the vicinity of the NE corner of the TOGA site to test performance of the Link Zone and the node junction of the Link Zone, Devonshire Street Tunnel, HDP and Lee Street Tunnel. Results show that the node is non-compliant mainly due to the high level of conflicting multi-directional pedestrian movements and the design of the node.

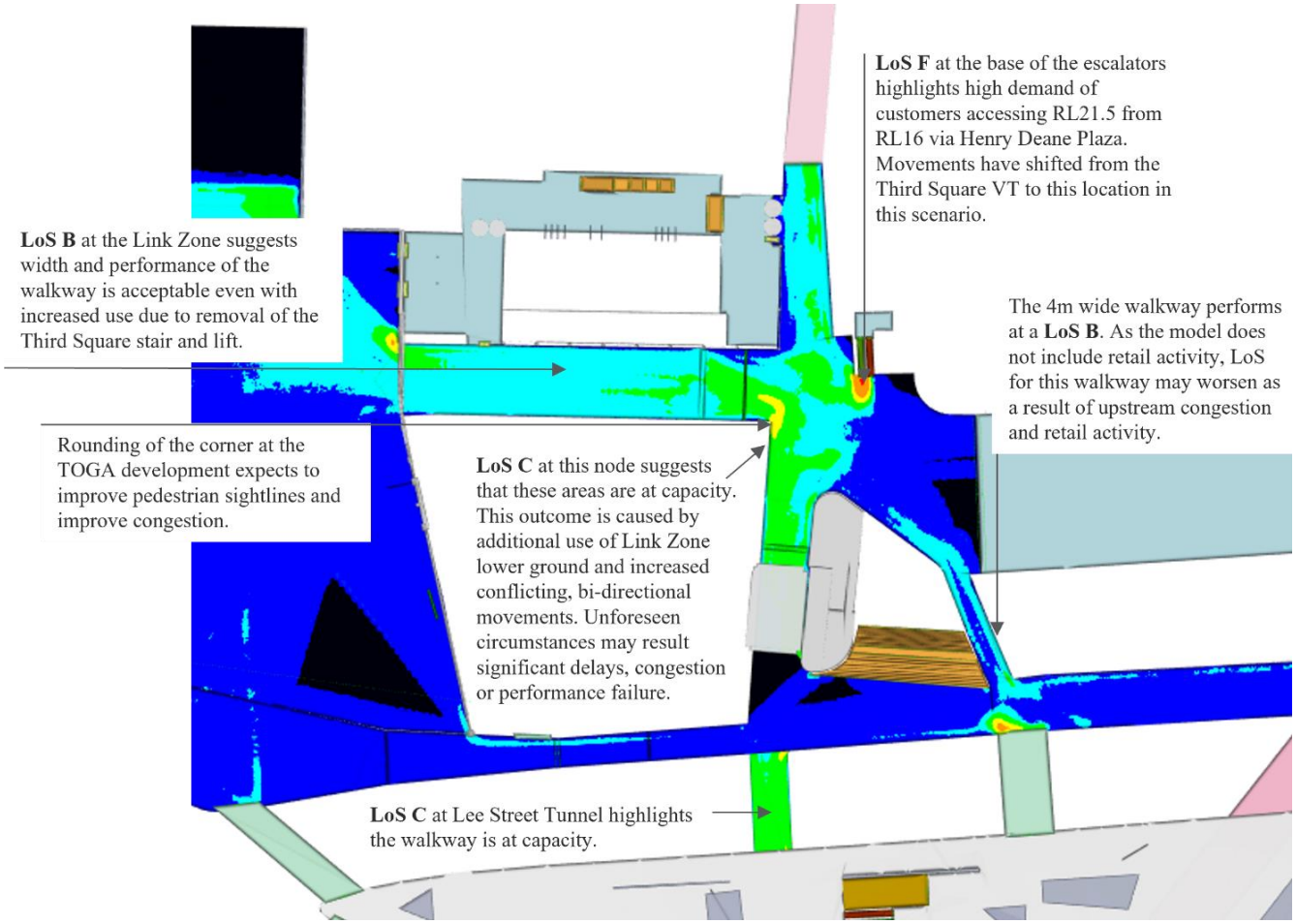


Figure 14: Level of Service Walkways - AM Peak 15 minutes at RL 16 (Model source: 029_2056_Central_DF)

RL 21 Upper Ground was found to be entirely compliant with results in the LoS A to LoS B range.

5.2 TOGA Baseline Model Outputs

The peak 15-minute interval is defined between 8:25 – 8:40 AM of the hourly profile. As per TfNSW requirements, Fruin Level of Service density maps reported within section 5.2.1 and 5.3 represent the peak 15-minutes of the AM peak hour.

5.2.1 Level of Service at RL 16 Lower Ground

Figure 15 shows a Level of Service density map for the RL16 Lower Ground with corresponding findings marked F1-F6 (Table 6 provides a summary of the findings).

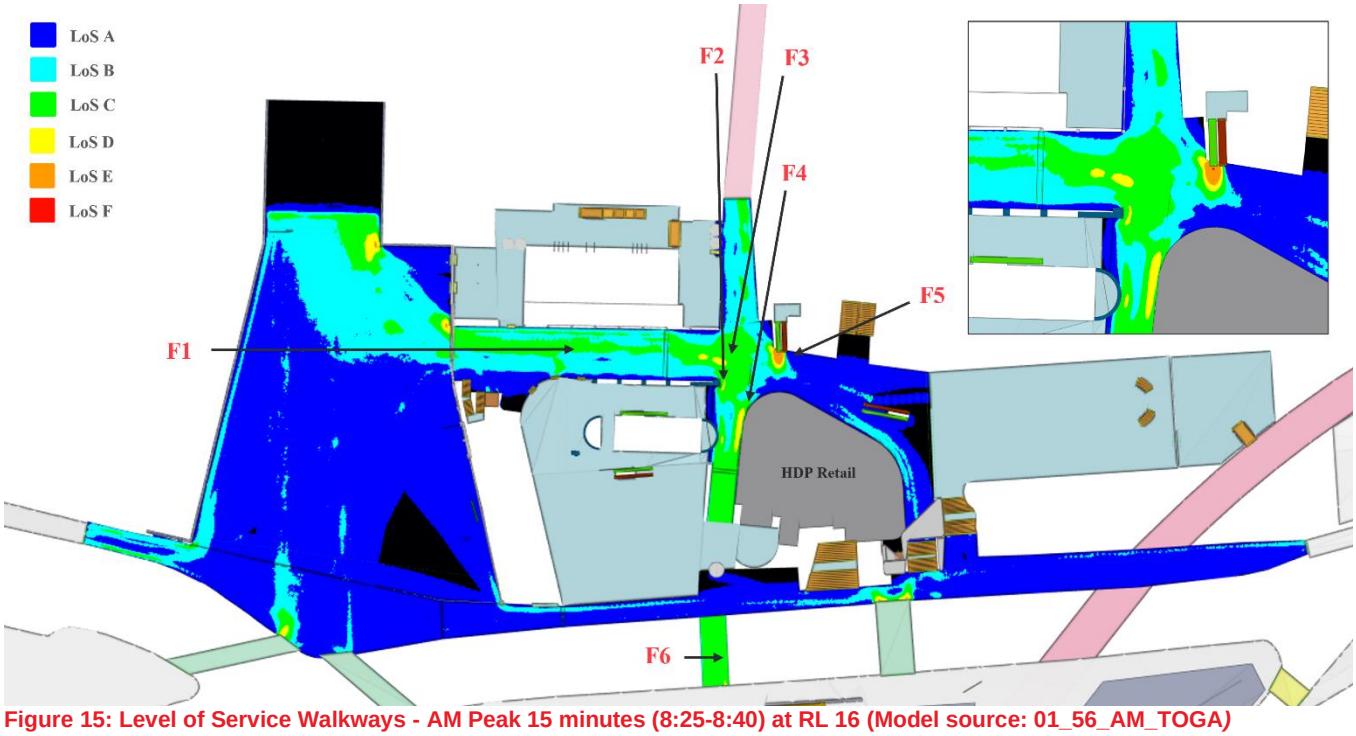


Figure 15: Level of Service Walkways - AM Peak 15 minutes (8:25-8:40) at RL 16 (Model source: 01_56_AM_TOGA)

Table 6: Summary of model output findings at RL 16 (Model source: 01_56_AM_TOGA)

Model Findings	Description
F1	**LoS B and areas performing at LoS C** in the Link Zone suggests width and performance of the walkway is acceptable with the addition of pedestrians destined to TOGA.
F2	Offsetting/shifting the heritage wall slightly to the north may improve pedestrian sightlines and help relieve some congestion in the node.
F3	**LoS C with spots of LoS D** at this node suggest the node is at capacity. This outcome is caused by additional use of Link Zone and increased conflicting, multi-directional movements. As noted in the prior analysis, unforeseen circumstances may result in significant delays, congestion, or performance failure.
F4	**LoS D** along the edge of the HDP retail frontage suggests that Lee Street Tunnel is at, or just over capacity. Widening the mouth of the Lee Street Tunnel may improve LoS results. Noting that this model does not account for retail associated in/out movements which would inherently cause more turbulence and likely worsen the LoS beyond what is shown in this modelling result.
F5	**LoS E** at the base of the escalators is a result of a high number of agents accessing the CPS development from Central Walk West Lower Ground via HDP to Upper Ground.
F6	**LoS C** at Lee Street Tunnel highlights the walkway is at its design capacity in this scenario.

5.2.2 Design Mitigation Measures

During the AM peak, congestion is likely to occur on the SE corner of TOGA Central's proposed building due to the heritage wall. In addition, the Lee Street tunnel is expected to operate at capacity in this design scenario. The following mitigation measures are considered in the following scenario tests:

1. Flattening, or straightening the curved wall on the southern boundary of the development to increase walkable area within Lee Street Tunnel;

2. Shifting heritage wall to the North to improve pedestrian sightlines and flow between the Lower Ground Link Zone, and Lee Street Tunnel through Henry Deane Plaza; and

3. When considering retail activity, it is important to plan for where access points and queuing may occur and whether these activities can be accommodated so they do not impede on pedestrian circulation routes.

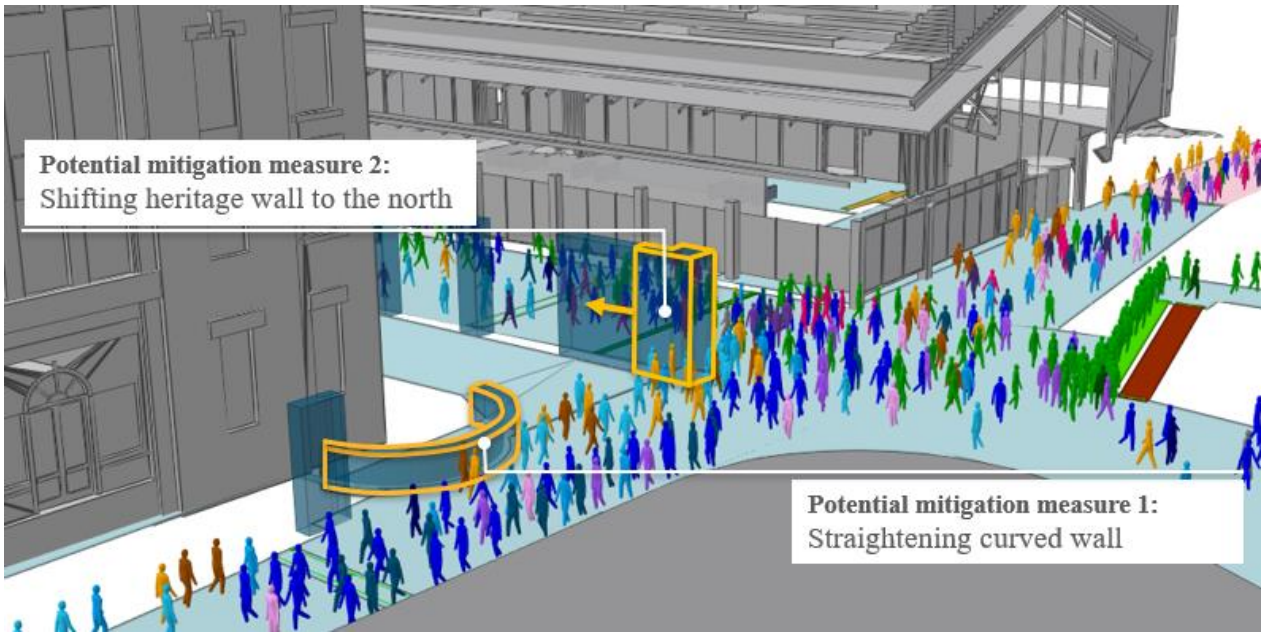


Figure 16: Potential design mitigation measures

5.3 Scenario Tests

In response to the findings from the Baseline model, additional scenarios have been developed to understand the impacts of the potential design mitigation measures. Table 8 highlights the attributes tested in each scenario. These attributes are adjusted incrementally to understand impact of individual design changes.

Table 7: Scenarios tested

Scenario	Mitigation measure 1 Flatten curved wall	Mitigation measure 2 Shift heritage wall to the north by approx.. 2.5m	Description
01 (Base)			**Base:** Test original design provided by TOGA and adoption of CPS movement from previous model
01a		X	**Design change:** Test the placement of the heritage wall
02	X		**Design change:** Test the impact of flattening the curved wall
02a	X	X	**Design change:** Test the impact of flattening the curved wall + heritage wall placement

Figure 17 shows specific geometry alterations applied to Scenario 01a, 02 and 02a.

- **Mitigation 1 - straightening curved wall** was developed in response to F4 and allows for Lee Street Tunnel to maintain a width of 6m
- **Mitigation 2 - shifting the heritage wall north** by approximately 2.5m was developed in response to F2 and allows for a wider opening for pedestrians accessing Lee Street Tunnel.

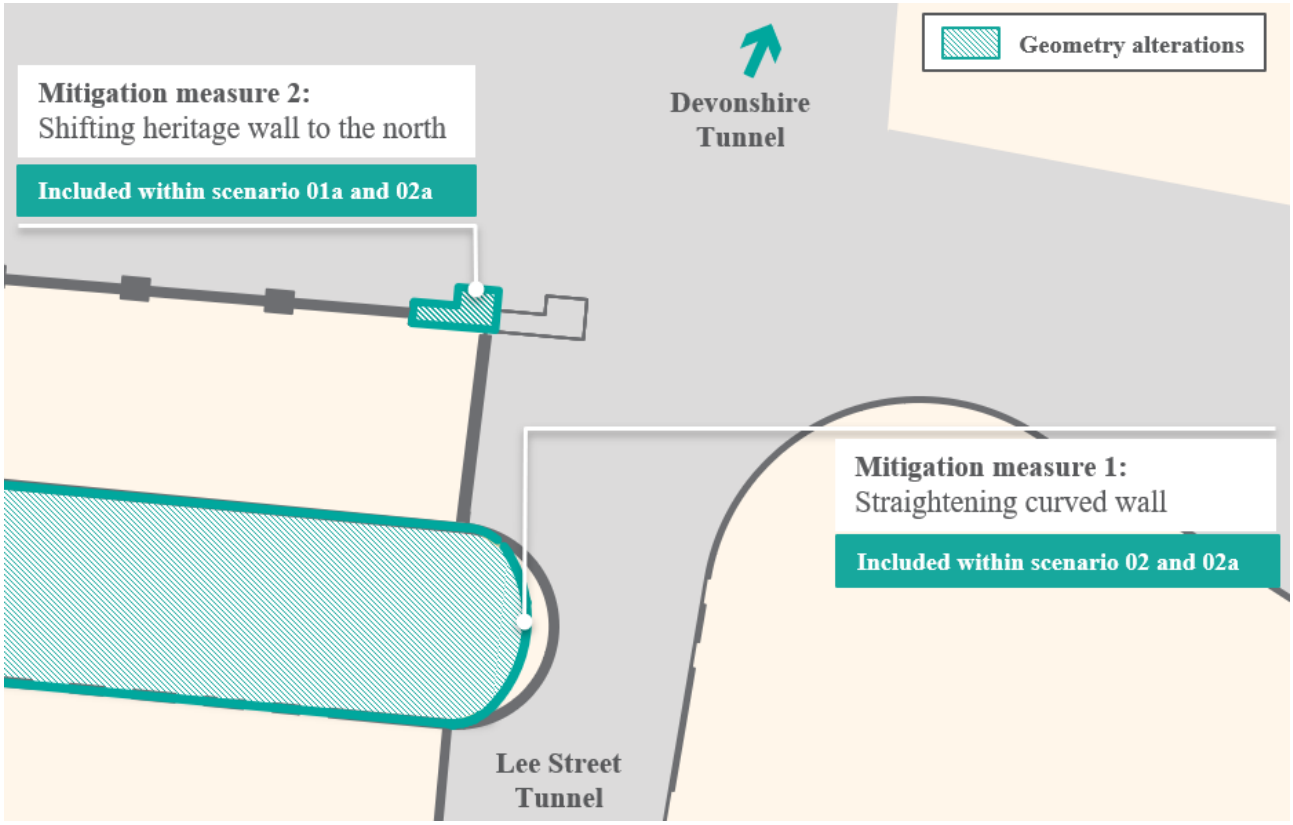


Figure 17: Scenario geometry alterations

5.3.1 Scenario 01a Results

Scenario 01a tests the impacts of shifting of the heritage wall north by approximately 2.5m whilst also maintaining the curved wall within Lee Street Tunnel. Figure 18 shows the density map extracted from the dynamic model. The outputs demonstrate that there are some improvements in the performance of the node where the Link Zone, Lee Street Tunnel and HDP converge when the passage to Lee Street is widened. Lee Street Tunnel performs predominately at LoS C with areas of LoS D adjacent to the HDP retail façade and at the curved wall. This LoS D is a result of conflicting bi-directional movements in the tunnel along with the decreased amount of walking space for pedestrians due to the curved wall which extends into the tunnel.

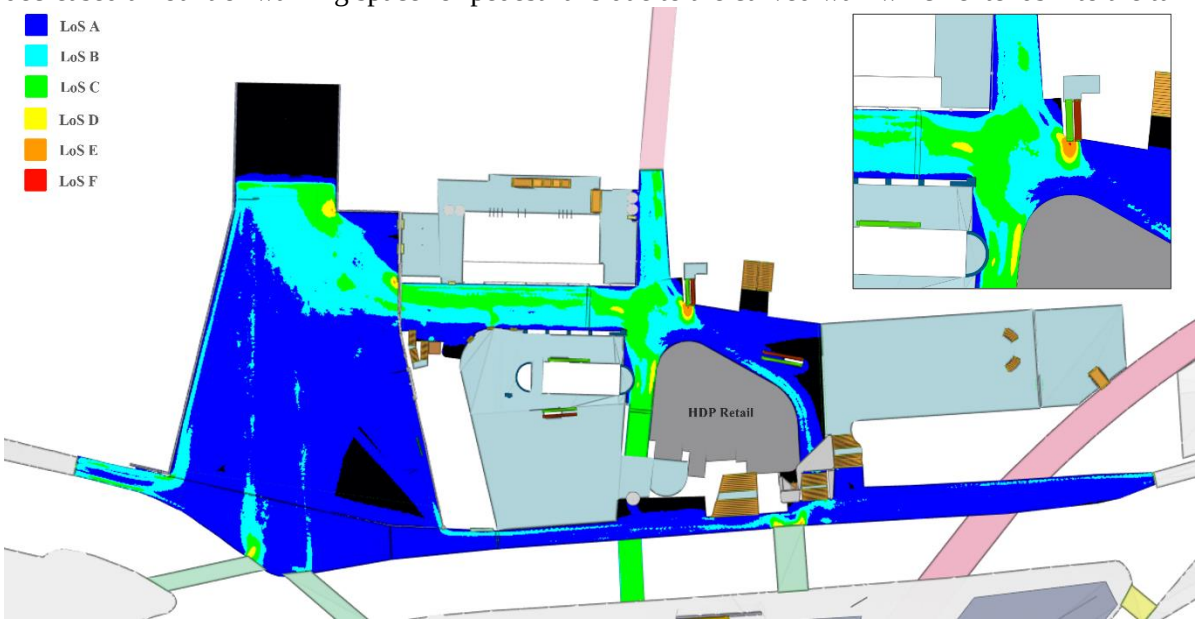


Figure 18: Level of Service Walkways - AM Peak 15 minutes (8:25-8:40) at RL 16 (Model source: 01a_56_AM_TOGA)

5.3.2 Scenario 02 Results

Scenario 02 tests the impacts of flattening the curved wall to allow for more circulation and walking space within Lee Street Tunnel. The location of the heritage wall is in its original position and has not shifted within this scenario. Figure 19 shows the density map extracted from the dynamic model. The outputs demonstrate that there are some improvements to the functionality of Lee Street Tunnel. LoS D results at the node remain consistent with the results of the Base model.

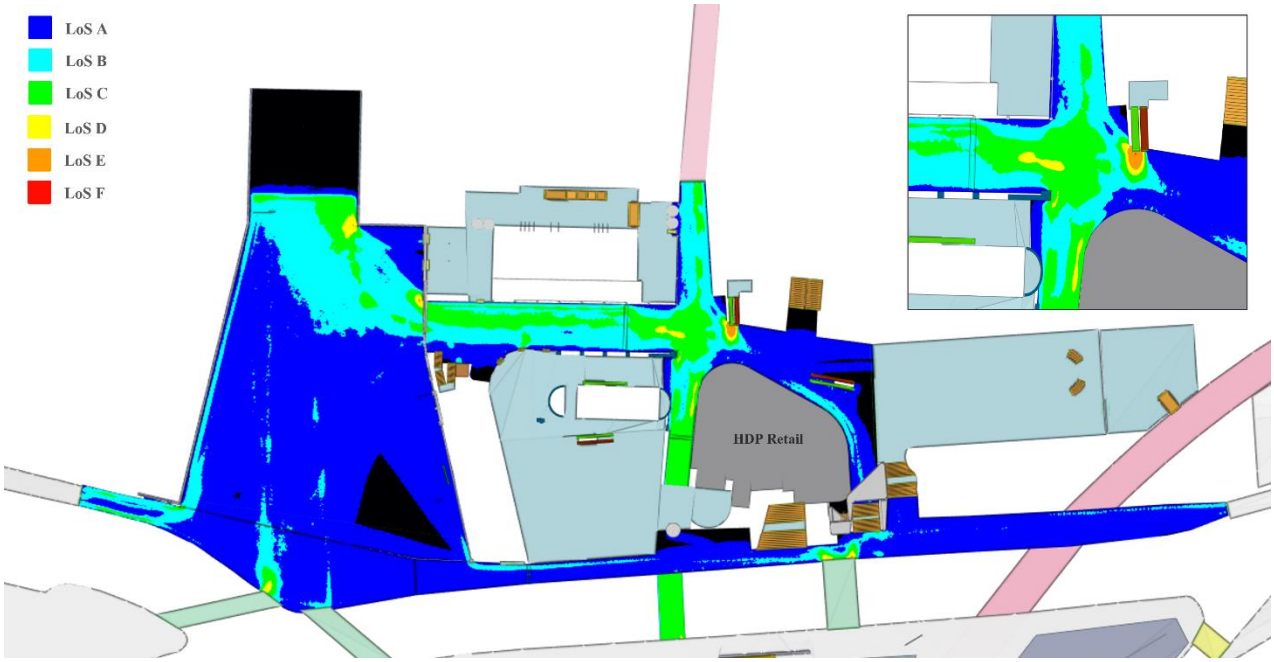


Figure 19: Level of Service Walkways - AM Peak 15 minutes (8:25-8:40) at RL 16 (Model source: 02_56_AM_TOGA)

5.3.3 Scenario 02a Results

Scenario 02a tests the combination of flattening the curved wall and the shifting of the heritage wall north by approximately 2.5m. Figure 20 shows the density map extracted from the dynamic model. Areas performing at LoS D at the node and within Lee Street Tunnel have reduced which demonstrate that the combination of both measures supports a better outcome for pedestrian movement when compared to Scenarios 01, 01a and 02. This result signifies the importance of opening the mouth of the Lee Street Tunnel where it meets the Link Zone, HDP and DST.

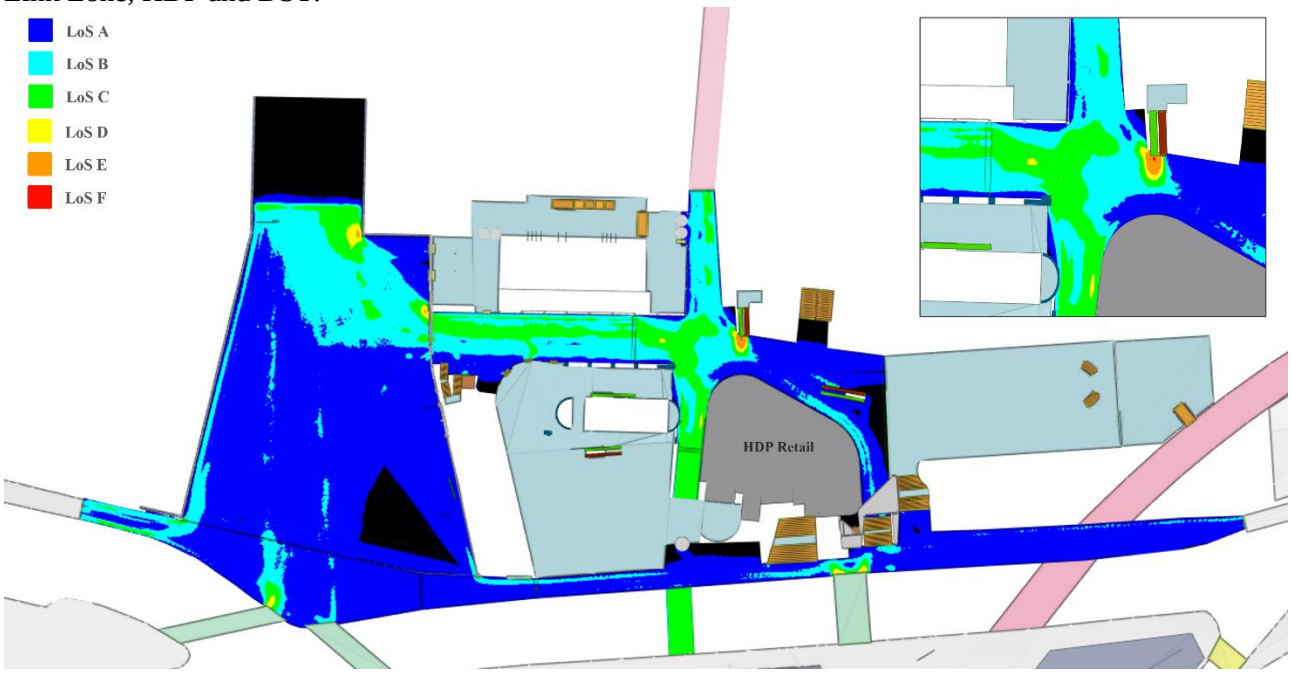


Figure 20: Level of Service Walkways - AM Peak 15 minutes (8:25-8:40) at RL 16 (Model source: 02a_56_AM_TOGA)

5.3.4 Additional Findings Commentary

It is worthwhile noting that all scenarios incorporate high usage of the Link Zone Lower Ground in that all people destined for CPS from Central Walk West travel through the Link Zone at the RL16 Lower Ground level. This scenario was the last version tested for TfNSW and was adopted here in terms of 'worst case' expected movements for the Link Zone and the node. If a convenient, publicly accessible stair is built within the Third Square, or in the Atlassian site adjacent to the NE corner of the TOGA site, some of these CPS movements would be expected to travel up to RL21 Upper Ground before traveling through the Link Zone and reaching the node, thereby improving the performance of this space.

It should also be noted that the findings in this report represent the outcomes from very specific scenarios incorporating assumptions for layout, pedestrian demand, and routing assumptions. As discussed previously, this scenario expects well-distributed and diffused movements between Central Walk West and UTS. If these assumptions are incorrect (e.g. during a rainy day when people choose to stay at Lower Ground beneath cover rather than walk at grade or Upper Ground) then the movement patterns change which will yield a different performance result.

Movements related to retail activity ins and outs are not incorporated within the models. Such activity will change movement patterns, potentially adding turbulence to movement corridors and thereby increasing densities.

6. Summary

Arup has reviewed the proposed TOGA Central development against the parameters and requirements set out in TfNSW's Final Transport and Customer Requirements. We have used the 2056 +15% MassMotion model as a baseline and have introduced TOGA's design and associated demand into the 3D model. TfNSW requires that the circulation space within the Precent achieve Fruin Level of Service C as an average across the AM peak 15-minute period (08:25 – 08:40).

Prior pedestrian movement studies for the Western Gateway Precinct showed that activity at the 'node' (point of convergence at Lee Street Tunnel, Lee Street Tunnel, Henry Deane Plaza and Devonshire Tunnel) has consistently performed at LoS D which is non-compliant to TfNSW requirements. The non-compliant LoS D result from the sharp heritage wall corner was identified in material previously illustrated to TfNSW in the development of the publicly accessible Space Strategy. It is worthy to note that TOGA's proposal does not worsen the result at this localised point of congestion.

A matrix of results for all scenarios tested for TOGA is shown in Figure 21. The node area performing at LoS D remains present, although in slightly decreasing scale, throughout all these scenarios. LoS D reduces in Scenarios 01a and 02a, which signifies the benefits of shifting the heritage wall north by approximately 2.5m. While cutting back the heritage wall has some benefit, it does not completely remove the small areas of non-compliance. In the context of Heritage considerations, it is acknowledged that a minor non-compliance within this zone could be a preferred outcome rather than modifying the position of the heritage wall. It is understood that TfNSW intends for a stair connection at or near the mouth of the Link Zone which is likely to remove some demand from the Link Zone, thereby mitigating some congestion at the node and further reducing the need to modify the heritage wall.

Results from pedestrian modelling also signifies the impact of flattening the curved wall. Scenario 02 shows improved results within the Lee Street Tunnel by providing more walkable area for pedestrian movement.

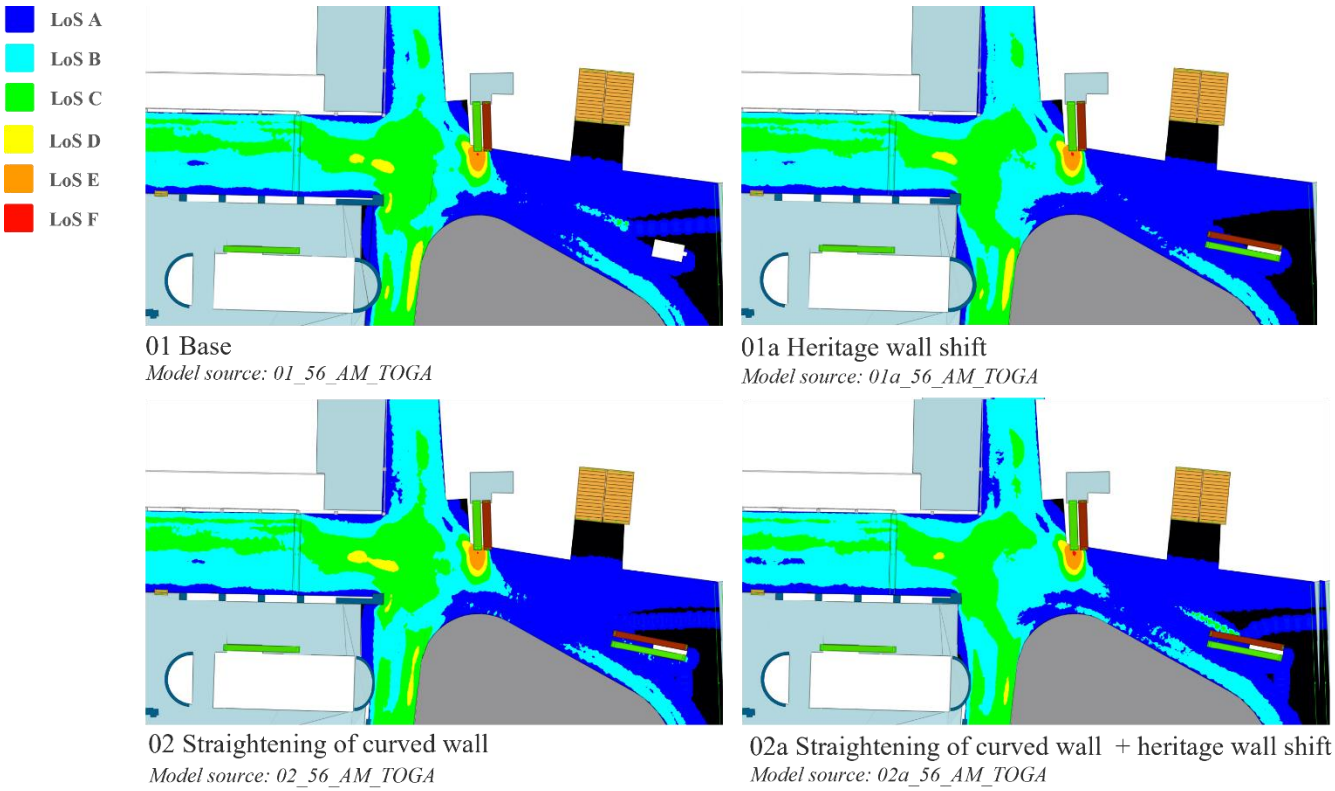


Figure 21: Matrix of LoS results (Walkways) for reported TOGA scenarios

It should be noted that the scenarios do not include retail movements which may further exacerbate crowding in this area.

A.1 Previous Demand Origin-Demand Matrix

	Eddy Ave	Elizabeth St North	Elizabeth St South	Devonshire St	Devonshire St	Chalmers St	Lee St West	Lee St East	Broadway South	Broadway North	The Goods Line	Quay St West	Quay St East	George St West	George St East	Rawson Lane	Pitt St exit	Northern concourse exit	Elizabeth St exit	Devonshire St exit	Western Concourse exit	Eastern Concourse exit	Eddy Ave bus	Elizabeth St bus	George St North bus	Railway Sq N	Railway Sq S	Lee St North bus	LR North	LR Chalmers St	OSD1A/B	Adina	Atlassian	USP Podium	USP Tower 1	USP Tower 2	OSD 1C	OSD 2	Bus Layover	Spare	Spare	Spare	Total
Eddy Ave	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	18	0	0	36	18	9	30	15	3	15	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	167
Elizabeth St North	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	166	232	0	0	265	71	219	109	28	109	28	0	0	54	0	39	30	40	27	66	0	7	0	0	0	1489
Elizabeth St South	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83	41	0	83	22	68	35	8	35	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	382
Devonshire St	0	0	0	0	0	0	21	14	20	228	76	37	55	46	133	35	0	0	0	125	0	125	27	82	41	10	41	10	0	0	88	0	64	49	65	44	108	0	11	0	0	0	1554
Devonshire St	0	0	0	0	0	0	21	14	20	228	76	37	55	46	133	35	0	0	0	125	0	125	27	82	41	10	41	10	0	0	88	0	64	49	65	44	108	0	11	0	0	0	1554
Chalmers St	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	113	0	113	24	75	37	9	37	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	416
Lee St West	0	0	0	18	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	70	0	7	21	10	2	10	2	0	0	25	0	18	14	19	12	31	0	3	0	0	0	372
Lee St East	0	0	0	49	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150	150	0	17	54	26	7	26	7	0	0	25	0	18	14	19	12	31	0	3	0	0	0	658
Broadway South	0	0	0	58	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	190	830	0	21	63	31	8	31	8	0	0	38	0	27	21	28	19	46	0	5	0	0	0	1481
Broadway North	0	0	0	49	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	180	760	0	17	54	26	7	26	7	0	0	38	0	27	21	28	19	46	0	5	0	0	0	1361
The Goods Line	0	0	0	53	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	240	490	0	18	59	29	7	29	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	984
Quay St West	0	0	0	34	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	170	0	12	37	18	5	18	5	0	0	14	0	10	8	10	7	17	0	2	0	0	0	470
Quay St East	0	0	0	40	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	190	0	14	44	22	6	22	6	0	0	14	0	10	8	10	7	17	0	2	0	0	0	531
George St West	0	0	0	12	12	0	0	0	0	0	0	0	0	0	0	0	2	6	0	160	610	0	5	13	7	1	7	1	0	0	21	0	15	11	15	10	25	0	3	0	0	0	936
George St East	0	0	0	7	7	0	0	0	0	0	0	0	0	0	0	0	1	3	0	140	530	0	2	8	3	1	3	1	0	0	21	0	15	11	15	10	25	0	3	0	0	0	808
Rawson Lane	0	0	0	10	10	0	0	0	0	0	0	0	0	0	0	0	16	0	0	60	140	0	3	10	6	1	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	263
Pitt St exit	450	0	0	0	0	0	0	0	0	0	0	0	0	66	190	490	0	0	0	240	1580	0	79	0	0	0	0	0	821	0	0	0	0	0	0	0	0	0	0	0	0	0	3915
Northern concourse exit	450	1504	0	0	0	0	0	0	0	0	0	0	0	197	568	0	0	0	0	0	0	0	141	0	0	0	0	0	821	0	0	0	0	0	0	0	0	0	0	0	0	0	3681
Elizabeth St exit	0	2107	1067	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	175	0	0	0	0	0	1286	0	0	0	0	0	0	0	0	0	0	0	0	4635
Devonshire St exit	0	0	534	692	692	399	300	210	10	120	660	130	190	160	470	120	200	0	0	0	0	0	0	152	63	68	274	33	117	0	0	0	287	222	295	197	0	0	49	0	0	0	6645
Western Concourse exit	898	0	0	0	0	0	340	240	410	4490	1500	920	1350	920	2610	420	780	0	0	0	0	0	0	0	77	84	334	900	143	0	0	0	1797	1385	1847	1231	0	0	308	0	0	0	22984
Eastern Concourse exit	450	2407	1067	692	692	399	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	421	0	0	0	0	0	5144	743	0	0	0	0	0	908	0	0	0	0	0	12923
Eddy Ave bus	49	132	59	30	30	17	13	9	13	144	48	23	35	29	84	22	87	201	0	0	0	0	0	0	0	0	0	0	0	0	126	0	91	70	93	62	154	0	16	0	0	0	1638
Elizabeth St bus	152	408	181	94	94	54	40	28	38	442	147	71	106	89	256	67	0	0	112	255	0	210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2843
George St North bus	76	205	91	47	47	28	21	14	20	221	74	36	53	45	129	33	0	0	0	0	152	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1289
Railway Sq N	20	51	23	12	12	7	5	3	5	55	18	9	14	12	32	8	0	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	322
Railway Sq S	76	205	91	47	47	28	21	14	20	221	74	36	53	45	129	33	0	0	0	0	152	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1289
Lee St North bus	20	51	23	12	12	7	5	3	5	55	18	9	14	12	32	8	0	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	322
LR North	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	144	144	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	288
LR Chalmers St	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	358	0	0	1433	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1791
OSD1A/B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Adina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atlassian	0	3	0	5	5	0	2	2	3	3	0	1	1	2	2	0	0	0	0	2	15	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	53
USP Podium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
USP Tower 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
USP Tower 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OSD 1C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OSD 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bus Layover	0	17	0	29	29	0	11	11	17	17	0	8	8	12	12	0	0	0	0	13	89	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	312
Spare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2639	7089	3135	1990	1990	938	798	563	578	6224	2691	1317	1933	1678	4780	1270	1249	538	784	2274	6039	2371	565	1665	598	266	1066	1047	1902	6430	1295	0	2481	1913	2549	1700	1581	0	428	0	0	0	78354