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FREEDOM OF INFORMATION REQUEST SCHEDULE

Please be aware that under the *Freedom of Information Act 2016*, some of the information provided to you will be released to the public through the ACT Government's Open Access Scheme. The Open Access release status column of the table below indicates what documents are intended for release online through open access.

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NAME	WHAT ARE THE PARAMETERS OF THE REQUEST
MPCFOI2024/08 **ACTFOI-RR/24/80001**	*Any reports or studies commissioned by the ACT Government which assess the viability and benefits of extending light rail to Mawson*

Section Ref No	Pages	Description	Date	Status	Reason for non-release or deferral	Open Access release status
1.	**1 – 2**	Release Schedule	23/12/2024	-	-	Yes
2.	**3 – 4**	Decision Letter	23/12/2024	-	-	Yes

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Section Ref No	Pages	Description	Date	Status	Reason for non-release or deferral	Open Access release status
3.	**5 – 104**	ARUP - Canberra Light Rail Stage 2 - Mawson Extension Design Report	04/06/2021	Full Release	N/A	Yes
4.	**105 – 148**	VLC - ACT Light Rail Stage 2 Mawson Extension	09/06/2021	Full Release	N/A	Yes
Total						
4						

ACT Government
Infrastructure Canberra

Our Ref: MPCFOI2024/08
Ombudsman Ref: AFOI-RR/24/80001

Schedule 2.2(a)(ii)
[redacted]

Dear Schedule 2.2(a)(ii)

FREEDOM OF INFORMATION REQUEST – OMBUDSMAN REVIEW [2024] AFOI-RR/24/80001

I refer to your application to the ACT Ombudsman made under section 75 of the *Freedom of Information Act 2016* (the Act), to review the access application decision made by Infrastructure Canberra (iCBR) formerly Major Projects Canberra.

In your information access request, you sought access to:

"Any reports or studies commissioned by the ACT Government which assess the viability and benefits of extending light rail to Mawson"

On 21 May 2024, I made a decision in relation to this access request, advising that two (2) documents were found to be within the scope of your request.

My decision in relation to the documents relevant to your request at the time was outlined as follows:

- Withhold access to two (2) documents

On 14 June 2024 you made an application to the Ombudsman to review the initial decision. On 2 December 2024, in response to your application to the ACT Ombudsman made a decision under section 75 of the Act to review the original access application decision made by iCBR.

The Delegate's decision is to set aside the primary decision made by iCBR under s82(2)(c) of the Act. Additionally, the delegate makes a substitute decision to give access to the Mawson extension reports.

The Delegate's decision summary is as follows:

2. "I do not consider the information is Cabinet information under Schedule 1, s 1.6 of the FOI Act",

35. "I *accept the Mawson extension reports informed a submission to Cabinet (21/212/CAB) but the reports themselves where not submitted to Cabinet for its consideration", and*

36. "I am not satisfied the Mawson extension reports contain information about Cabinet's analysis of the issues raised in the Cabinet submission, discussion about the information in the reports, or consideration of proposed options".

ACT Government
Infrastructure Canberra

Authority

I am an Information Officer appointed by the Director General under section 18 of the Act to deal with access applications made under Part 5 of the Act. This decision is made pursuant to section 83 of the Act.

Decision on access

I have decided to waive an ACT Civil and Administrative Tribunal (ACAT) Review of the Ombudsman's decision.

The further information identified by the Ombudsman outlined below is attached to this correspondence.

- Report 1: ARUP - Canberra Light Rail Stage 2 - Mawson Extension Design Report
- Report 2: VLC - ACT Light Rail Stage 2 Mawson Extension

Online Publishing – Disclosure Log

Under secion 28 of the Act, iCBR maintains and official online record of access applications called a Disclosure Log. The Ombudsman's decision, the further unredacted release material and this decision will be published in the iCBR's Disclosure Log on the date of this decision.

Your personal details will not be published.

You may view the iCBR Disclosure Log at: Disclosure Log - Infrastructure Canberra (act.gov.au)

Should you have any queries in relation to your request, please contact me by telephone on (02) 6207 0058 or email iCBR.FOI@act.gov.au.

Yours sincerely,

Schedule 2.2(a)(ii)

Nikki Pulford
Information Officer
Infrastructure Canberra
31 January 2025

Major Projects Canberra

Canberra Light Rail Stage 2 - Mawson Extension

Design Report

C2W-14RAAL01-RPT-000002

Draft 1 | 4 June 2021

Job number 254319

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Document verification

ARUP

Job title		Canberra Light Rail Stage 2 - Mawson Extension			**Job number** 254319
Document title		Design Report			**File reference**
Document ref		C2W-14RAAL01-RPT-000002			
Revision	**Date**	**Filename**			
Draft 1	4 June 2021	Description	First draft		
			Prepared by	Checked by	Approved by
		Name	Macarena Martinez, Annalie Boston, Kelvin Davis, Kelvin Robson, Toby Heading	Dan Tadic	Dylan Coote
		Signature			
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				Issue Document verification with document	✓

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Executive Summary

Major Projects Canberra (MPC) are fulfilling a Canberra Light Rail Network Plan and visions for a modern public transport network in Canberra that can meet the future aspirations of the community, support a sustainable future for the environment, and respond to the social and economic challenges of the 21st century.

This report is to support MPC's quest in producing a Rapid Business Case Assessment as part of a proposal to extend light rail from Woden to Mawson and opportunities for further extension beyond Mawson, with a particular focus around its interface with duplicated Athllon Drive corridor. The overall scope of work is to generate and review alignment, stop location options and adjacent SLA developments in conjunction with MPC and its stakeholders. Leading to a suite of developed design documentation for the preferred option including high-level light rail operations assessments and advice.

A range of light rail alignments are possible on the selected corridor. Various routes and stop locations have been investigated, all with a view of realising a preferred alignment in the context of:

- People (access and connection) – understanding the travel needs of the local community
- Place (identity) – identifying the development opportunities that could transform the corridor
- Landscape (landform) – developing a strategy to enhance an urban corridor
- Cost – considering engineering implications and potential costs

The eastern verge option was deemed the most suitable of the explored alignments to take forward with a median running alignment from Woden through Hindmarsh Drive, with a transition from median to side running within the vicinity of Shea Street to Melrose Drive. The hybrid arrangement characterises the positives associated with both a central and eastern verge alignment and as a result this combined option has been taken forward as the emerging opportunity for a light rail corridor extending towards Mawson Town Centre.

1 Introduction

Major Projects Canberra (MPC) is currently developing an extension of the existing Gungahlin to Alinga Street light rail line to Woden (CLR2). MPC has commissioned ARUP to develop a preliminary design for a further extension from Woden to Mawson to inform a future decision on the final scope of the CLR2 project.

In broad terms, the base-case extension to Mawson would continue the alignment from Woden along Callam Street and Athllon Drive and include one or more intermediate stops with a terminus at Mawson. If extended, turnback movements would occur at Mawson rather than at Woden as currently planned. In addition to the base-case, an option has been looked at to continue the alignment beyond Mawson to Beasley Street South.

MPC have asked ARUP to design this potential extension to a level of detail sufficient to inform a Rapid Business Case to be presented to Cabinet. The scope of this design work consists on:

- Developing three credible alignment options within the corridor constraints;
- Evaluating the above-mentioned options against an agreed set of Multi-Criteria and choose one as an emerging alignment;
- Providing location options for a satellite stabling facility and a park and ride;
- Coordinate the spaceproofing with the known projects in the area (ie Athllon Drive duplication and Athllon Drive bus depot);
- Identify next steps, risks and opportunities.

This report documents the design undertaken to satisfy the above points.

2 Context

The extension from Woden to Mawson would be approximately 2,500m of additional track and as noted above would generally follow Callam Street and Athllon Drive. The location is shown in Figure 1 below.

The land immediately to the east of Athllon Drive and south of Hindmarsh Drive in the study area is relatively un-developed as it includes the Yarralumla Channel, which is known to flood in large rain events. Land to the west of Athllon Drive is developed to the road reserve up to Melrose Drive. Beyond Melrose Drive, the western edge of Athllon Drive is fronted by playing fields and school grounds.

The Suburban Land Agency (SLA) recently published an options report for residential development along the Athllon Drive corridor from Hindmarsh Drive

to Mawson Drive[1]. The report describes several proposals for a significant release of residential land in the currently undeveloped land to the east of Athllon Drive between Hindmarsh Drive and Mawson Drive. An indicative option for part of this release is shown outlined in purple in Figure 2.

While the land release options in the SLA Development Options Report are not confirmed as policy, it is expected that at least some of the land under consideration would be released for future residential development and therefore any extension of light rail from Woden to Mawson should ideally be designed to service this.

Figure 1 - Location plan

[1] "Development Options Report Athllon Drive Residential Corridor", prepared for SLA by Calibre Consulting (ACT) Pty. Ltd., dated 3 March 2022

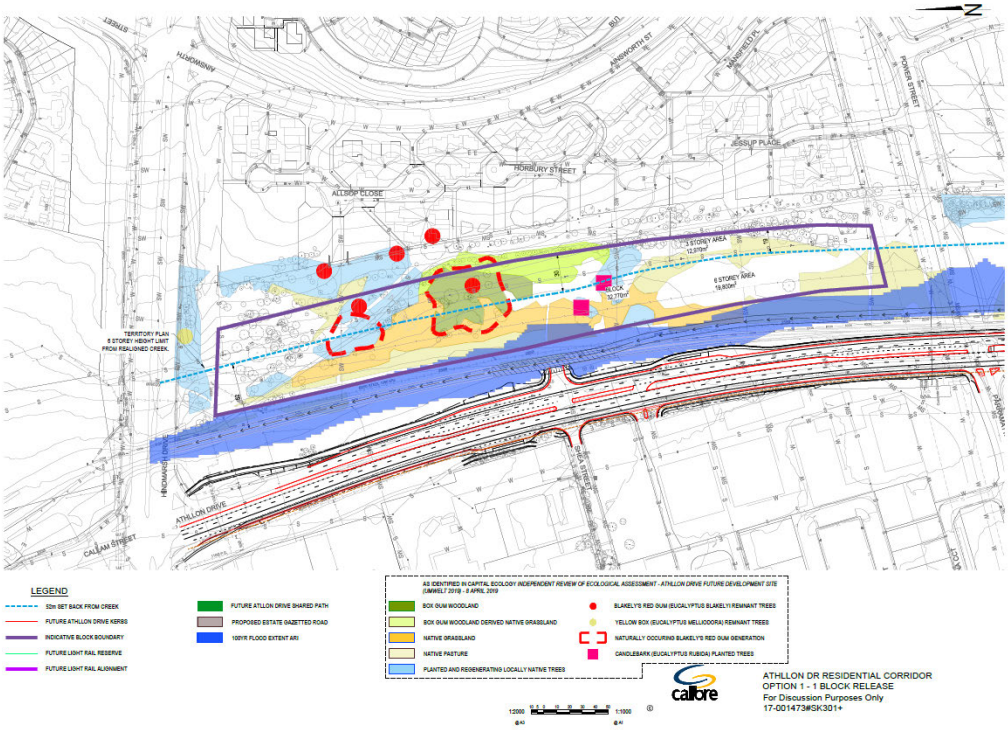


Figure 2 - Athllon Drive land release option (SLA Development Options Report, p. 86)

Although not available for review, ARUP understands that the SLA also has land release proposals around the Mawson Town Centre which should be taken into account in the light rail design.

3 Interface with other projects

3.1 Suburban Land Agency land release

A further interface in the development of a light rail corridor from Woden to Mawson is the relationship to the Suburban Land Agencies (SLA) pending development opportunity to deliver 580 dwellings to satisfy the intentions of the Territory Plan and Precinct Codes for Phillip and Mawson. These planning documents mandate a 'tiering' of building heights from six storeys fronting Athllon Drive and three storeys fronting existing residences in Swinger Hill and Mawson. The SLA's current planning investigations based on the LRI design can only just realise the 580 dwellings and tiered development targets.

Further to this, it has been agreed that further collaboration and agreement is required between SLA, TCCS and MPC around a preferred transition point from median alignment to eastern verge alignment. The Shea St intersection (current favoured transition zone) is proposed to be the sole point of vehicular access to the SLA's future residential development east of the channel. The details around a transition and one which satisfies the integration of a road, light rail intersection, and diverted Yarralumla Creek is key in progressing on the SLA's proposed access plans and long-term development strategy along the Athllon Corridor.

3.2 Athllon Drive Duplication

A major interface to the proposed development of a light rail extension from Woden to Mawson is the proposed Athllon Drive Duplication design. ARUP completed a review of the Concept Design developed by Cardno in relation to the road duplication and its suitability to accommodate a light rail extension.

A collaborative workshop was held on the 20th May 2021 with both TCCS in partnership with Cardno and ARUP in partnership with MPC to discuss and understand the intended plans in the duplication of Athllon Drive and how it may integrate with a future light rail corridor.

It is noted that the two projects are at varying stages of their development and thus further collaboration and planning is necessary to achieve a decision towards achieving the territories mission for a vibrant Athllon Corridor.

At this stage, the main complication on this interface is the limited width of the corridor, in particular between Parramatta Street and Melrose Drive. Having the two adjacent infrastructure projects results in some treatment to the Yarralumla Creek required, most likely realignment.

ARUP has produced an indicative cross section at the corridor's pinch point with the purpose of identifying the compromises required from the Athllon Drive Duplication project to safeguard space for a future light rail extension to Mawson. As shown in Figure 3, the distance between the existing Athllon Drive northbound kerb and the proposed SLA development access road is approximately 47m. It should be noted that the SLA plans include a walkway that would reduce the available width, it is assumed that this walkway could be relocated to the other side of the access road.

The indicative cross section accounts for the following elements:

- Duplicated Athllon Drive with a width of 23.4m from edge of existing northbound kerb to edge of new southbound kerb, comprising of:
    - Three through lanes on the northbound carriageway,
    - Two through lanes and one right turn lane on the southbound carriageway,
    - A median with a maximum width of 2.4m,
- 1m-wide hardstand between road and light rail, including kerbs and gutters required for road longitudinal drainage.
- 8m-wide rail corridor, which is sufficient for the swept path and 300mm clearance to delineation kerbs on each side.
- 1m-wide landscaping zone. This will probably be limited to low bush or a grassed verge as it is not wide enough to cater large trees.
- 3m-wide bi-directional shared path. This width seems insufficient and it is recommended that MPC investigates options to increase this width if the CLR2 extension to Mawson goes ahead. Some alternatives could be:
    - Culvert the creek along this section, providing additional available space on its top.

- Place the shared path on a structure that cantilevers over the creek.
- Underground the creek. It is understood that this has been looked at previously by the ACT government and has been discounted due to its impacts downstream.
- Relocating the creek to the east side of the SLA development. The topography of the area and the need to maintain invert levels will increase the depth of the channel and therefore its width.

- Relocated Yarralumla Creek. A like-for-like replacement has been assumed at this stage. There is an opportunity to steepen the walls of the creek and therefore reduce its width.
- Separation fence between residential access road and the creek.
- From a high-level review of the existing utilities on the east side of Athllon Drive, it appears only a street-lighting conduit and a small water main will need to be relocated. They could be relocated to under the shared path, and therefore do not require greater cross-sectional space.

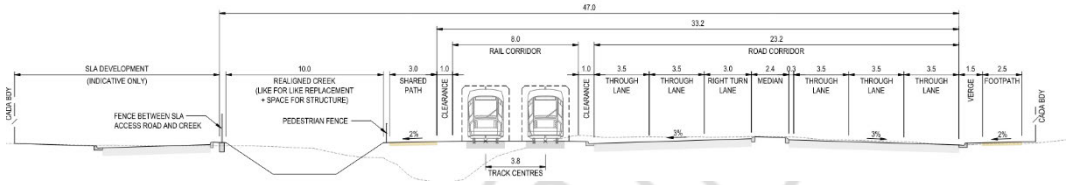


Figure 3 - Indicative cross section at pinch point. Extract of CLR-ARU-C2W-14CIAL01-SKT-000002

A full-size version of this section is appended to this report (Appendix D2).

3.3 Athllon Drive Bus Depot

The emerging alignment option is in some way influenced by the location of the Athllon Drive Bus Depot, currently planned to be constructed in the land parcel shown in Figure 4.

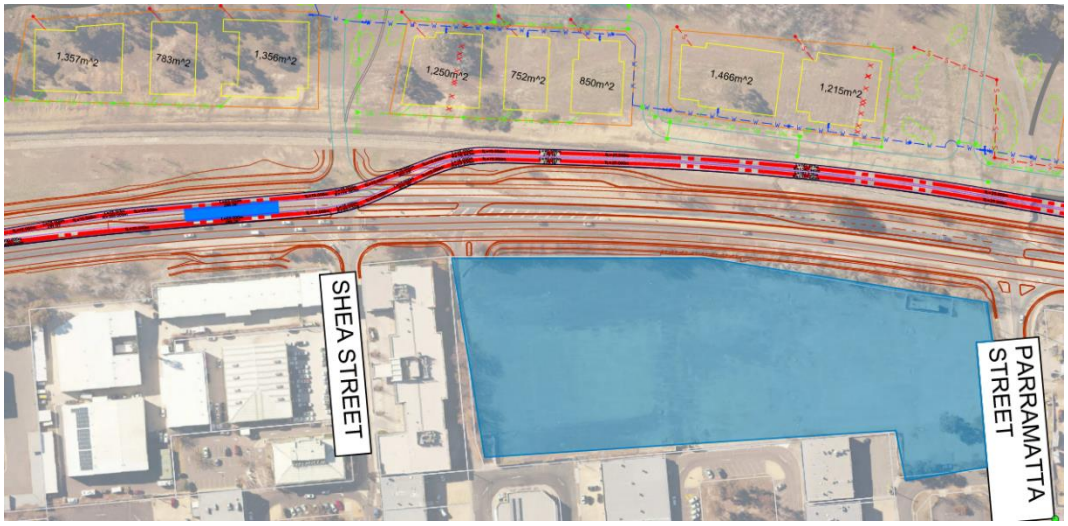


Figure 4 - Bus Depot indicative location

The vehicles leaving the depot can currently exit with right turn onto the Athllon Drive southbound carriageway. At this stage, the proposed light rail alignment has retained this possibility by transitioning to the eastern verge north of Shea Street. If the light rail was to continue on the median through the access to the depot, it is likely that the complexity of the intersection would impact the depot operation.

4 Multi Criteria Assessment

ARUP developed three alignments for the extension. The “Green” alignment occupies the median of Athllon Drive, the “Blue” alignment is on the eastern verge and the “Red” alignment is on the western verge of Athllon Drive. All of these alignments take account of the TCCS proposal to widen a section of Athllon Drive as well as the proposed stop locations noted in Section 5.7 below.

The alignment continues south from the currently planned Woden terminus, running in the median of Callam Street, crossing Hindmarsh Drive, and again in the median of Athllon Drive. The three alignment options diverge near Shea Street, where the Blue option transitions to the east, the Red option transitions to the West and the Green option continues in the median.

ARUP, jointly with MPC, developed a suite of multi-criteria around the themes Landscape, People and Place. The three options were rated against these criteria and presented to key stakeholders on two workshops held on 01/04/2021 and 06/05/2021. Upon review of the obtained ratings, a hybrid solution was identified as the emerging preferred. This alignment runs in the median from the stop at Woden and through the Hindmarsh intersection, until the intersection of Athllon Drive and Shea Street, where it transitions to the eastern verge and runs in parallel to Athllon Drive until the Mawson Centre Stop, which would initially be the new terminus.

An option has been looked at to continue the alignment beyond Mawson to Beasley Street South to demonstrate how the line could be extended further in the future and accommodate a stop at a potential Park and Ride facility at Beasley

Street South. A stabling facility could also be provided adjacent to Beasley Street South if needed.

The three alignments are shown in Appendix B and discussed further below. The MCA criteria, process and workshops are further described in the MCA Report (C2W-14RAAL01-RPT-000002).

5 Design summary

5.1 Rail Alignment

The feasibility alignment design undertaken to inform this report and support the Rapid Business Case is based on the LRS1 Scope and Performance Requirements (SPR) Appendix 17 – Trackwork (Capital Metro, 2016). To date, there are no known issues with the parameters defined therein and hence it is considered appropriate.

The horizontal and vertical alignments are designed for a maximum LRV speed of 70km/h. The design speed will generally reflect the operating environment and will not exceed the speed on Callam or Athllon Drive. Design of track geometry first assumes nominal, not maximum, passenger comfort criteria.

Cant is generally applied in a ratio of 2:1 Cant to Deficiency. This will be refined in future design stages as the operational speed can be more accurately assessed. At this stage, this is a useful assumption to assess required transition length and DKE.

Stops are located to suit customer and urban design requirements and have dictated the alignment. As per LRS1 stop locations are safeguarded for future extension to 45m.

The vertical design is generally informed by minimising necessary alterations to existing ground and adjacent roads.

Further design development will be necessary at future design stages to optimise horizontal and vertical alignment.

For costing purposes, it is considered adequate to utilise trackform designs in keeping with the existing LRS1 track slab construction.

5.1.1 Woden to Hindmarsh Drive

The CLR2 Woden terminus is proposed to be in the centre of Callam Street, Woden and is approximately 500m north of the Hindmarsh Drive intersection. the extension alignment continues south on the median on all options considered. The reason for not considering an alignment on the verge along Callam Street is its likely major impact to Hindmarsh intersection with disrupted traffic phasing and significant road/bridge widening works adjacent to Yarralumla Creek. Intersection Modelling has been undertaken to test this decision with results contained in Appendix E. Hence, the proposal is to retain centre running through this

intersection and transition to side running at a signalised intersection further south.

5.1.2 Hindmarsh Drive to Mawson

The MCA results showed that an eastern-running alignment achieved generally better outcomes than the median-running alternative. After having navigated the Hindmarsh Drive intersection with the minimum possible disruption, the intention is to transition to the east as early as possible. Ideally, this transition will be located at a road intersection to limit the impacts on traffic movements to the southbound carriageway only.

After review of the existing constraints and following a workshop with main stakeholders, the transition has been provisionally located at the intersection between Athllon Drive and Shea Street, as shown in Figure 5. This approach will have to be validated during future design with further intersection modelling.

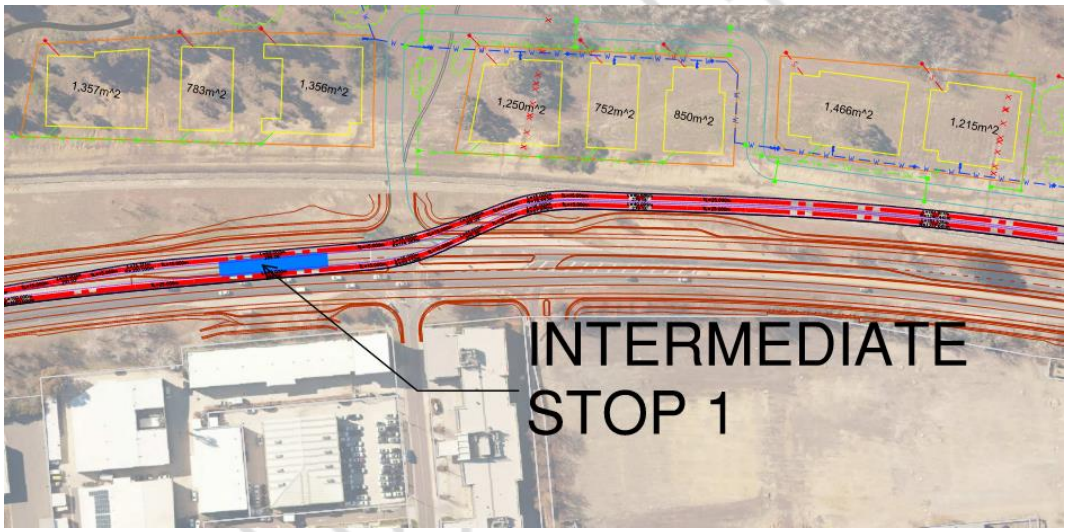


Figure 5 - Transition from centre running to side running near Shea Street

The alignment would continue towards Mawson in the same position relative to Athllon Drive as it is south of the transition point, i.e. no further transition to centre or side running is proposed. The portion of the alignment between Shea Street and Melrose Drive runs between Athllon Drive and several residential blocks planned for release. Also in this corridor runs the Yarralumla Creek. As described in Section 3.2, the space in this portion of the alignment is tight and some compromises need to be considered. A potential solution for the cross section at this location can be found in Appendix D2 with the main risks and opportunities highlighted in Section 6.

The location of stops is presented in more detail in Section 5.7.

5.1.3 Mawson to Beasley Street south

The proposal for Mawson locates the stop adjacent to Athllon Drive (i.e. the alignment does not enter the Mawson Town Centre) as shown in Figure 6.

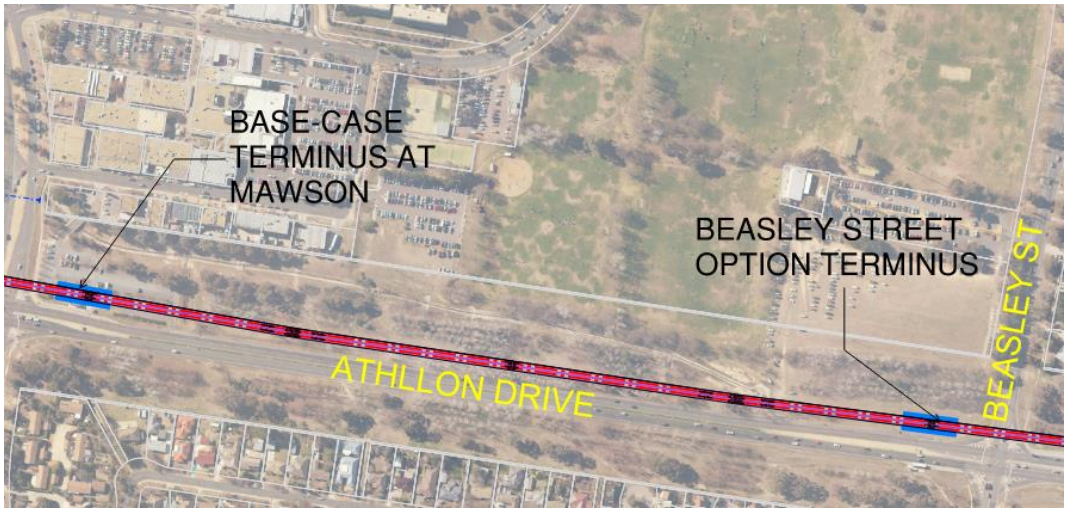


Figure 6 - Alignment and stops at Mawson

While it is feasible to locate the stop in the town centre, doing so would require the alignment to turn up Mawson Drive and then into the town centre itself via Mawson Place or Heard Street. This would result in a longer journey time, due to both the additional alignment length and the tight radius curves required to make the turns. Additionally, extending light rail further to the south (e.g. to Tuggeranong) would be more difficult as it would likely require the alignment to return to the Athllon Drive corridor.

A possible extension of the alignment to Beasley Street South is shown in dashed lines in Figure 6 and a stop could be located next to Beasley Street as shown. The length of this potential further extension is approximately 650m.

5.2 Transport modelling

ARUP has undertaken microsimulation modelling to inform the possible Mawson extension of light rail (LR) along Callam Street and Athllon Drive. The scope of the modelling involves developing 2026 future-year option traffic models, using VISSIM, to assess the operational performance of light rail and its potential impact on road traffic operations at the Hindmarsh Drive and Athllon Drive intersection.

Several VISSIM models were completed and presented to TCLR previously as the project design and operational assumptions were developed. This version of the model builds upon the previous State Circle Reference Case (SCRC) model that represented the light rail alignment passing through to Barton[2].

The traffic modelling has assessed two options associated with the upgrade at the Hindmarsh Drive / Athllon Drive signalised intersection, for a 2026 horizon. These options were:

- Option 1 – Median Alignment; light rail running directly through the middle of the Hindmarsh Drive / Athllon Drive intersection;

[2] Design changes from definition design through to RC can be referenced on *254319_TN005_ReferenceCase_Final.docx*.

- Option 2 – Eastern Alignment; light rail crossover to the north and south of the Hindmarsh Drive / Athllon Drive intersection, side-running on the eastern verge.

The SCRC model incorporates several changes to the previous RC design, notably:

- Extension of light rail along Callam Street and Athllon Drive.
- Hindmarsh Drive / Athllon Drive intersection configuration and signal phasing changes.
- LR crossover on Callam Street and Athllon Drive from the median to side-running on Hindmarsh Drive / Athllon Drive intersection (in Option 2).
- One new LR station on Athllon Drive at the southern terminus.
- For each option, the performance of each intersection was reported in terms of average delay, level of service and maximum queue length.

In terms of light rail performance, the modelling shows that the average LRT delay times are expected to be less than 30 seconds in both directions of travel, with LoS ranging from A-B, during both peak periods, in both Option 1 and Option 2.

The modelling also found that changing the LR alignment from median-running in Option 1 to side-running in Option 2 at the intersection significantly worsens the southbound left-turn movement from an average delay ranging between 8-10 seconds and LoS A in Option 1, to an average delay ranging between 83-112 seconds and LoS F in Option 2. An assessment of level of service for overall road traffic at the intersection showed that Option 1 exhibited better performance in terms of average approach delays and maximum queues compared with Option 2.

As such, it is recommended that, should the CLR2 extension to Mawson progress, Option 1 upgrade for the Hindmarsh Drive / Athllon Drive intersection is developed and further refined.

More detail on the traffic assessment, the two options considered and the obtained results can be found in Appendix E.

5.3 Road Design

Preliminary road layouts have been developed in the areas that would require modification due to the construction of the light rail alignment, and are included in Appendix D.

Major road upgrades are required along Athllon Drive between Hindmarsh Drive and Melrose Drive, including the intersection of Shea Street, where the light rail switches from centre running to side running (eastern verge).

Bus stops at Shea Street have been shown in similar locations to existing, however further planning of pedestrian movements to and from southbound stop should be considered.

The intersection of Athllon/Beasley/Mawson requires only minor road upgrades. Turn lanes that are impacted by the track alignment should be extended where possible to maintain or improve storage. Signalising left turn movements that interact with the track alignment will be required, as well as replacing zebra crossings with signalised crossings. Existing traffic islands are assumed to only require modifications to suit the track alignment.

Further consideration of cyclist and pedestrian safety and facilities will be required at later stages, including track crossing angles for cyclists.

5.4 Utility impacts

A high-level review of potentially affected public utilities has been undertaken on the emerging alignment option for the Mawson Extension to identify, document, and investigate the need for any works on public utilities infrastructure that may be affected as a result of the proposed light rail corridor and stations works.

For this review, public utilities information data has been obtained via undertaking Dial-Before-You-Dig (DBYD) enquiries along the preferred option corridor. Where public utilities have been identified, these have been defined by where surface and excavation works are proposed that may impact on above and below ground public utilities.

It should be noted that all utilities assessments to date have been undertaken as desktop assessment using Quality Level D utilities data information as per AS5488, and more detailed utilities investigations will be required during the following design stages of the project to confirm alignments and depths of utilities considered to be impacted by the proposed works.

Utilities works will be required along the proposed project corridor to protect, adjust, or relocate utilities that are potentially impacted by the proposed design. This project will comprise of works that interface with fully developed residential and commercial areas. Some utilities located within the project corridor are critical infrastructure (Department of Finance communications network, Optus's Intercity Optic Fibre Network, and Jemena's Trunk Primary gas main) and may be impacted by the proposed light rail and road corridor upgrade works. These utilities are critical to servicing of surrounding residential and commercial developments and cannot be interrupted or temporarily taken out of service without prior approval from the respective utility service authority. It is strongly recommended for the proposed projects work to aim to avoid any impacts to these assets. If impacts cannot be avoided, it is essential for discussions with the impacted utility authority to commence as soon as possible in order to help de-risk the project from any potential programme delays due to the need for detailed utilities investigations and relocation designs. If relocations are required, the programme may potentially be de-risked by undertaking some of the critical utility relocation works as "Early Project Works".

More detail on the assessment of the impact the Mawson extension has on existing utility services can be found in Appendix F.

5.5 Flooding

Appendix G contains a review of the existing flooding information pertaining to the study area, including:

- A desktop, qualitative assessment of the likely impact of the alignment options and any proposals to modify the existing Yarralumla Creek on the existing flood behaviour of the corridor;
- Scoping potential mitigation measures required to offset potential flood impact of the proposal/s; and
- Outlining a methodology for refining the Cardno flood model (following a model review) for a robust assessment in the subsequent stage.

5.6 Depot

This section covers the TA's study undertaken to outline the benefits and challenges associated with the available depot options. The three options considered are:

- Option 1: Stabling facilities at Mawson;
- Option 2: Satellite Depot with minimal maintenance capability at Mawson;
- Option 3: Expansion of the existing depot at Mitchell.

Current situation

The current depot at Mitchell is situated approximately mid-way on the Stage 1 alignment between Gungahlin and Alinga Street. This supports minimum dead running of light rail vehicles (LRV) at service commencement with start-up journey times averaging around 10 minutes in both directions, not accounting for the reduced speed of the initial safety LRV run. Services commence at 06:00am on weekdays meaning that first trip drivers are able to sign on at approximately 5:30am which minimises both driver fatigue and operational costs.

The Stage 1 Peak LRV requirement is 12 LRVs. This is calculated assuming 6-minute layovers, 5-minute headways, and a total return journey time of 1 hour. The maintenance and hot spare allowance of 2 LRVs supports a total fleet of 14 LRVs which are all stabled at the Mitchell Depot. There is current capacity both within the maintenance depot and the stabling facility to accommodate a total fleet of around 20 LRVs.

Stage 2

The Stage 2 Peak LRV requirement is 22 LRVs, assuming 6-minute layovers, 5-minute headways, and the modelled total return journey time of 1 hour and 47 minutes. The maintenance and hot spare allowance of 3 LRVs supports a total fleet of 25 LRVs. The current capacity of the Mitchell Depot can accommodate a total fleet of around 20 LRVs.

Mawson Extension (base-case)

The anticipated journey time from the current Mitchell Depot to the Mawson terminal is around 42 minutes based on the information presented in the assumptions in outlined in Table 1. This is a considerable increase (around 32 minutes extra) from the current depot to terminal journey times which presents a number of challenges around operational efficiency, managing driver fatigue and ability of the operator to respond to service disruptions.

If CLR2 was extended to Mawson, the Peak LRV requirement would be 24 LRVs. This is calculated assuming 6-minute layovers, 5-minute headways, and a total return journey time of 1 hours and 59 minutes. With a 10% maintenance and hot spare allowance of 3 LRVs, the total fleet would be 27 LRVs. Hence, a CLR2 terminating at Mawson would require an additional 2 LRVs compared to the current proposal to terminate at Woden.

Mawson Extension (Beasley Street South)

The sub-option to extend CLR2 until Beasley Street South increases the return journey time to 2 hours and 2 minutes, which equates to 25 Peak LRV required using consistent assumptions (6-minute layovers, 5-minute headways). With a 10% maintenance and hot spare allowance of 3 LRVs, the total fleet would be 28 LRVs, one more than if the extension terminates at Mawson.

It should be noted that this could be reduced by 1 LRV through introducing 5-minute layovers, however; this would likely involve Industrial Relations discussions and the change in operational culture may not be palatable to management.

Base assumptions

Table 1 outlines the base assumptions used to inform the depot options defined below.

Table 1 Base assumptions for operations of Stage 2 extended to Beasley Street

Category	Units	Assumptions
Operational Assumptions		
Total Run Time Southbound	0:54:31	Opentrack analysis, estimated dwell times and intersection wait times
Total Run Time Northbound	0:54:33	
Return Journey time	2:02:00	6-minute layover
Headway	0:05:00	
Fleet Requirement		
Peak LRV requirement	25	
Maintenance LRV requirement	3	10% of PVR (Peak Vehicle Requirement)
Total LRV Fleet	28	

5.6.1 Options

Option 1: Stabling facilities at Mawson

The primary purpose of operating stabling facilities would be to minimise dead running at the start and end of the day. Further operational benefits include:

- the opportunity of locating a spare at the stabling facility as resilience against service disruption;
- providing a relief location for drivers including a break room and sign-on facilities to manage fatigue and enable flexibility in driver shifts;
- support future expansion of the network towards Tuggeranong.

Figure 7 - Potential location of stabling facilities (Green) at Mawson

Figure 7 above shows an approximate footprint of the stabling facilities at Mawson, adjacent to the Mawson terminus and in currently government-owned land. It should be noted that there are two carparks in the vicinity that could potentially become a Park & Ride if the base-case of this extension was to go forward.

The key components within the stabling facilities are shown in Table 2 below.

Table 2 – Stabling facility components

Category	Units	Details
Operational requirements		
Stabling capacity	4 - 5 LRVs	Assuming 15-minute headway. Minimum 4 LRVs to be stabled

		overnight, 1 spare would provide operational resilience.
Track	200m track Turnout	Use crossover at Mawson to access to/from both lines. 33m LRV – 39m per stabling position
Driver facilities	1 portacabin	2 unisex toilets in washroom, meal break room with minimal kitchen facilities, security guard hut
Security guards	2 working 24/7	Assuming lone working is not allowed
High security fencing, boom gates, rail access		To be determined
Road access, parking for 5 vehicles		To be determined
CCTV, systems access, internet & telephone access, lighting		Drivers should be able to sign on at this location

The journey time from Mitchell to the Mawson terminal is around 42 minutes. At service commencement, the headway will likely remain at 15 minutes between services with a LRV requirement of 9 LRVs for the entire alignment. A stabling facility at Mawson would support 4 LRVs commencing from Mawson terminal based on a 15-minute headway and a journey time from Gungahlin of just under 55 minutes. If practical, it would be beneficial to stable a spare LRV for operational resilience purposes at Mawson.

If the initial headway increased to 10 minutes in the first hour, it would be advisable to stable 5 LRVs (plus 1 spare) at Mitchell, with 1 LRV dead running from Mitchell ready to commence operation at the 50-minute mark. The depot origin at 10-minute headways are shown in Table .

Table 3 - LRV Depot origin at 10-minute headway

LRV	Origin Depot	Start time from Mawson
1	Mawson	6:00
2	Mawson	6:10
3	Mawson	6:20
4	Mawson	6:30
5	Mawson	6:40
6	Mitchell	6:50
7	Mitchell	7:00 (1st train block, Return trip to Gungahlin)

Operating a stabling facility at Mawson would require security both in terms of physical security guards overnight and installation of CCTV with continual monitoring by the OCC. The associated costs of security guards working in tandem along with supporting infrastructure such as toilet facilities and break room could offset any operational cost savings.

First trip drivers may be required to sign in at the main depot at Mitchell, however; this could be circumvented with appropriate procedures and processes.

Option 2: Satellite Depot with minimal maintenance capability

Operating a Satellite Depot at Mawson would mainly support future expansion of the network towards Tuggeranong, as the costs anticipated in either duplicating or relocating specific maintenance tasks to the small depot could ease transition to the more substantial network. As with the satellite stabling facilities, further operational benefits include:

- minimise dead running at the start and end of the day
- the opportunity of locating a spare at the satellite depot as resilience against service disruption
- providing a relief location for Drivers including a break room and sign on facilities to manage fatigue and enable flexibility in driver shifts

A balance should be found between the dead running savings of travelling a shorter distance from Mawson than from Mitchell and the critical mass of maintenance tasks to make a satellite self-sufficient. With the sub option of extending to Beasley Street South, there is an opportunity to use a substantial area of land potentially available for development to the south of Mawson, as shown in Figure 8, for park and ride facilities, in addition to an extended satellite depot that could then support further expansion.

Figure 8 - Potential location of satellite facilities (Orange) at Mawson

The key components within the Satellite Depot, in addition to those identified as per the stabling facilities option, are shown in Table 4

Table 4 - Depot components in addition to the Stabling facilities option (Table 2)

Category	Units	Details
Operational requirements		
Train Wash, industrial water supply	1	
Energy connections		To be determined
Additional parking facilities		To be determined
LRV Cleaning facilities		To be determined

As with the stabling facilities at Mawson, a satellite depot would require security both in terms of physical security guards overnight and installation of CCTV with continual monitoring by the OCC. There may be restrictions on the types and time of maintenance activities that could be undertaken in this zone depending on the development and land uses already preserved at Mawson.

Light maintenance tasks such as cleaning, light body works and regular maintenance checks (category A) could be undertaken at this location, however; the costs of relocating and the associated supporting infrastructure required should be considered appropriately.

Development of this site should be considered through the lens of any further expansion opportunities including future-proofing stabling and maintenance facility zones for network expansion. Through a staged implementation, the Mawson extension would likely remain a satellite depot and move to a standalone depot as further network stages were activated.

Option 3: Expand existing depot at Mitchell

The initial plans for the Depot at Mitchell included future proofing for expansion to 41 LRVs which remains well within the requirements of the Stage 2 fleet. However, development of the extended nominated area behind the Mitchell depot suggests limited potential for expansion with an estimated 9 additional stabling positions without major reconfiguration. This would mean a total capacity in the order of 29 LRVs which would be sufficient for the Stage 2 fleet requirement.

Figure 9 - Expansion potential of stabling facility (Blue) at Mitchell

The operational cost considerations of stabling the entire fleet at the existing depot at Mitchell would include managing operational efficiency, driver fatigue and ability of the operator to respond to service disruptions. Given the additional 32-minute journey time to position at Mawson for the commencement of services, and the lack of dedicated driver facilities along the route to support change overs, comfort and meal breaks, if this option were to be activated, it would be pertinent to provide driver facilities at the Mawson Terminal. These would enable driver change overs to support operational efficiency. Furthermore, a siding at the terminus would provide the operator greater flexibility to respond appropriately to service disruption and if appropriate, special events.

Journey time assumptions

The estimated journey times mentioned in this section are based on an Opentrack model and the following assumptions:

- Opentrack running time approximately 28:00 including only sectional running time and dwell time at committed stops (excluding future proofed stops);
- Approx. 14 intersections along alignment from Alinga Street Stop to Mawson;
- all services operate the complete alignment between Gungahlin and Mawson.

5.7 Stops and pedestrian access

As noted in Section 2, the extension to Mawson would be in the order of 2,500m long. As a rule of thumb, light rail stops should be located around 800m apart which provides for a five-minute walking time to adjacent stops without overlap.

Applying this rule suggests that there should be at least two intermediate stops between Woden and Mawson, not including the terminus at Mawson. In conjunction with MPC, ARUP reviewed the local road and pedestrian traffic network and current and future development in the study area and identified two suitable locations for intermediate stops. These are shown in Figure 10.

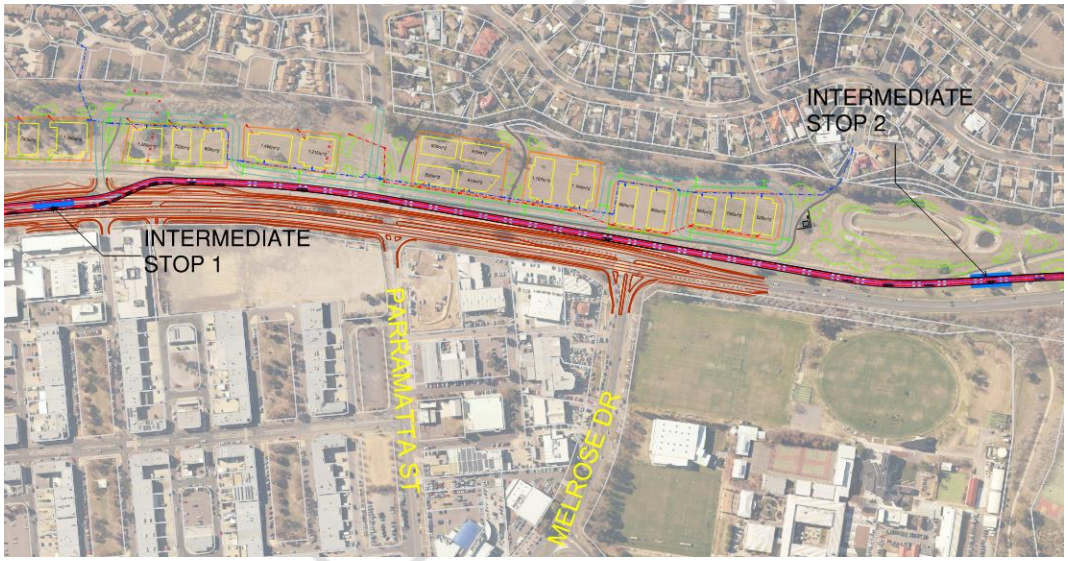


Figure 10 - Location of intermediate stops

5.7.1 Intermediate Stop 1

The corridor available for the light rail is very narrow between Shea Street and Melrose Drive, as it is constrained by the Athllon Drive southbound carriageway on the west and the proposed SLA land development on the east. Hence a stop has been proposed just north of this section, before the intersection at Shea Street. This location would serve the existing development on the western side of Athllon Drive as well as the current residential area and future residential area proposed by the SLA on the eastern side of Athllon Drive. Access to the stop would be by the existing signalised pedestrian crossing at Shea Street. It is the current intention of the SLA development plans to formalise some of the informal pedestrian paths on the east side of Athllon Drive opposite Shea Street.

With regards to the stop typology, Intermediate Stop 1 on the median-running section of the alignment is an island platform with the purpose of reducing the corridor width.

5.7.2 Intermediate Stop 2

Intermediate Stop 2 would be located opposite Marist College Canberra and Melrose High School. It would serve both schools and the adjacent playing fields as well as the residential development to the east of Athllon Drive. There is an already well-established pedestrian path network to the east that converges at this location and crosses Athllon Drive via an underpass. Access to this stop would be via this path network, providing safe access for school students without requiring them to cross to the stop at traffic signals on Athllon Drive.

5.7.3 Terminus

The terminus in the base-case extension will be in the south east corner of the intersection between Athllon Drive and Mawson Drive. Locating light rail stops next to road intersections reduces the journey time and provides a more integrated pedestrian route and access to public transport. It is also consistent with CLR Stage 1. However, selecting these locations for Intermediate Stop 2 and the Mawson terminus means there is a considerable overlap of the patronage catchments of the two, as shown in

Figure 12 below.

With the option to extend further south, the terminus would be located in the intersection between Athllon Drive and Beasley Street South.

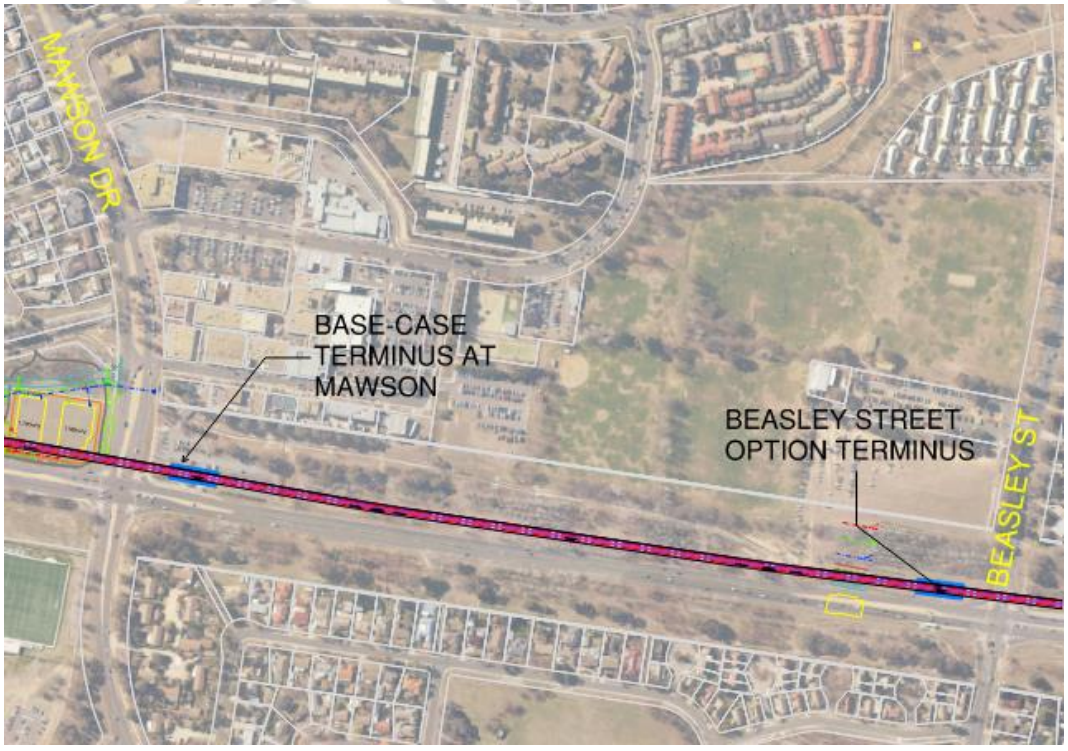


Figure 11 - Termini options

The stops locations will need to be reviewed during future stages of the project when more information on patronage is available and when there is more certainty on the option to extend until Beasley Street South.

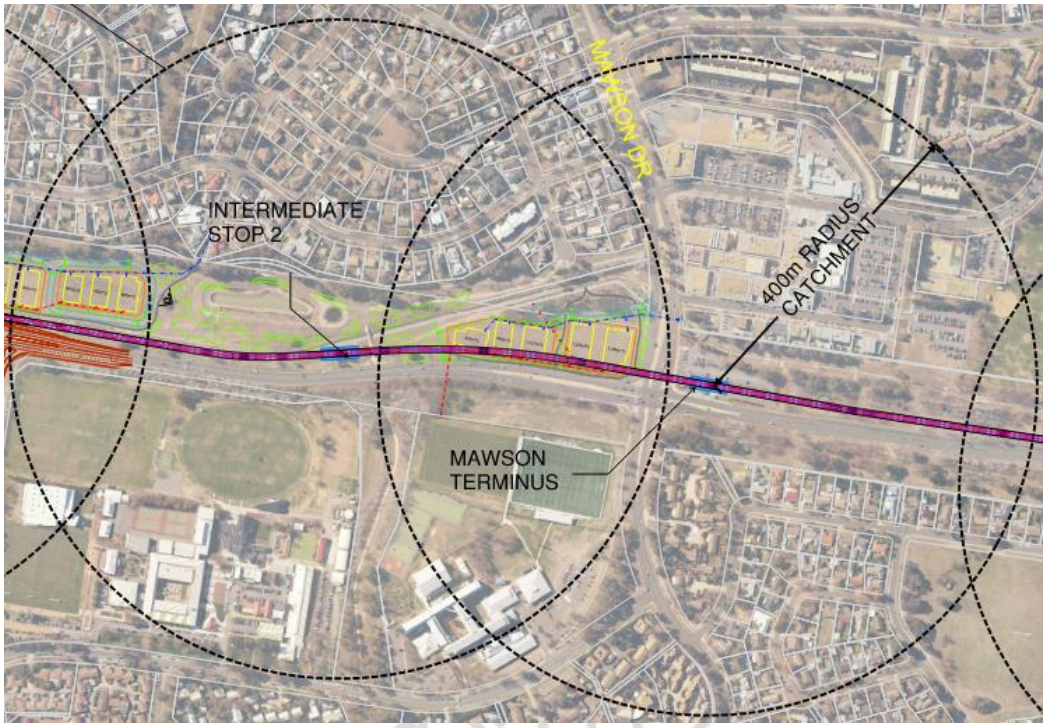


Figure 12 - Patronage Catchment Overlap

Intermediate Stop 2 and both Termini options, all on verge alignment sections, are side platforms, which generally facilitate a straighter alignment.

The station layout that has been used for the purpose of this report is consistent with the Stage 1 stops:

- Island platforms are 5.5m in width;
- Side platforms are 4m in width each;
- All platforms shown are 45m in length. It is understood that if the Mawson extension was to proceed, the stops will be 33m-long on day 1 but the alignment will need to allow for an extension to 45m.

The following summary is provided as a snapshot of the Veitch Lister Consulting's modelling of patronage forecast and travel demand analysis around the four planned stations. The analysis suggests a strong demand for destinations along the light rail corridor and that these journeys would be well served with a Mawson light rail extension

2036 Boardings							
	Base (Total LRS1 & 2)	Mawson TC	Difference	%	Beasley St	Difference	%
Northbound							
Daily	**19,152**	**20,615**	**1,463**	**7.6%**	**20,716**	**1,565**	**8.2%**
AM Peak	4,366	4,767	401	**9.2%**	4,842	476	0
InterPk	6,304	7,009	705	**11.2%**	7,030	726	0
PM Peak	5,365	5,542	177	**3.3%**	5,548	183	0
Off Pk	3,117	3,297	180	**5.8%**	3,296	180	0
Southbound							
Daily	**18,811**	**20,489**	**1,678**	**8.9%**	**20,630**	**1,819**	**9.7%**
AM Peak	5,500	5,833	333	**6.1%**	5,824	324	0
InterPk	5,890	6,548	657	**11.2%**	6,614	724	0
PM Peak	4,405	4,809	405	**9.2%**	4,867	463	0
Off Pk	3,016	3,299	283	**9.4%**	3,324	308	0
Total							
Daily	**37,963**	**41,104**	**3,142**	**8.3%**	**41,346**	**3,383**	**8.9%**
AM Peak	9,865	10,600	735	**7.4%**	10,666	801	**8.1%**
InterPk	12,195	13,556	1,362	**11.2%**	13,644	1,450	**11.9%**
PM Peak	9,769	10,351	582	**6.0%**	10,415	646	**6.6%**
Off Pk	6,133	6,596	463	**7.5%**	6,621	488	**8.0%**
Notes:							
Base Case Boardings spread from Woden across southern stops - relieving pressure on Woden as the interchange (also see transfer access below							

Car Access (Daily)	Base (Total LRS1 & 2)	Mawson TC	Beasley St
Beasley St	-	0	316
Mawson	-	200	85
Schools	-	0	0
Shea St	-	150	170
Woden	304	183	145

Transfer Access (Daily)	Base (Total LRS1 & 2)	Mawson TC	Beasley St
Beasley St	-	-	667
Mawson	-	1,882	1,195
Schools	-	-	-
Shea St	-	321	333
Woden	3,021	1,158	1,174

Figure 13 - Patronage forecast and travel demand

5.8 Overhead wiring and substation

The current proposal for the CLR2 traction system is a wire-free section of route from Alinga Street Stop to Kent Street Stop (approx. 7km), with overhead wiring installed between Kent Street Stop and Philip Oval Stop (approx. 3km) and a further section of wire free from Philip Oval Stop to Woden Stop (approx. 1km).

Three traction power substations (TPSs) are proposed to supply the overhead wiring section.

The reason for wire-free running into Woden is the negative aesthetics of overhead wiring along the Callam Street business precinct. As the proposed Mawson extension continues along Callam Street, there is an opportunity to continue the wire free section approximately 800m to the first Athlon Drive/Shea Street Stop, maintaining the aesthetics of wire free along Callam Street. Overhead wiring would then be installed for the remainder of the extension to the Mawson terminus (approx. 1,700m). On completion of both CLR2 and the Mawson extension, the overall Woden section of wire-free running would be approx. 1.8km. Overhead wiring must begin at a stop location as the LRVs cannot raise or lower pantographs whilst in motion.

A TPS is required to supply the overhead wiring section of the Mawson extension. The proposed stabling facility adjacent to Beasley Street South is an ideal location for the TPS, being a short distance from the Mawson Terminus and also being ideally placed to supply any possible further extension beyond Mawson.

A parcel of land approximately 30m x 15m will be required to accommodate the overall substation, inclusive of building, parking, access, and security fencing. The stabling facility is the most likely land take within the proposed corridor to accommodate the TPS. Should the stabling facility not proceed, an alternative parcel of land will be required as close as possible to the Mawson Terminus to support both the Mawson extension wired section and future proof for any possible further extension.

An 11kV Evoenergy supply will be required to provide bulk supply to the TPS. A traction power model will be required to determine the required capacity of the TPS (any traction power model can be an addendum to the overall CLR traction power model). Further, Evoenergy will be required to undertake an Electricity Supply Network Study (as per CLR1 and CLR2) to determine the most expedient Evoenergy 11kV supply point. This may be a loop-in, loop-out connection within an existing 11kV feeder or a dedicated feeder from an Evoenergy Zone Substation. Should an existing feeder be used for the bulk supply, augmentation of either the existing feeder or adjacent feeders may be required. The distance of the proposed Evoenergy bulk supply feeder may be several kilometres long, depending on the outcome of the Network Study.

To ensure a robust traction power system architecture across the full alignment from Alinga Street to Mawson under conditions of n-1 operation (i.e. with any one of the proposed TPSs offline), an interconnecting 11kV feeder should be installed within the track slab from the proposed Philip Oval TPS (aka TPS10) to the Mawson TPS, a distance of approximately 2km, to enable the proposed Mawson TPS to support the adjacent TPSs and vice versa with any given TPS offline.

Given the design of CLR2 is now proceeding, the proposed TPS10 must be space proofed and all required in-ground conduits installed to seamlessly accommodate the additional 11kV AC and 750V DC circuit breakers, isolators and feeder cabling to facilitate the traction network extension without costly reworks.

6 Next steps

For the project to deliver on its goals it is important that further interface planning and coordination is managed to govern the project proceeding from its current infancies, these next steps include:

- Understand in more detail the “movement” aspirations for the future in the area, in particular the road hierarchy, e.g. role of Athllon Drive, Melrose Drive and other roads for through movement.
- Expand the current traffic models to cover the whole study area to better understand the wider traffic implications and the project integration at a district level.

- Protect and reserve areas of land for light rail in the future, for example the pockets between Mawson Town Centre and Beasley St South.
- Further detail and agree the alignment, in particular the location for the transition from median running to eastern running. The current preferred Shea St transition needs to be validated with further traffic modelling that accounts for the bus depot access/egress. There are alternatives to this location right up to Melrose Drive as point of change.
- Review the treatment options for Yarralumla Creek (listed in Section 3.2) and undertake detailed flood modelling to assess viability and inform the decision.
- Define the landscaping needs for the corridor and break down into requirements to the individual projects to ensure the objectives are met on the end state.
- Define the active transport needs for the corridor.
- Confirm the SLA development plans. It is understood that there are more recent layouts of these, however at the time of writing this report they had not been provided.
- Seek agreement with the SLA regarding the clash between the light rail alignment and the land release plans at the north-east corner of the intersection between Athllon Drive and Mawson Drive.

6.1 Risks and opportunities to base scope

One of the key decisions to be addressed through further design is the point at which the alignment crosses from the median of Athllon Drive to the eastern verge. There are three obvious locations where this could occur without requiring a mid-block crossing and additional set of traffic signals: Shea Street, Parramatta Street and Melrose Drive.

Risks

- Detailed flood modelling needs to be undertaken when the new alignment is confirmed. There is a risk that this study concludes that a wider creek is required and therefore the space for the light rail and the road duplication is further constrained.
- The intersection at Shea Street is a complex intersection, with the light rail transitioning to the east, the only access to the SLA development and the bus depot access in close vicinity. Traffic modelling may conclude that further works at this location are required to increase the capacity.
- The Athllon Drive Duplication project is progressing into detailed design imminently. Therefore, there is a risk that in the absence of a timely decision on the Mawson Extension the final design does not integrate fully with the future light rail.

Opportunities

- The Athllon Drive duplication project could include the utilities diversions required for the light rail as part of its early works to avoid redundant works.

- There is an opportunity to reduce the number of lanes on Athllon Drive, depending on the strategic mobility plans, resulting in a less constrained corridor.
- There is an opportunity to reduce the width of the cross section, by providing a solution that allows the active transport corridor to be on top of the Yarralumla Creek. Some example of this possibility are shown in Figure 14 and Figure 15.

Figure 14 - Shared path on structure over swale at Alison Road (Sydney)

Figure 15 - Example of walkway

- Athllon Drive will be constructed before the light rail extension, and therefore there will inevitably be some redundant works from the former. There is an opportunity to minimise the amount of these by undertaking sufficient coordination during the next stages of design.

6.2 Opportunity to extend to Beasley Street South

As covered in previous sections of this report, the base-case extension of the CLR2 would terminate at Mawson. However, it has been identified that there are some benefits associated with terminating at Beasley Street South, around 650m south of the Mawson town centre.

This extension allows the capture of passengers from the nearby residential catchment, enhancing a network connection point with the local sporting fields combining a light rail stop/terminus and park n ride facility utilising a pocket of land which is in prime location for enrichment. This extension would also ease the pressure on current capacities within the Mawson Town Centre. It provides an opportunity to locate a satellite depot in some land parcels already in government property. See Figure 8.

7 Conclusion and Recommendations

Extending light rail to Mawson from Woden requires further coordination and planning, however the opportunities for urban renewal and city shaping development along the Mawson corridor fulfill the aspirations of a vibrant community whilst delivering good connections with a safe and effective people moving network between the City and Mawson and allowing visions of any future extensions of a light rail network through to Tuggeranong.

There are still several engineering challenges facing this corridor around a spacing constraint in integrating a duplicated Athllon Drive, light rail network, pedestrian and cycleway mixed with a diverted Yarralumla Creek and access to future SLA developments. Although with challenges comes opportunity and with careful planning and coordination these aspects can be married as one to deliver a vibrant Mawson corridor.

Appendix A

Workshop minutes

A1 Workshop minutes

Minutes

ARUP

Project title	Mawson Extension	Job number	266938-47
Meeting name and number	Stakeholder meeting	File reference	CLR-ARU-C2W-14RAAL03-MIN-000003
Location	MPC Office Dickson	Time and date	9:30 am 6 May 2021
Purpose of meeting	Stakeholder Workshop No.1		
Present	Tim Heffernan, Pam Nelson, Fiona Smith Du Toit, Julie Pearson, Mark Overton, Ross Savedge, Jamie Fraser, Hector Lambie, David Munson, Tim Rampton, Duncan Stuart, Daniel Tadic, Macarena Martinez, Steve Anderson, Wim DeBeckker		
Apologies			
Circulation	Those present		

1. Fiona presented urban design and land use of area between the Woden interchange and Beasley South Street.

1.1 Yarralumla Creek not likely to be naturalised due to high flow speed. The Athllon Drive duplication project will consider an option to divert the creek to remove the spatial constraint for Athllon Drive including the potential light rail extension.

1.2 Highlighted that strategic planning for the area is key to understanding movement on the corridor. The Athllon Drive duplication and the Mawson extension projects will ideally consider the requirements from this strategic planning and establish a compromise between movement and place. Noted that there has been some strategic traffic modelling done to date; unfortunately, it does not extend south to Sulwood Drive which is likely to be the main artery for private vehicle traffic.

2. Some considerations with regards to transport integration:

2.1 Private car traffic likely to be limited. Street geometry, and in particular cross section, to include all means of transport including active transport.

2.2 Large deliveries to town centre need to be accounted for in the design.

Prepared by	Macarena Martinez
Date of circulation	06/04/2021
Date of next meeting	20/05/2021

Minutes

Project title	Job number	Date of Meeting
Mawson Extension	266938-47	6 May 2021

2.3 Callam Street is bus only.

2.4 East-west connections need to be strong and including active transport.

2.5 Public transport connection to Canberra Hospital could be improved.

2.6 The Woden bus depot needs an exit to Athllon Drive both northbound and southbound. The light rail on the median at this location will be difficult for the exit movement from buses during peak times, hence it was agreed to update the alignment to transition from the median to the eastern verge just north of Shea Street. This intersection will need to be modelled during future stages of design, considering the bus depot and the access to SLA development.

2.7 Melrose Drive transition from median to eastern - intersection probably won't work with traffic volumes.

2.8 Assumption AD remains at 80km/h from Melrose south. It is 60 km/h north of it

3. Options previously considered:

3.1 An eastern verge alignment through the Hindmarsh intersection has been considered but discarded on the basis that the intersection already operates at capacity and inclusion of the light rail will impact the intersection performance negatively. Noted that there will be structural works required at this intersection for either option. LRI advised that the Athllon Drive duplication project does not include any works at Hindmarsh Dr intersection

3.2 Stop at Mawson Town Centre. Previous alignments turning into the town centre were considered but discarded due to increased travel time and opportunity to still connect the town centre with a stop in the intersection between Mawson Place and Athllon Drive.

4. Park and Ride block of land at Beasley South is government owned. Weekend use of the playfields to be considered, and pedestrian connection to Mawson town centre to be provided.

4.1 Not building the extension to Beasley pushes the interchange opportunity to Mawson, land plot west of carpark and tennis club is currently vacant land and would likely need to be acquired quickly to allow for further parking and stabling facilities

5. Residential Development currently planned between Shea Street and Power Street with a gap due to environmental constraints Power Street and more development south between Power Street and Melrose Drive. Access to new development is across

Minutes

Project title	Job number	Date of Meeting
Mawson Extension	266938-47	6 May 2021

the bridge that SLA will provide at Shea Street. Alignment will consider the SLA development

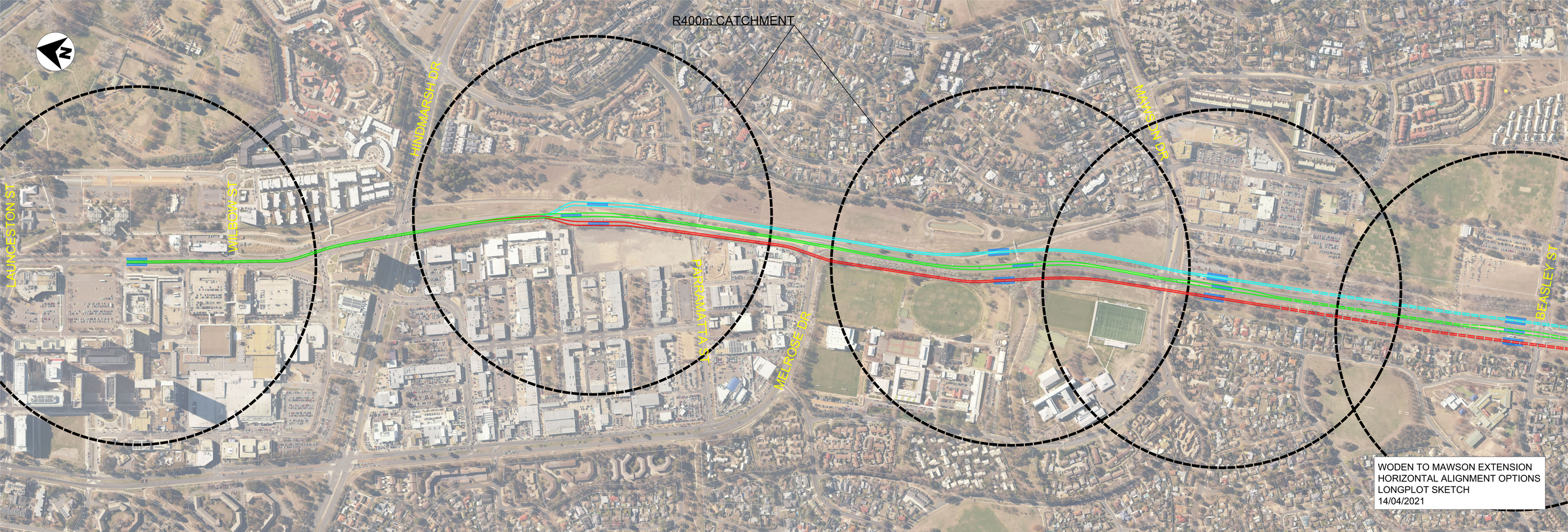
6. Need to consider landscaping in the space proofing, considering utilities and opportunity/restriction to plant over them.

7. At this stage agreed stop locations are Shea St, near schools, Mawson Dr and Beasley St south.

8. The Athllon Drive duplication project is soon progressing to detailed design. Agreed that there will be a coordination session with Arup and Cardno to jointly review the spatial requirements of the two projects along the corridor. (20th May 11am). Noted that Light Rail will only be able to provide space proofing comments at this time as their timeframes do not match with the Athllon Dr duplication nor the SLA land release.

Appendix B

Alignment Options


R400m CATCHMENT
LAUNCESTON ST
WILLOCH ST
HINDMARSH DR
FERNMATAN
MELROSE DR
MAWSON DR
BEASLEY ST
WODEN TO MAWSON EXTENSION
HORIZONTAL ALIGNMENT OPTIONS
LONGPLOT SKETCH
14/04/2021

B1 Alignment options

Appendix C

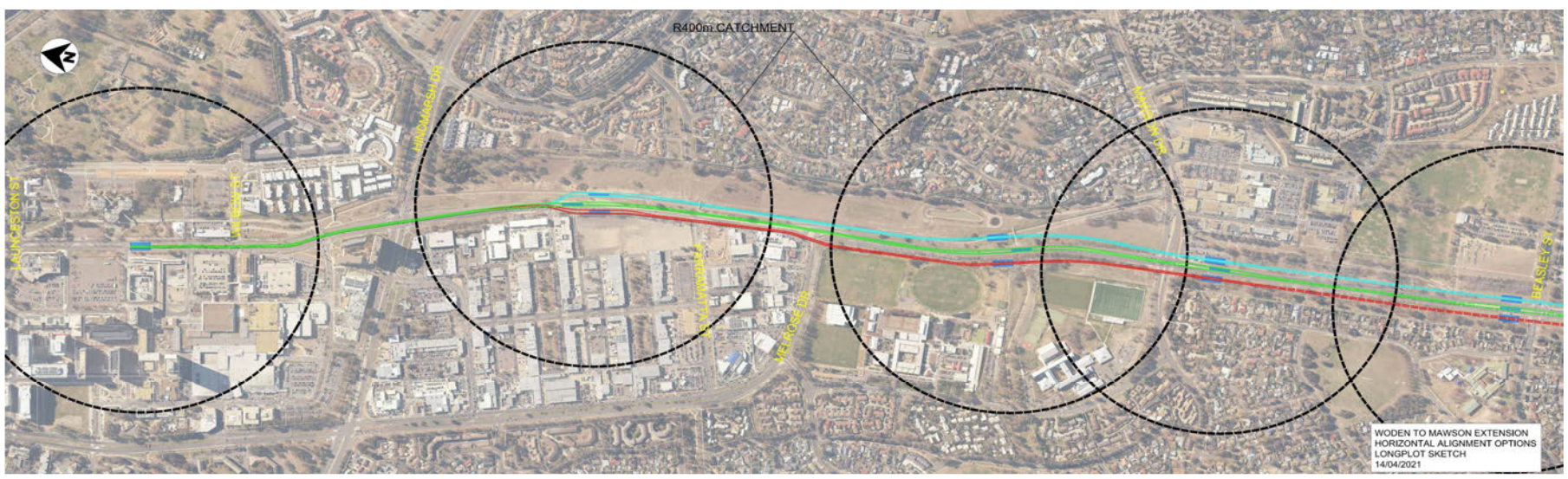
Multi Criteria Assessment Results

C1 MCA results

Canberra Light Rail Stage 2 - Mawson Extension

Summary of MCA Workshop Findings

		Median Option			Eastern Verge Option			Western Verge Option		
		Rating	Description	WIP Comment	Rating	Description	WIP Comment	Rating	Description	WIP Comment
Cost		Negative	Athllon Drive will need to be realigned from Melrose Drive to Mawson to allow for a wider median to accommodate light rail. Melrose Drive intersection would need to be converted from roundabout to signalised intersection		Positive	No carriageway realignment needed. Reduced work required at signalised intersections; Melrose Drive could remain as a roundabout		Negative	A major high pressure as main runs in the western verge of Athllon Drive from Hindmarsh Drive to Mawson. It would need to be relocated. This may require realignment of Athllon Drive to fit it in. Melrose Drive intersection would need to be converted from roundabout to signalised intersection	
Landscape	**Environmental** Flora and fauna (including endangered species), contamination, waterways	Positive	There would be low impact on current flora. No direct impact to Yarralumla Creek however it would need to be realigned as part of the Athllon Drive/Light Rail overall project		Neutral	Combined road and light rail reserve is likely to be same width for east side and median therefore neutral impact. Unknown presence of endangered species (e.g. Golden Sun Moth) but recent studies for other projects show unlikely to be present		Negative	Requires removal of existing street trees south of Hindmarsh Drive with little opportunity for replanting	
People	**Wider transport network impacts** Impacts on road traffic through Hindmarsh Drive and other major intersections, cycle paths, bus depot, bus routes etc.	Neutral	Light rail movements may result in minor impacts at each intersection but not expected to be significant as light rail will move with the north-south traffic on Athllon Drive		Positive	Minimal impact but good connectivity to bus iterchange at Mawson		Negative	Significant disruption to road traffic through Melrose Drive and to shared path on western verge during light rail operations	
	Light Rail operations considerations Network expansion, journey time, stabling facilities, additional vehicles, intersection delays	Neutral	Will need a signalised intersection/crossing to a stabling facility on the ea		Positive	Good access to potential stabling sites		Negative	No stabling location available (unless can redesign bus depot)	
	Passenger connectivity and catchment area Walk-up distance, pedestrian routes, park and ride	Negative	Passengers will always need to cross one Athllon Drive carriageway when accessing or leaving the stops. Will need either set of lights at school or connection from existing underpass to island stop in median		Positive	Good connectivity to existing park and ride facility at Mawson and potential facility at Beasley Street South. Provides good local bus interchange		Neutral	Good access for school students, not good for Mawson Town Centre or industrial area at northern end of Phillip. No room for park and ride at Mawson/Beasley Street. Existing bus interchange is on east side	
Place	**Ability to achieve placemaking outcomes** Proximity to developable land, proximity to established centres/destinations, ability to integrate with other transport modes/networks	Neutral	Positive is this will provide good connectivity with buses on Athllon Drive. Negative is stops become isolated from the already well established pedestrian movement lines the east side of Athllon Drive		Positive	The space available between Athllon Drive and the light rail alignment provides good opportunity for placemaking, including for planting and for providing active transport links		Negative	As the available space would be taken up by light rail infrastructure, all placemaking development/measures would have to occur on the east side of Athllon Drive, thereby creating a disjointed environment.	
	Integration with land release SLA vision, EPSDD strategic planning framework	Neutral	Light rail stops will be close to the current SLA land release proposals however will require passengers to cross one carriageway of Athllon Drive		Positive	Light rail stops will be on the same side of Athllon Drive as the current SLA land release proposals		Negative	Light rail stops will be on the opposite side of Athllon Drive to the current SLA land release proposals	
	OVERALL RATING	Neutral			Positive			Negative		



Appendix D

Drawings

D1 Emerging option

0 20 40 60 80 100m

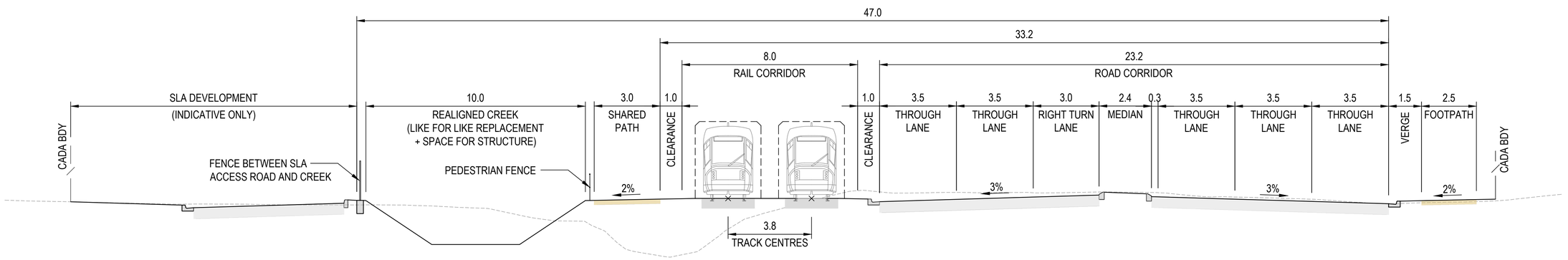
20

NOT FOR CONSTRUCTION

UNCLASSIFIED - FOR OFFICIAL USE ONLY

Client	Job Title	Drawing Title
ACT Government Major Projects Canberra	CANBERRA LIGHT RAIL STAGE 2A	MAWSON EXTENSION CONCEPT LONG PLOT
	ARUP	Sketch Status: FOR INFORMATION
		Sketch No: CLR-ARU-C2W-14CIAL01-SKT-000001 / Issue

D2 Cross section



SECTION 1
1:100 001

ATHLLON DRIVE

1 0 1 2 3 4 5m

Scales 1:100(A1)/1:200(A3)

Do not scale

NOT FOR CONSTRUCTION
UNCLASSIFIED - FOR OFFICIAL USE ONLY

Client

ACT Government
Major Projects Canberra

Job Title
CANBERRA LIGHT RAIL
STAGE 2A

ARUP

Drawing Title
MAWSON EXTENSION
TYPICAL SECTIONS

Sketch Status
FOR INFORMATION

Sketch No
CLR-ARU-C2W-14CIAL01-SKT-000002

Issue

Appendix E

Traffic modelling technical note

E1 Traffic Modelling Technical note

Technical Note

266938-47 19 May 2021

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Project title	Mawson Extension - Hindmarsh Drive Modelling Analysis	Job number	266938-47
cc		File reference	TN-001
Prepared by	Christopher Dinh	Date	19 May 2021
Subject	Hindmarsh Drive Model Results		

1 Introduction

Arup has been commissioned by Transport Canberra Light Rail (TCLR) to undertake microsimulation modelling to support a possible extension of light rail (LR) along Callam Street and Athllon Drive. The scope of the project involves developing 2026 future-year option traffic models, using VISSIM, to assess the operational performance of light rail and its potential impact on road traffic operations at the Hindmarsh Drive and Athllon Drive intersection.

Several VISSIM models were completed and presented to TCLR previously as the project design and operational assumptions were developed. This version of the model builds upon the previous State Circle Reference Case (SCRC) model that represented the light rail alignment passing through to Barton[1].

The traffic modelling described in this technical note summarises the assessment of two initial proposed options associated with the upgrade at the Hindmarsh Drive / Athllon Drive signalised intersection, for a 2026 horizon.

[1] Design changes from definition design through to RC can be referenced on *254319_TN005_ReferenceCase_Final.docx*.

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2 Background

A technical note was produced (reference *260935 TN002 State Circle Reference Case.docx* – 2 July 2019) to provide an overview of the VISSIM model development process for the State Circle Reference Case model. This revised Reference Case (RC) alignment model passes through State Circle.

The modelled network for the SCRC model was based on the previous RC model network with the applicable design changes included. The Barton section of the RC model was removed and replaced with the State Circle east corridor. The model follows the State Circle east-running light rail alignment option and generally extends from the intersection of Northbourne Avenue / Alinga Street in the north, to the intersection of Yamba Drive / Hindmarsh Drive in the south. It follows London Circuit, Commonwealth Avenue, State Circle east and connects to Adelaide Avenue by crossing Capital Circle as shown in Figure 1 below. The key intersection that is being assessed is circled in red, Hindmarsh Drive / Athllon Drive.

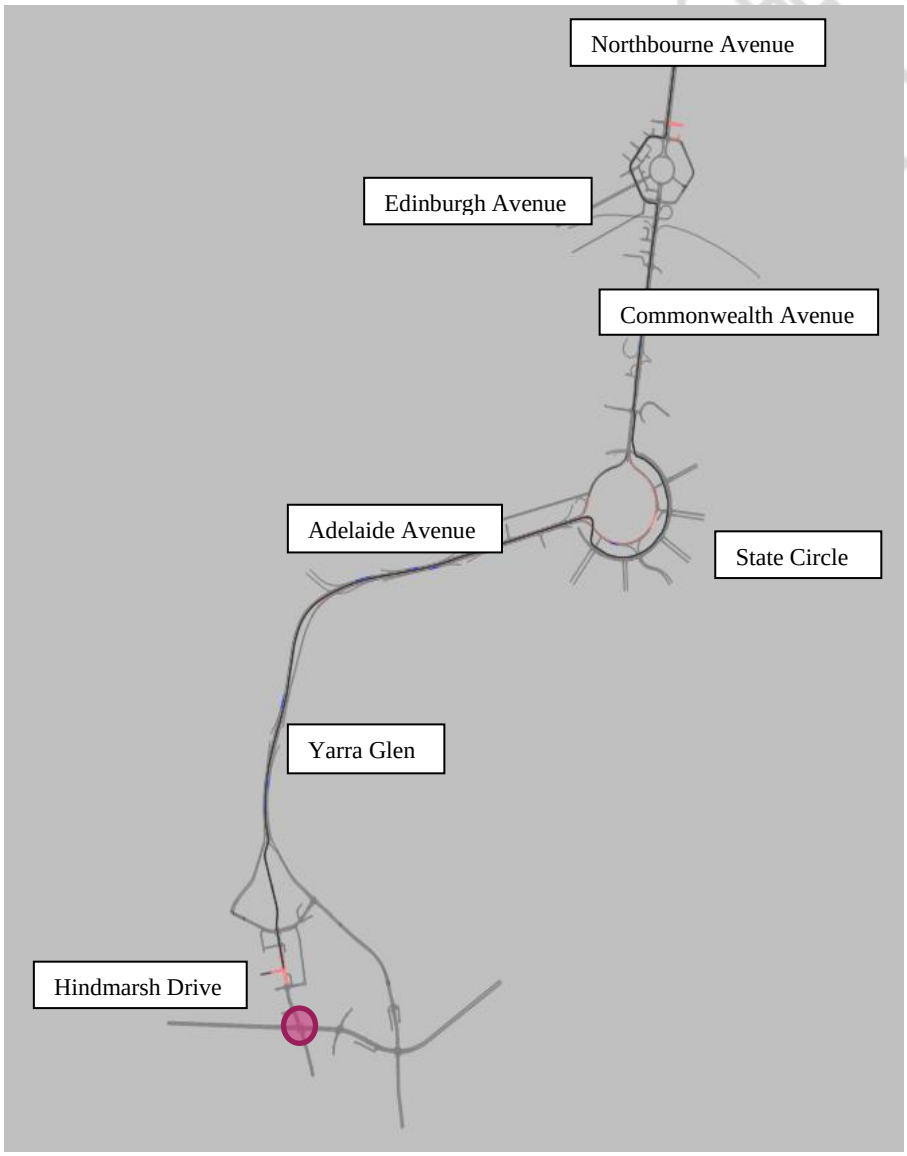

Figure 1 – SCRC VISSIM model network

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3 Options Development

This study assessed two different options upgrades for the extension of light rail through the Hindmarsh Drive / Athllon Drive intersection along the Callam Street and Athllon Drive corridor for the future-year 2026:

- Option 1 – Median Alignment; light rail running directly through the middle of the Hindmarsh Drive / Athllon Drive intersection (see Figure 1);
- Option 2 – Eastern Alignment; light rail crossover to the north and south of the Hindmarsh Drive / Athllon Drive intersection, side-running on the eastern verge (see Figure 2).

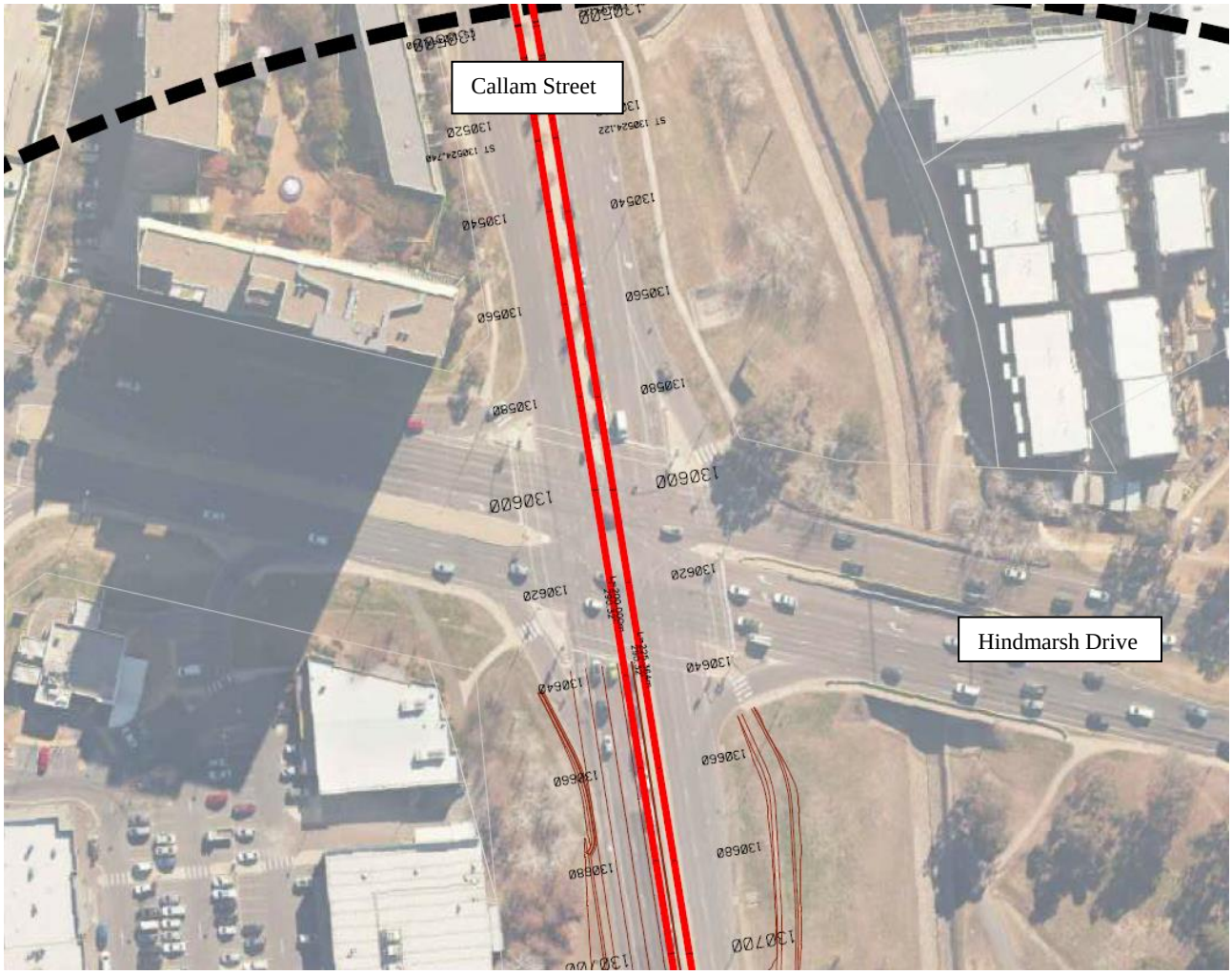

Figure 1: Option 1 upgrade option - light rail running directly through the middle of the Hindmarsh Drive / Athllon Drive intersection (in red).

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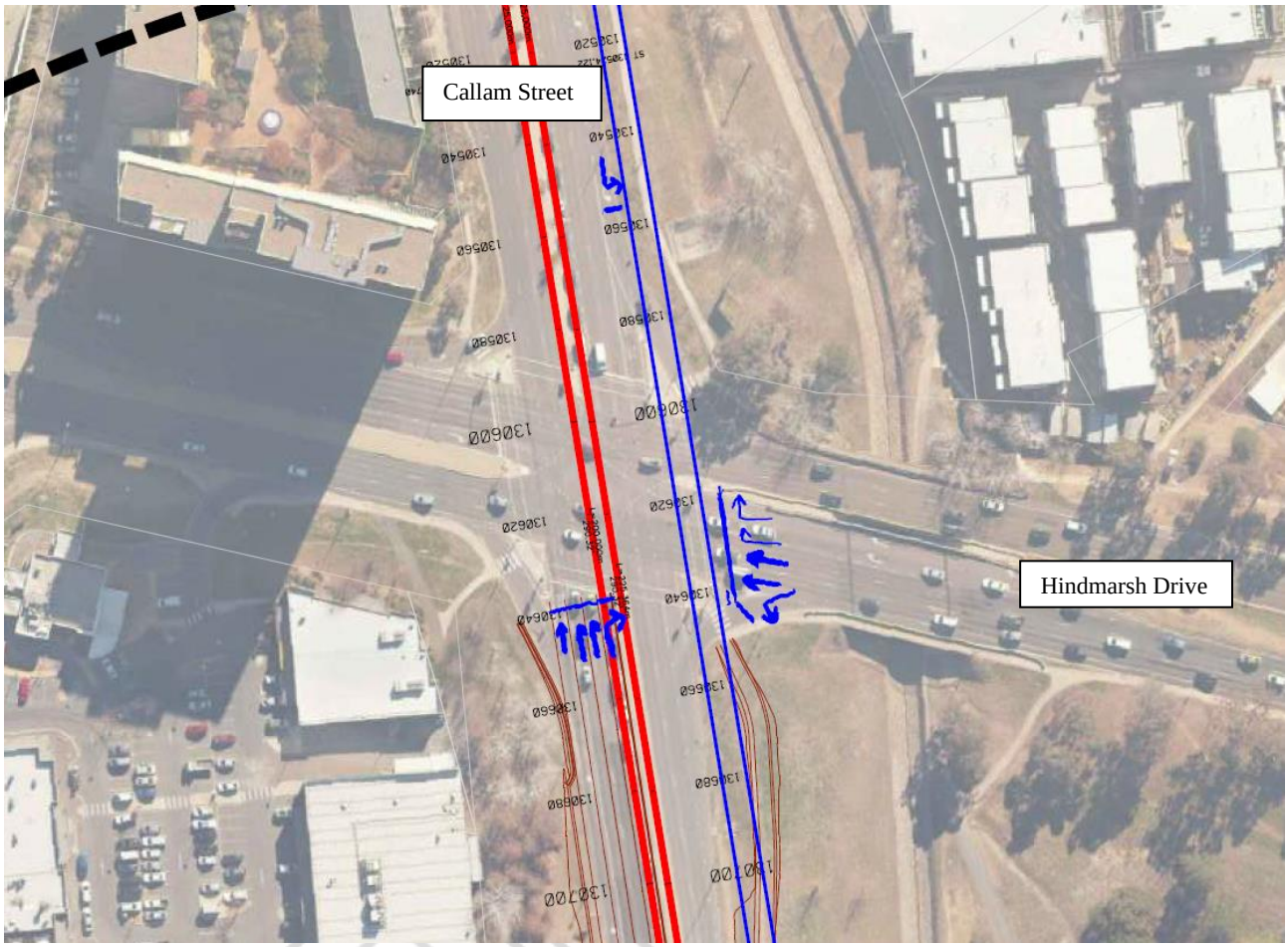

Figure 2: Option 2 upgrade option - light rail running on the eastern verge of the Hindmarsh Drive / Athllon Drive intersection (in blue).

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4 Model Development

4.1 Design Changes from SCRC

4.1.1 Hindmarsh Drive / Athllon Drive intersection configuration change

Option 1

The LR route is median-running through the Hindmarsh Drive / Athllon Drive intersection. This intersection is running a diamond phasing sequence. This intersection experiences high traffic demand particularly in the AM peak.

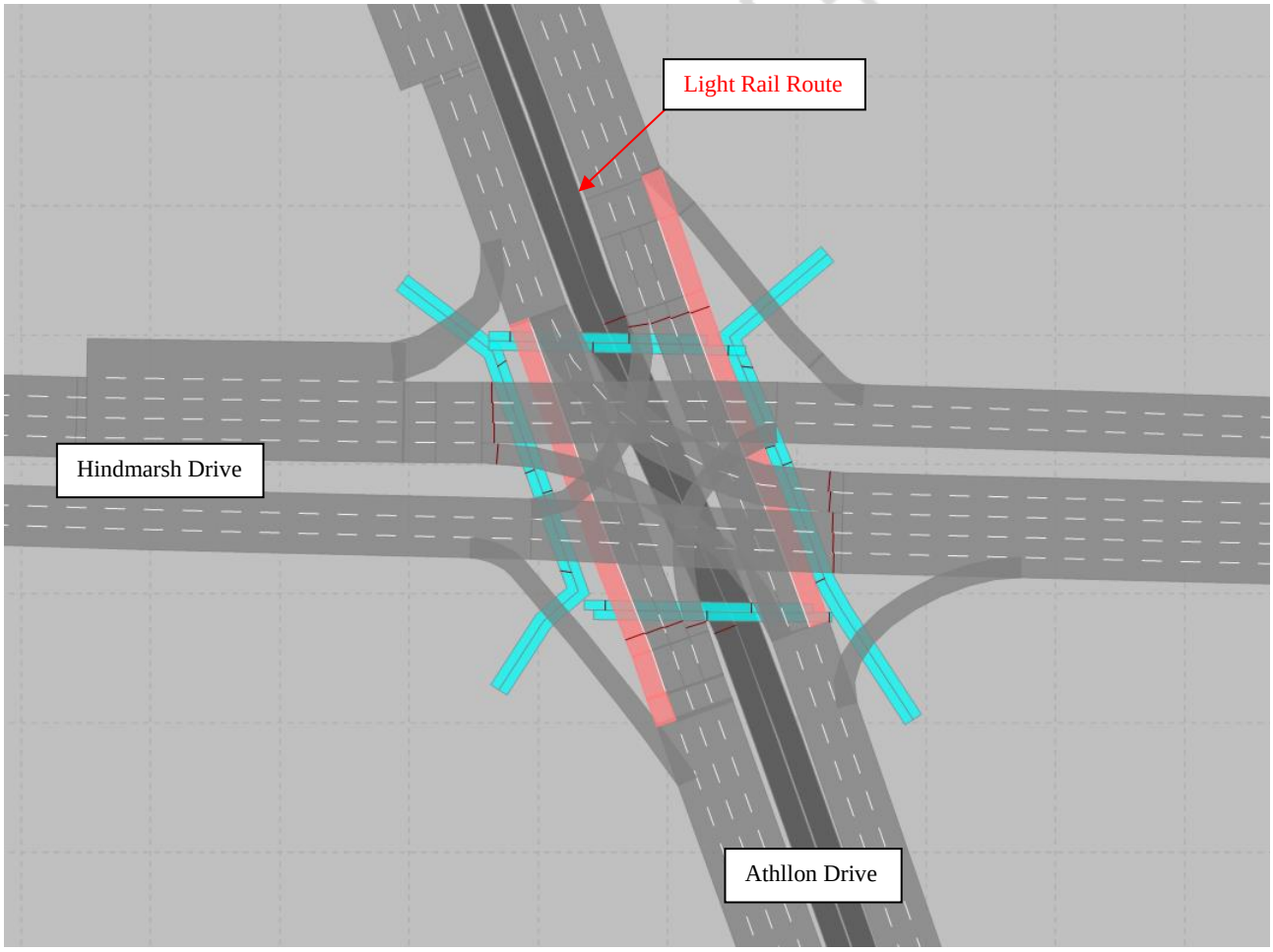

Figure 3 – Lane configuration on Hindmarsh Drive / Athllon Drive intersection

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Option 2

The LR route is side-running along Athllon Drive and crosses at points north and south of the intersection. This intersection is running a diamond phasing sequence. Both the west and east through movements have high demands compared to the other movements at this intersection.

The main consequence of side-running the LR route along Athllon Drive is the inability to allow the southbound left-turn movement to run during the same phase as LR. To reduce the impact of LR phase insertions, the southbound left-turn movement has been allocated a higher minimum phase green time which alleviates delays slightly.

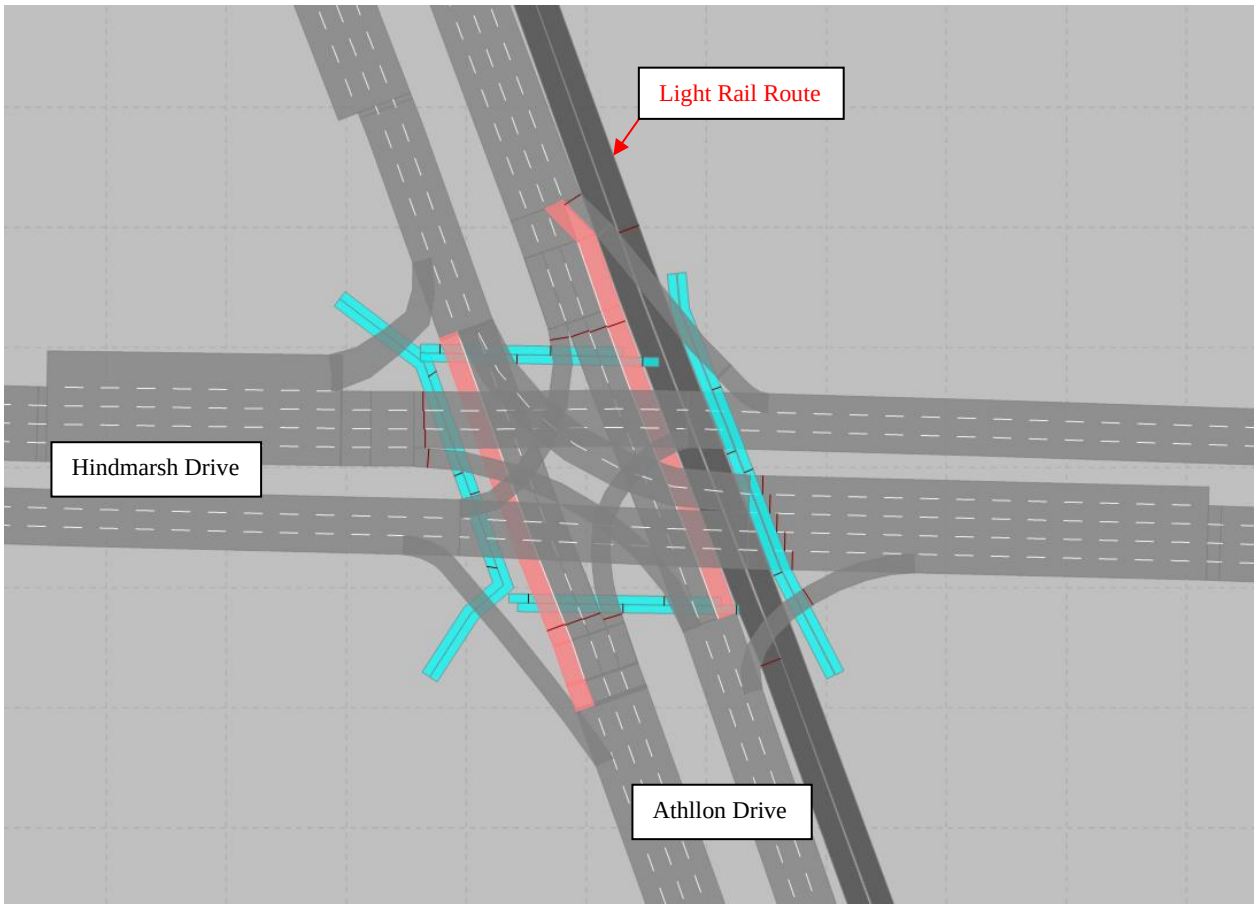

Figure 4 – Lane configuration on Hindmarsh Drive / Athllon Drive intersection

North and west approach left-turn slip lanes signalisation and lane reassignments

Moving the LR alignment from median- to side-running in Option 2 at the intersection required the left-turn slip lanes (shown in 5, left) to be signalised as shown in Figur, right.

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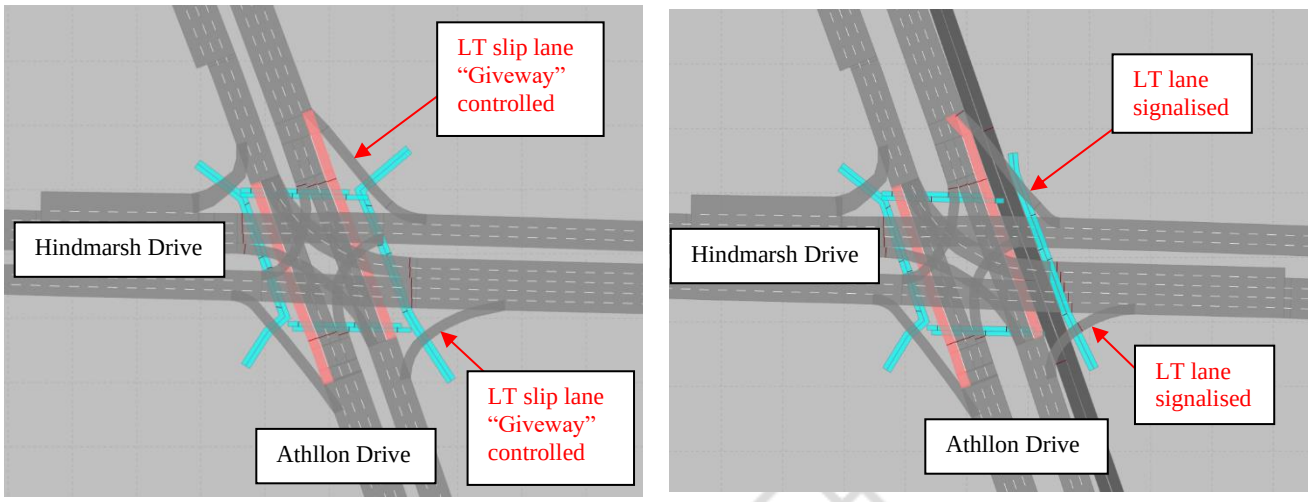

Figure 5 and 6 – SCRC left turn slip lane treatments: SCRC (left) and Option 2 (right)

4.1.2 LR Station

As a result of extending the light rail line through the Hindmarsh Drive / Athllon Drive intersection into Athllon Drive, a new LR station has been added in the model approximately 300m south of Hindmarsh Drive. The new station is located between Woden Station and the new terminus at the southern end of the model.

4.1.3 Traffic Signals

The traffic signals at the Hindmarsh Drive / Athllon Drive intersection were revised to incorporate an LRT priority signal scheme. This scheme employs full LR signal priority in both Option 1 and Option 2. While the cycle time was not amended from the 140s used in the SCRC, the general traffic signal timings and signal phase sequences were amended to suit the revised network geometry in both options. A priority light rail phase was also included which is inserted into the phase sequence when an LRV is detected outside of the main Callam-Athllon phase.

4.1.4 LRV Detectors

LRV detectors have been included at the Hindmarsh Drive / Athllon Drive intersection to perform 3 different functions, to give more realistic simulation of LRV signalling, similar to other LRV signalised intersections in the model. These 3 functions are described below:

1. **Prepare** –

   These detectors are the furthest upstream detector located away from the intersection. If LRV is detected during a non-compatible traffic phase, traffic phase will terminate after a determined minimum phase time and insert the LRV phase.

2. **Extend** –

   This detector acts to maintain the LRV signal logic call from the 'Prepare' detector (described above), and to also extend the LRV phase if an LRV phase is active.

3. **Clearance** –

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Located within the signalised intersection, this detector, when triggered, will hold the LRV phase until the LRV clears the intersection.

Modelled signal logic for the Hindmarsh Drive / Athllon Drive intersection was revised to include updated detector functions: prepare, call/extend, and clearance.

5 Model Results

TCLR is seeking to understand the predicted intersection traffic performance for each of the options and to inform the selection of a preferred option to carry forward for further, more detailed investigation. As such, a comparison of the options are presented in the following sections for the 2026 design year.

For each option, the performance of each intersection are reported in terms of average delay, level of service and maximum queue length.

5.1 LR Performance

5.1.1 LR intersection performance

Error! Reference source not found. 1 and Table 2 show the 2026 LR performance at the Hindmarsh Drive / Athllon Drive intersection for Options 1 and 2, for the AM and PM peaks respectively. For both the AM and PM peaks, both options exhibited comparable performance in both directions. It should be noted that 95th percentile queues for either option did not reach further than 4m due to the provision of high priority given to LR.

Table 1 – Comparison of LR intersection performance – AM Peak (8:00AM – 9:00AM)

Hindmarsh Drive / Athllon Drive		**2026 AM Peak**					
		Option 1			**Option 2**		
Approach	**Turn**	95th % Q (m)	Avg. Delay (seconds / vehicle)	LoS	95th % Q (m)	Avg. Delay (seconds / vehicle)	LoS
Tram (southbound)	TH	3	17	**B**	4	14	**A**
Tram (northbound)	TH	1	13	**A**	2	17	**B**

Table 2 – Comparison of LR intersection performance – PM Peak (5:00PM – 6:00PM)

Hindmarsh Drive / Athllon Drive		**2026 PM Peak**					
		Option 1			**Option 2**		
Approach	**Turn**	95th % Q (m)	Avg. Delay (seconds / vehicle)	LoS	95th % Q (m)	Avg. Delay (seconds / vehicle)	LoS
Tram (southbound)	TH	4	25	**B**	1	8	**A**
Tram (northbound)	TH	4	27	**B**	1	21	**B**

The level of delay experienced by LRVs at the Hindmarsh Drive / Athllon Drive intersection along the Mawson extension is shown in Table 1 and Table 2. The results showed that the level of LRV average delay at the intersection is expected to be less than 30 seconds, with the highest LoS B.

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The delays occurring at the Hindmarsh Drive / Athllon Drive intersection in both southbound and northbound directions are due to the amount of phase green time provided for the major east-west through movement. During both peak periods, the majority of green time is allocated to the main Hindmarsh Drive A-phase. As through movement demands in both peak periods are relatively high, the LRVs are often having to wait during the minimum phase time, even though having been detected properly to time an LRT phase insertion.

5.2 Traffic Performance

5.2.1 Intersection operation

Intersection performance results for general traffic have also been assessed. The project has adopted a level of service assessment framework based on average delay as described in RMS guidelines. The criteria for road traffic delay-based level of service in RMS guidelines is shown in Table 3.

Table 3 – RMS guidelines intersection LOS definitions

RMS Guidance	
Rating	**Average delay per vehicle at signalised intersection**
LOS A	< 14.5s
LOS B	14.5s to 28.5s
LOS C	28.5s to 42.5s
LOS D	42.5s to 56.5s
LOS E	56.5s to 70.5s
LOS F	>70.5s

2026 intersection performance (including at the overall intersection level) statistics are shown in Table 4 and Table 5 below. As shown in the tables, there was little difference between the two options in terms of intersection performance for 2026. Option 1 exhibited slightly better performance in terms of average approach delays and maximum queues compared with Option 2. The analysis shows that in peak periods, most movements are shown to operate at LoS C or better.

Note, moving the LR alignment from median- to side-running in Option 2 at the intersection requires the signalisation of the southbound and westbound left-turn slip lanes. As a result, the southbound left-turn performance significantly worsens from an average delay ranging between 8-10 seconds and LoS A in Option 1, to an average delay ranging between 83-112 seconds and LoS F in Option 2.

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Table 4 – Intersection average delays and LoS summary – 2026 AM Peak (8:00AM – 9:00AM)

Hindmarsh Drive / Athllon Drive		2026 AM Peak					
		Option 1			Option 2		
Approach	**Turn**	95th % Q (m)	Avg. Delay (seconds / vehicle)	LoS	95th % Q (m)	Avg. Delay (seconds / vehicle)	LoS
Callam Street (N)	LT	10	8	**A**	24	83	**F**
	TH	17	38	**C**	42	34	**C**
	RT	11	52	**D**	33	53	**D**
Hindmarsh Drive (E)	LT	9	16	**B**	54	32	**C**
	TH	55	41	**C**	57	43	**D**
	RT	56	107	**F**	57	95	**F**
Athllon Drive (S)	LT	0	3	**A**	0	4	**A**
	TH	233	47	**D**	224	46	**D**
	RT	232	175	**F**	223	231	**F**
Hindmarsh Drive (W)	LT	74	14	**A**	97	18	**B**
	TH	80	42	**C**	104	48	**D**
	RT	81	67	**E**	105	69	**E**
Intersection Total		233	51	**D**	224	58	**E**

Table 5 – Intersection average delays and LoS summary – 2026 PM Peak (5:00PM – 6:00PM)

Hindmarsh Drive / Athllon Drive		2026 PM Peak					
		Option 1			Option 2		
Approach	**Turn**	95th % Q (m)	Avg. Delay (seconds / vehicle)	LoS	95th % Q (m)	Avg. Delay (seconds / vehicle)	LoS
Callam Street (N)	LT	3	10	**A**	72	112	**F**
	TH	34	42	**C**	94	48	**D**
	RT	34	56	**D**	92	57	**E**
Hindmarsh Drive (E)	LT	0	18	**B**	79	36	**C**
	TH	77	42	**C**	81	41	**C**
	RT	78	65	**E**	81	63	**E**
Athllon Drive (S)	LT	0	3	**A**	0	4	**A**
	TH	23	40	**C**	23	46	**D**
	RT	21	47	**D**	22	48	**D**
Hindmarsh Drive (W)	LT	23	8	**A**	24	8	**A**
	TH	36	35	**C**	34	35	**C**
	RT	37	67	**E**	36	61	**E**
Intersection Total		78	39	**C**	94	46	**D**

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6 Summary and Conclusions

State Circle Reference Case (SCRC) model runs for the 2026 design year have been completed using VISSIM microsimulation modelling. These models were used as a starting point to assess two initial proposed upgrade options for the Hindmarsh Drive and Athllon Drive intersection, to accommodate the extension of light rail (LR) along Callam Street and Athllon Drive. The options assessed included:

- Option 1 – Median Alignment; light rail running directly through the middle of the Hindmarsh Drive / Athllon Drive intersection;
- Option 2 – Eastern Alignment; light rail crossover to the north and south of the Hindmarsh Drive / Athllon Drive intersection, side-running on the eastern verge.

The SCRC model incorporates several changes to the previous RC design, notably:

- Extension of light rail (LR) along Callam Street and Athllon Drive.
- Hindmarsh Drive / Athllon Drive intersection configuration and signal phasing changes.
- LR crossover on Callam Street and Athllon Drive from the median to side-running on Hindmarsh Drive / Athllon Drive intersection (in Option 2).
- One new LR station on Athllon Drive at the southern terminus.

For each option, the performance of each intersection was reported in terms of average delay, level of service and maximum queue length.

In terms of light rail performance, the modelling shows that the average LRT delay times are expected to be less than 30 seconds in both directions of travel, with LoS ranging from A-B, during both peak periods, in both Option 1 and Option 2.

The modelling also found that changing the LR alignment from median-running in Option 1 to side-running in Option 2 at the intersection significantly worsens the southbound left-turn movement from an average delay ranging between 8-10 seconds and LoS A in Option 1, to an average delay ranging between 83-112 seconds and LoS F in Option 2. An assessment of level of service for overall road traffic at the intersection showed that Option 1 exhibited better performance in terms of average approach delays and maximum queues compared with Option 2.

As such, it is recommended that TCLR progresses development and further refinement of the Option 1 upgrade for the Hindmarsh Drive / Athllon Drive intersection.

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DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name	Christopher Dinh	Roland Cathcart	
Signature			

Appendix F

Utility Impact Assessment
Technical Note

F1 Utility Impact Assessment Technical Note

Technical Note

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Project title	Mawson Extension	Job number	
cc		File reference	
Prepared by	Vlatko Stoilovski	Date	4 June 2021
Subject	Existing Utilities Review Utilities Impact Assessment		

This report outlines the process for reviewing utilities potentially affected by the proposed CLR extension routes. This process has been used to undertake a high-level review of potentially affected public utilities.

Public utilities are infrastructure within the route area such as pipes, cables, tunnels, pits and structures that are used for protecting, housing or transporting chargeable consumables such as water supply, sewer, power, communications, and gas to the public.

For this review, public utilities information data has been obtained via undertaking Dial-Before-You-Dig (DBYD) enquiries along the preferred option corridor. Where public utilities have been identified, these have been defined by where surface and excavation works are proposed that may impact on above and below ground public utilities.

It should be noted that all utilities assessments to date have been undertaken as desktop assessment using Quality Level D utilities data information as per AS5488, and more detailed utilities investigations will be required during the following design stages of the project to confirm alignments and depths of utilities considered to be impacted by the proposed works.

1 Introduction

Major Projects Canberra (MPC) is currently developing an extension of the existing Gungahlin to Alinga Street light rail line to Woden (CLR2). MPC has commissioned Arup (the TA) to develop a preliminary design for a further extension from Woden to Mawson to inform a future decision on the final scope of the CLR2 project.

In broad terms an extension to Mawson would continue the alignment from Woden along Callam Street and Athllon Drive and include one or more intermediate stops with a terminus at Mawson. If extended, turnback movements would occur at Mawson rather than at Woden as currently planned.

MPC asked the TA to consider the relative merits of three alignment options (in the median or to the eastern or western sides of Athllon Drive) and determine the most suitable option for further development using a multi-criteria analysis.

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This report documents the multi-criteria analysis process and its outcome.

2 Context

The extension from Woden to Mawson would be approximately 2,500m of additional track and as noted above would generally follow Callam Street and Athllon Drive. The location is shown in Figure 1 below.

Figure 1 - Location plan

2.1 Stops

As noted above, the extension to Mawson would be in the order of 2,500m long. As a rule of thumb, light rail stops should be located around 800m apart which provides for a five-minute walking time to adjacent stops without overlap.

Applying this rule suggests that there should be at least two intermediate stops between Woden and Mawson (not including Mawson itself).

In conjunction with MPC, the TA reviewed the local road and pedestrian traffic network and current and future development in the study area and identified two suitable locations for intermediate stops. These are shown in Figure 2.

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Figure 2 - Proposed intermediate stop locations

Intermediate Stop 1 would be located on the southern side of Shea Street. It would serve the existing development on the western side of Athllon Drive as well as the current residential area and future residential area proposed by the SLA on the eastern side of Athllon Drive. Access to the stop would be by the existing signalised pedestrian crossing at Shea Street.

Intermediate Stop 2 would be located opposite Marist College Canberra and Melrose High School. It would serve both schools and the adjacent playing fields as well as the residential development to the east of Athllon Drive. There is an already well-established pedestrian path network to the east that converges at this location and crosses Athllon Drive via an underpass. Access to this stop would be via this path network, providing safe access for school students without requiring them to cross to the stop at traffic signals on Athllon Drive.

2.2 Purpose of Report

The primary purpose of this report is to undertake a high level utilities impact assessment to identify, document, and investigate the need for any works on public utilities infrastructure that may be affected as a result of the proposed light rail corridor and stations works.

This report provides an overview of the principles and practices that would apply to the management of utilities during the construction of the project. It includes a list of major utilities located within or adjacent to the construction footprint that have the potential to be affected by construction of the project and outlines the approach to management of mitigation measures and adjustments to utilities.

This report has been produced to:

- Inform stakeholders about the proposed infrastructure works
- Detail the utilities in the project area

- Provide the basis for discussions with utility providers for proposed realignment and or upgrade works.

3 Utilities analysis and data

For this report the definition of a public utility is a company or organisation that provides a service to the public (i.e. supplies water / sewer / power / communications), can be public or privately owned and generally maintains the pipe / cable / conduit / pits assets.

Public utilities include (but are not limited to):

- Evoenergy – transmission, sub-transmission, and distribution power cables above and below ground, pits, substations, poles, towers, and gas mains
- Telstra (plus other communications providers i.e. NBN Co, Optus, TPG, etc.) – cables above and below ground, tunnels, buildings, towers, pits
- Jemena (Gas) - conduits, pipes, pits, structures
- Icon Water (sewer/water/effluent) – tunnels, buildings, pipes, pits, structures
- Transport Canberra and City Services (TCCS) – underground and overhead power cables, pits, poles, structures
- Department of Finance (DoF) – communications cables above and below ground, tunnels, buildings, towers, pits

Utility that is not considered as public utilities in this report is stormwater infrastructure as this is covered within other reports.

3.1 Utilities classification

Public utility assets that are understood to be impacted and may require relocation or protection measures have been identified along the proposed alignment design. Areas outside of the project footprint may be impacted by planned utility works, such as the route selected for the installation of construction power or permanent operational power which are required to support the project. Assets critical to the utility service providers and their customers will require early discussions with providers to understand their risks and requirements and to reduce risk of future adjustments and cost implications.

During further design stages of the project, other utilities that may be impacted by the project may be identified in consultation with utility service providers.

New public utility services connections associated with the proposed works are not discussed in this report.

3.2 Clash mitigation strategy

To resolve utility clashes along the proposed alignment, any or all of the following will be required:

- Where possible, redesign the works to allow retention of the utility in its current position

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- Utility adjustment or relocation
- Utility protection
- Removal of abandoned utilities and infrastructure, if required; and
- The possibility to accommodate the utility within the proposed design.

The current approach does not allow for the upgrading of utilities apart from any upgrades required to manage potential impacts arising from the project such as upgrades of infrastructure or power supply connections.

There is considerable program risk associated with works on any major utility's assets, therefore these works need to be targeted as to be carried out early in the construction program.

Utilities comprising of asbestos materials have been identified as potentially impacted by the proposed works. All work to these utilities is to be undertaken by a licenced asbestos removal company with an appropriate asbestos management plan in place, in accordance with the specific laws about working with asbestos as per Chapter 8 of the Work Health and Safety Regulation 2017, and in accordance with SafeWork NSW practices and guidelines.

3.3 DBYD benchmark

Desktop investigations using DBYD search results have been used as a starting point to locate and identify any key issues in the planning stages of the design

DBYD searches are considered within the industry as a mandatory requirement when undertaking utilities investigations and excavation activities. The DBYD makes a good starting point and can be used as a benchmark for undertaking utilities gap analysis.

4 Utilities risk and opportunity

There is high degree of risk associated with impacts on existing utilities infrastructure and as such it is recommended to engage into early discussions with all utility authorities identified as potentially being impacted by the proposed works.

4.1 Utilities risk

The quality of available utilities information that the preliminary assessment is based on (DBYD information) is a key risk for the project going forward. Further utility investigations combined with detailed input from utilities providers will be key to the success of the project.

The lack of certainty around locations of utilities creates a degree of risk. Where utilities are not in their assumed location, a different treatment may be required. For all assets, this has cost and/or program implications.

To minimise the risk of potential discovery of unknown underground services, it is recommended that services searches and pot-holing is carried at the early stages of the project at critical locations and prior to commencement of excavation works at locations where excavation works are proposed on public areas (roads, footpaths, open spaces).

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To identify utilities risk, a systematic approach is required to ensure all aspects and effects of the impacts are captured.

4.2 Opportunities

Additional potential changes/opportunities that may be investigated to further inform the route/alignment selection are outlined below (subject to further investigation and environmental assessment):

- It is unknown if any utility service providers have any works planned in or around the corridor. There may be an opportunity to integrate new utility works with the project, either along the corridor or at crossing points (e.g. bridges/underpasses)

5 High level public utilities review

Over the length of the alignment, there are number of areas where the alignment is in close proximity to or crosses public utilities infrastructure. Due to the length of the proposed alignment corridor, the DBYD search area was divided into the following sub areas in order to obtain existing utilities information particularly relating to Evoenergy and Icon Water who request smaller search areas:

Area 1 – Bowes Street to Hindmarsh Drive

Area 2 – Hindmarsh Drive to Parramatta Street

Area 3 – Parramatta Street to Mawson Drive

Area 4 – Mawson Drive to Beasley Street

High level utilities impact assessment was undertaken for each area and the details of the assessment are noted in **Error! Reference source not found.**.

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DBYD Search Area	Utility Owner / Type	Size / Description	Utility Information and Assessment
Area 1	DoF	Communications	Government fibre optic communications network managed by Commence Communications. No details of the alignment provided in the DBYD response apart from noting it is present within the search area. The location of the asset is to be confirmed via contacting Commence Communications to arrange for an on-site appointment. This is a critical government fibre optic network.

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DBYD Search Area	Utility Owner / Type	Size / Description	Utility Information and Assessment
Area 1	NBN Co	Communications	Fibre optic communications network crossing the proposed alignment at Bradley Street and south of Corinna Street. Subject to confirmation of the network alignment and depth, these assets may require local adjustment / lowering or relocation. The final mitigation measure is to be discussed and agreed with NBN.
Area 1	Optus	Communications	Optus fibre optic communications network part through own ducts and part through Telstra leased conduits crossing the proposed alignment at Corinna Street and just south of Corinna Street and Callam Street intersection. Subject to confirmation of the network alignment and depth, these assets may require local adjustment / lowering or relocation. The final mitigation measure is to be discussed and agreed with Optus.
Area 1	Telstra	Communications	Communications network comprising of both major (CC) and local area network (DA) crosses the proposed alignment and will likely require adjustment or relocation. Optus cables also present through the Telstra ducts. The depth and alignment of the crossing will need to be confirmed and the final mitigation measure to be discussed and agreed with Telstra.
Area 1	TPG / TransACT	Communications	TransACT duct along the eastern side of Callam Street to the north of Wilbow Street and crossing under the northern leg of Callam Street and Hindmarch Drive intersection. Asset will likely require lowering or relocation.

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DBYD Search Area	Utility Owner / Type	Size / Description	Utility Information and Assessment
Area 1	TCCS	Electricity – street lighting	Underground cables network and poles along Callam Street. The network will require relocations / adjustments to suit the proposed corridor and alignment works.
Area 1	Evoenergy – Electricity	High voltage, low voltage, and street lighting	Electrical network crossing the proposed alignment under the northern leg of Callam Street and Hindmarch Drive intersection including multiple crossings to the north. The network will likely require relocation works in sections to suit the proposed corridor and alignment works.
Area 1	Evoenergy – Gas	50mm steel, 1050kPa, Secondary gas main	Crossing under Callam Street just to the south of the intersection with Wilbow Street. Subject to depth and alignment confirmation, will likely require lowering.
Area 1	Evoenergy – Gas	100mm steel, 1050kPa, Secondary gas main	Crossing under Callam Street and Bradley Street intersection. Similar to above, subject to depth and alignment confirmation, will likely require lowering.
Area 1	Evoenergy – Gas	A 250mm and a 150mm steel, 1050kPa, Secondary gas mains	Crossing under the northern leg of Callam Street and Hindmarsh Drive intersection. Similar to above, subject to depth and alignment confirmation, will likely require lowering.
Area 1	Icon Water – Effluent	N/A	Based on current DBYD information there are no existing effluent mains present within the search area.
Area 1	Icon Water – Sewer	600mm	Sewer carrier along the eastern side of Callam Street heading south towards the intersection with Hindmarsh Drive where it crosses over to the western side of Athllon Drive. Due to its size, it is assumed for the sewer main to be deep enough and not impacted by the proposed works over.

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DBYD Search Area	Utility Owner / Type	Size / Description	Utility Information and Assessment
Area 1	Icon Water – Sewer	300mm	Sewer main crossing under Callam Street just to the north of Bradley Street. Assumed to be deep enough and not impacted by the proposed works over.
Area 1	Icon Water – Sewer	300mm	Sewer main crossing under Callam Street just to the south of Corinna Street. Assumed to be deep enough and not impacted by the proposed works over.
Area 1	Icon Water – Water	150mm and 225mm	Water mains along the eastern side of Callam Street between Bowes Street and Hindmarsh Drive. Assumed works constrained to the road existing road carriageway hence not impacted.
Area 1	Icon Water – Water	150mm – multiple mains	Water mains crossing under Callam Street at Bowes Street, Bradley Street and Corinna Street will likely require lowering to suit the proposed track works over.
Area 1	Icon Water – Water	250mm	Water mains crossing under the northern leg of Callam Street and Hindmarsh Drive intersection will likely require lowering to suit the proposed track works over.
Area 2	DoF	N/A	Based on current DBYD information there are no existing assets present within the search area.
Area 2	NBN Co	N/A	Based on current DBYD information there are no existing assets present within the search area.
Area 2	TPG	N/A	Based on current DBYD information there are no existing assets present within the search area.

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DBYD Search Area	Utility Owner / Type	Size / Description	Utility Information and Assessment
Area 2	Telstra	Communications	Major (CC)communications network comprising of 2 x P100 conduits through a shared trench along the eastern side of Athllon Drive between Hindmarsh Drive to a crossing under Athllon Drive just to the north of the intersection with Parramatta Street. Likely to require relocation to suit the proposed road and rail corridor works. Currently shown as vacant ducts on Telstra's DBYD plan.
Area 2	TCCS	Electricity – street lighting	Underground cables network and poles along Athllon Drive. The network will require relocations / adjustments to suit the proposed corridor and alignment works.
Area 2	Evoenergy – Electricity	High voltage, low voltage, and street lighting	Electrical network along both the eastern and western side of Athllon Drive between Hindmarsh Drive and Parramatta Street, including a 10 pair copper communication pilot cable. High voltage overhead lines pass over the Athllon Drive and Parramatta Street intersection. The power pole at the south-eastern corner of the intersection is impacted and will require relocation.
Area 2	Evoenergy – Gas	110mm PE, 210kPa, Distribution main	Crossing under Athllon Drive just to the south of the southern leg of the intersection with Hindmarsh Drive and will likely need to be relocated or lowered. Also includes a District Regulator and Isolation valve set at the south-western corner of the same intersection. Valve set assumed not affected. If impacted, these can take significant time to plan for design and relocation.

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DBYD Search Area	Utility Owner / Type	Size / Description	Utility Information and Assessment
Area 2	Evoenergy – Gas	250mm steel, 1050kPa, Secondary gas main	Along the western side of Athllon Drive between Hindmarsh Drive and Parramatta Street. Likely to require protection or relocation due to the proposed widening works for Athllon Drive northbound.
Area 2	Jemena Gas Networks (JGN)	250mm steel, 6895kPa, trunk primary gas main	Along the northern side of Hindmarsh Drive heading west towards the intersection with Callam Street / Athllon Drive. It crosses under Hindmarsh Drive just to the east of the intersection, across the south-eastern corner, and then heads south along the eastern side of Athllon Drive toward Parramatta Street. Just north of Parramatta St it crosses under Athllon Drive to a Primary Regulating Station on the western side of Athllon Drive. This is a critical asset and the asset alignment and depth need to be confirmed with Jemena. Assumed the alignment will be designed so impact to this asset is avoided. Subject to depth, it is likely that a protection measure will be required, and it may result in special conditions from Jemena for building over or working adjacent to this asset.
Area 2	Icon Water – Effluent	N/A	Based on current DBYD information there are no existing effluent mains present within the search area.
Area 2	Icon Water – Sewer	525mm and 375/450mm	525mm main along the western side and a 375mm along the eastern side of Athllon Drive. Assumed to be deep enough and not impacted by the proposed works over.

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DBYD Search Area	Utility Owner / Type	Size / Description	Utility Information and Assessment
Area 2	Icon Water – Water	675mm and 225mm	2 water mains crossing in an east-west direction under Athllon Drive at approximately Parramatta Street to Power Street alignment. Likely to require protection or relocation subject to depth and alignment confirmation.
Area 3	DoF	N/A	Based on current DBYD information there are no existing assets present within the search area.
Area 3	NBN Co	Communications	Along the western side of Athllon Drive from south of the intersection with Melrose Drive to immediately south of the pedestrian underpass north of Melrose High School. Then heads west towards Marr Street through the open space area. Not affected. Outside the project area.
Area 3	NBN Co	Communications	Crossing under Athllon Drive at the southern leg of the intersection with Mawson Drive / Beasley Street. Will require relocation or lowering.
Area 3	TPG	N/A	Based on current DBYD information there are no existing assets present within the search area.
Area 3	Optus	Communications	Optus major network including the Intercity Optic Fibre cables at the south-eastern corner of Athllon Drive and Mawson Drive / Beasley Street intersection then heading south along the western side of Athllon Drive. The alignment and depth along the western side to be confirmed to help investigate the option of trying to maintain this asset insitu.

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DBYD Search Area	Utility Owner / Type	Size / Description	Utility Information and Assessment
Area 3	Telstra	Communications	Major (CC)communications network crossing under Athllon Drive at the southern leg of the intersection with Mawson Drive / Beasley Street. Will require relocation or lowering at crossing with the proposed alignment. Includes Optus assets through the Telstra network.
Area 3	TCCS	Electricity – street lighting	Underground cables network and poles along Athllon Drive. Section of network just to south of Melrose Street will result in the need for TCCS adjustments of the poles and cables, and potential impact to the assets at the Athllon Drive and Mawson Drive / Beasley Street intersection.
Area 3	Evoenergy – Electricity	Low voltage and street lighting	Electrical network will require relocation to the extent of proposed roadworks to the south of Melrose Drive, and potentially at the pedestrian underpass. Subject to confirmation of underground cables and alignment and depth. Network also impacted at both the northern and southern side of Mawson Drive to the east of the intersection with Athllon Drive and the commuter car park at the south-eastern corner of the intersection.
Area 3	Evoenergy – Gas	110mm PE, 210kPa, Distribution main	Along the northern side of Mawson Drive / Beasley Street and crossing under the northern leg of the intersection with Athllon Drive. Will require lowering and / or protection at the crossover with the proposed alignment. Subject to confirmation of depth and alignment of the existing gas main.

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DBYD Search Area	Utility Owner / Type	Size / Description	Utility Information and Assessment
Area 3	Icon Water – Effluent	N/A	Based on current DBYD information there are no existing effluent present within the search area.
Area 3	Icon Water – Sewer	N/A	Based on current DBYD information there are no existing assets present within the search area.
Area 3	Icon Water – Water	300mm	Water supply main along the southern side of Mawson Drive / Beasley Street intersection and under the southern leg of the intersection with Athllon Drive. Likely to be impacted by the proposed alignment works and will require lowering and / or protection. Subject to confirmation of depth and alignment of the existing main.
Area 4	DoF	N/A	Based on current DBYD information there are no existing assets present within the search area.
Area 4	NBN Co	Communications	Outside the project area. Not affected.
Area 4	TPG	N/A	Based on current DBYD information there are no existing assets present within the search area.
Area 4	Optus	Communications	Optus major network including the Intercity Optic Fibre cables along the eastern side of Athllon Drive from the south-east corner of the intersection with Mawson Drive heading south past the intersection with Beasley Street. The alignment and depth to be confirmed to help investigate the option of trying to maintain this asset insitu. Includes an underground cable run under Beasley Street northern side from the north-east corner of the intersection with Athllon Drive heading east.

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DBYD Search Area	Utility Owner / Type	Size / Description	Utility Information and Assessment
Area 4	Telstra	Communications	Outside the project area. Not affected.
Area 4	TCCS	Electricity – street lighting Communications	Outside the project area. Not affected.
Area 4	Evoenergy – Electricity	High voltage overhead powerlines	Powerlines crossing over the proposed corridor / alignment at approximately Harrocks Street alignment to the west. Impacted and will need to be relocated / undergrounded. Proposed stop at this location as well. Potential impact to the low voltage and street lighting at the southern side of Beasley Street to the east of the intersection with Athllon Drive.
Area 4	Evoenergy – Gas	110mm PE and 160mm PE, 210kPa, Distribution mains	2 off gas main at the southern side of Beasley Street to the east of the intersection with Athllon Drive likely to require lowering or protection subject to confirmation of the depth and alignment of the assets.
Area 4	Icon Water – Effluent	N/A	Based on current DBYD information there are no existing effluent present within the search area.
Area 3	Icon Water – Sewer	375mm	Sewer main crossing the proposed alignment diagonally at approximately Harrocks Street under Athllon Drive and heading in a south-easterly direction. Assumed not affected, however the depth and the alignment of the sewer needs to be confirmed to better inform the impact assessment.
Area 4	Icon Water – Water	375mm	Water main at the southern side of Beasley Street to the east of the intersection with Athllon Drive likely to require lowering or protection subject to confirmation of the depth and alignment of the assets.

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6 Recommendations and next steps

Impacts on utilities will require further investigation and the development of detailed designs and mitigation strategies during the project's detailed design and construction phases.

As the design is further developed, the following steps should be undertaken to further inform the utilities assessment and impact mitigation strategies:

- MPC to undertake potholing of and surveying of potential conflict points between critical / major utility assets to elevate the quality level of information above Quality Level D (DBYD) data as per AS5488. Notify the relevant service authority of upcoming pothole and survey investigations and confirm any requirements imposed by the service authority such as hand or non-destructive digging
- Review and update utilities impact assessment with information from further utilities investigations and further input from utility providers
- Modelling of major utilities in 3d
- Further engagement with utility authorities to confirm service authority contacts for any design work
- Detailed design of the key utility asset realignments
- Continue consultation with utility authorities so that there is a consistent approach to the design and that the service providers requirements are considered appropriately
- Allow for potential relocation costs, investigation, and design costs within revised cost estimate to support the current preferred alignment.

Appendix A - DBYD search areas

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name	Vlatko Stoilovski	Dan Tadic	Dylan Coote
Signature			

Appendix G

Flooding review Technical Note

G1 Flooding review Technical Note

File Note

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Project title	Mawson Extension	Job number	266938
cc	Daniel Tadic; Macarena Martinez	File reference	
Prepared by	Toby Heading Karen Seeto	Date	4 June 2021
Subject	Mawson Extension Flood Risk - Draft		

1 Introduction

This technical note has been prepared to document the qualitative flood assessment undertaken for the Athllon Drive and Canberra Light Rail project (the Project) in Mawson, Canberra. This document supports the Draft Design Report that informs the Rapid Business Case.

2 Scope

Reviewing existing flooding information pertaining to the study area, including:

- A desktop, qualitative assessment of the likely impact of the alignment options (maximum 3) and any proposals to modify the existing Yarralumla Creek on the existing flood behaviour of the corridor;
- Scoping potential mitigation measures required to offset potential flood impact of the proposal/s; and
- Outlining a methodology for refining the Cardno flood model (following a model review) for a robust assessment in the subsequent stage.

3 Available Information

The following information was provided by the Infrastructure Delivery Partners for the review or prepared previously by Arup to inform the assessment:

- *"Concept Design Report – Northern Section, Athllon Drive Infrastructure Study and Duplications Concept Design"*, 19 November 2020, prepared by Cardno for Infrastructure Delivery Partners. Section 5.6 and Appendix G of this report addressed the flood assessment;
- *"Athllon Drive Infrastructure Study and Duplication, Review – Cardno Concept Design"*, 9 February 2021, prepared by Arup for Infrastructure Delivery Partners;

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- Mawson_GRC TUFLOW Model, November 2020, prepared by Cardno to support the Concept Design Report;
- Canberra Light Rail Mawson Preferred Eastern Verge Option, Arup, 1 June 2021; and
- Athllon Drive Residential Corridor, Calibre and SLA, May 2021

4 Hydrological Context

Athllon Drive is located in the district of Woden Valley which falls within the Yarralumla Creek catchment, as shown in Figure 1. The catchment discharges to Molonglo River located to the north, downstream of Scrivener Dam. Both Yarralumla Creek and its major tributary, i.e. Long Gully, service the catchment and flow generally in a northerly direction. The catchment can be regarded as fully developed with residential developments found generally in the upstream section and commercial developments found in the central section, adjacent to Yarralumla Creek.

The upper catchment terrain is relatively steep in Torrens, Farrer and Isaacs before flattening throughout Mawson where Yarralumla Creek is channelised in a formalised concrete channel.

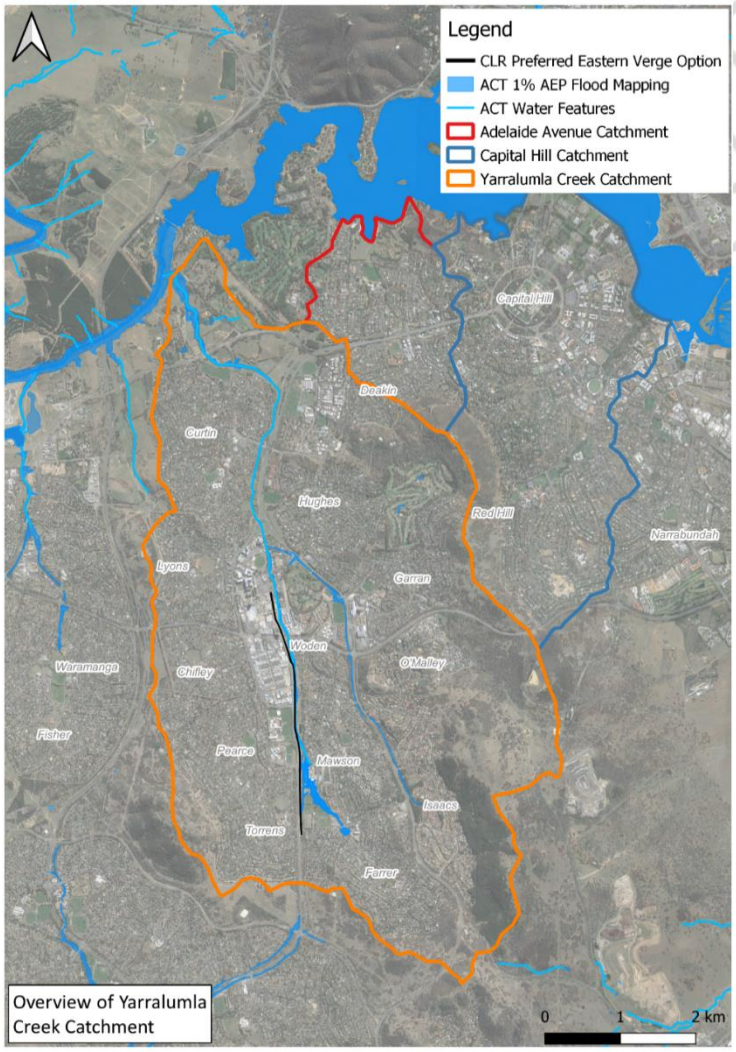

Figure 1: Yarralumla Creek Catchment overview

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5 Existing Flood Behaviour

The existing flood behaviour for Athllon Drive was informed by the flood modelling results developed for the *Concept Design Report – Northern Section, Athllon Drive Infrastructure Study and Duplications Concept Design* (Cardno 2020). This flood assessment is based on:

- Adopting an existing flood model of the catchment within which the site is located (ie the 2019 SMEC Yarralumla Creek floodway model); and
- Amending the existing flood model to incorporate detailed survey made available by the project and establishing this amended flood model as the basis of assessing the existing conditions.

Fluvial flooding is largely contained within the Yarralumla Creek corridor which passes parallel to Athllon Drive from south to north as shown in Figure 2. Yarralumla Creek is formed of a trapezoidal, concrete lined channel for the majority of its length and passes through numerous bridge and culvert structures. Surface water flooding has not been assessed as part of this document.

Figure 2: Flood risk context

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6 Light Rail Alignment Overview

The Woden to Mawson Preferred Eastern Verge Light Rail Option (01 June 2021) has been reviewed to assess the potential flood risk impacts. This section of the light rail alignment is located between Callam Street (north) and Beasley Street (south) and follows the Athllon Drive corridor.

The alignment is located within the Athllon Drive central median between Callam Street and Shea Street. The alignment then crosses to the east of Athllon Drive where it follows the road south until the intersection with Beasley Street as presented in Figure 2 above.

The Suburban Land Agency (SLA) has proposed a key development located to the east of the alignment between Hindmarsh Drive and Mawson Drive as shown in Figure 3.

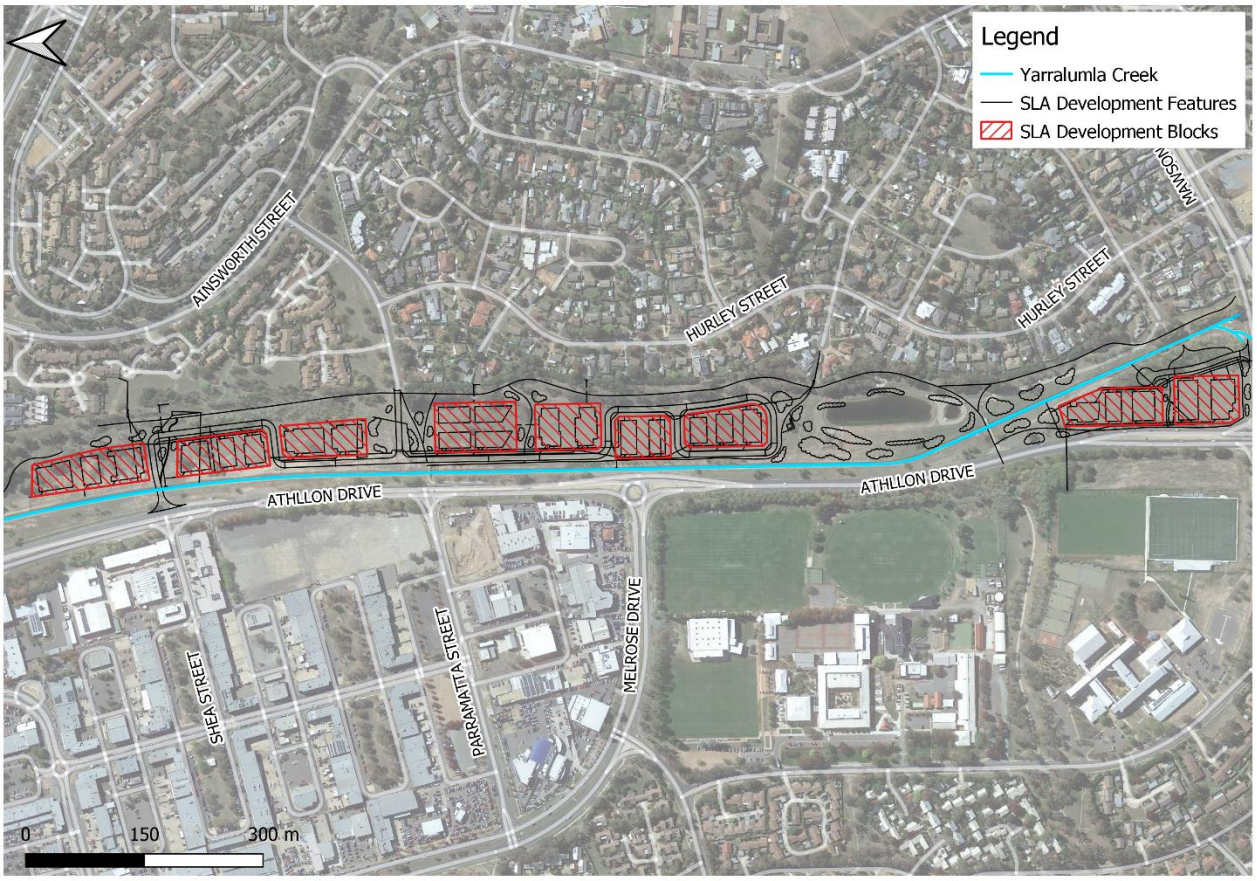

Figure 3: SLA Development

Between Mawson Drive and Hindmarsh Drive, the rail alignment significantly impacts the Yarralumla Creek where it crosses and for sections, is placed directly on top of the watercourse alignment. As a result, Yarralumla Creek will require realigning through this section.

A sketch of the proposed alignment cross section is shown in Figure 4.

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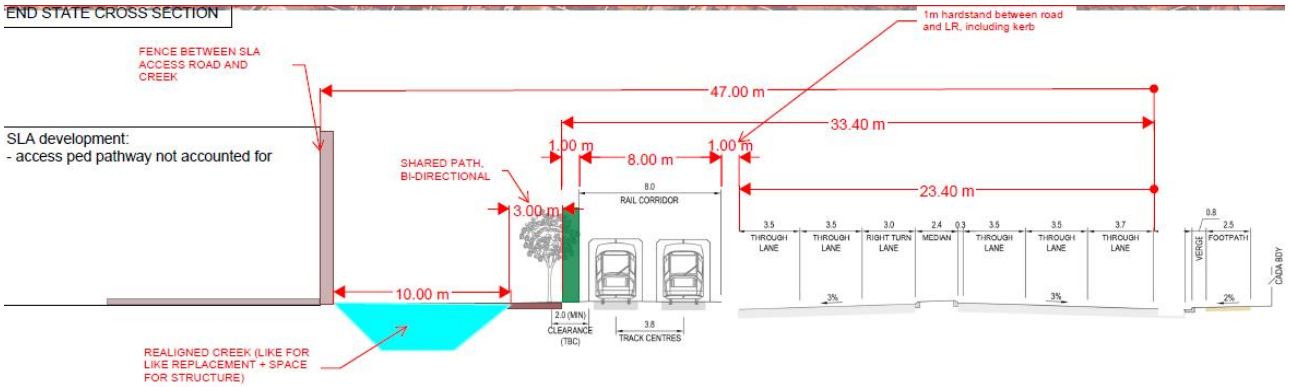

Figure 4: Proposed Light Rail cross section sketch

6.1 Yarralumla Creek Realignment Constraints

The proposed realignment of Yarralumla Creek is constrained by a number of key items which are summarised below and illustrated in Figure 5:

- Maintaining hydraulic capacity and grade of the watercourse
- Potential to increase the flood levels upstream or downstream of the alignment, resulting in impacts to private properties
- Potential impacts to the SLA development located to the east including:
  - Increased localised flood levels resulting in higher flood planning level resulting in increased pad elevations
  - Flooding of development access roads and paths
  - Footprint of the realignment watercourse clashing with the development plots
- Higher ground elevations to the east result in a larger footprint of the realigned channel due to tie-ins with the side slopes of the trapezoidal channel
- Potential impacts to Mawson Pond

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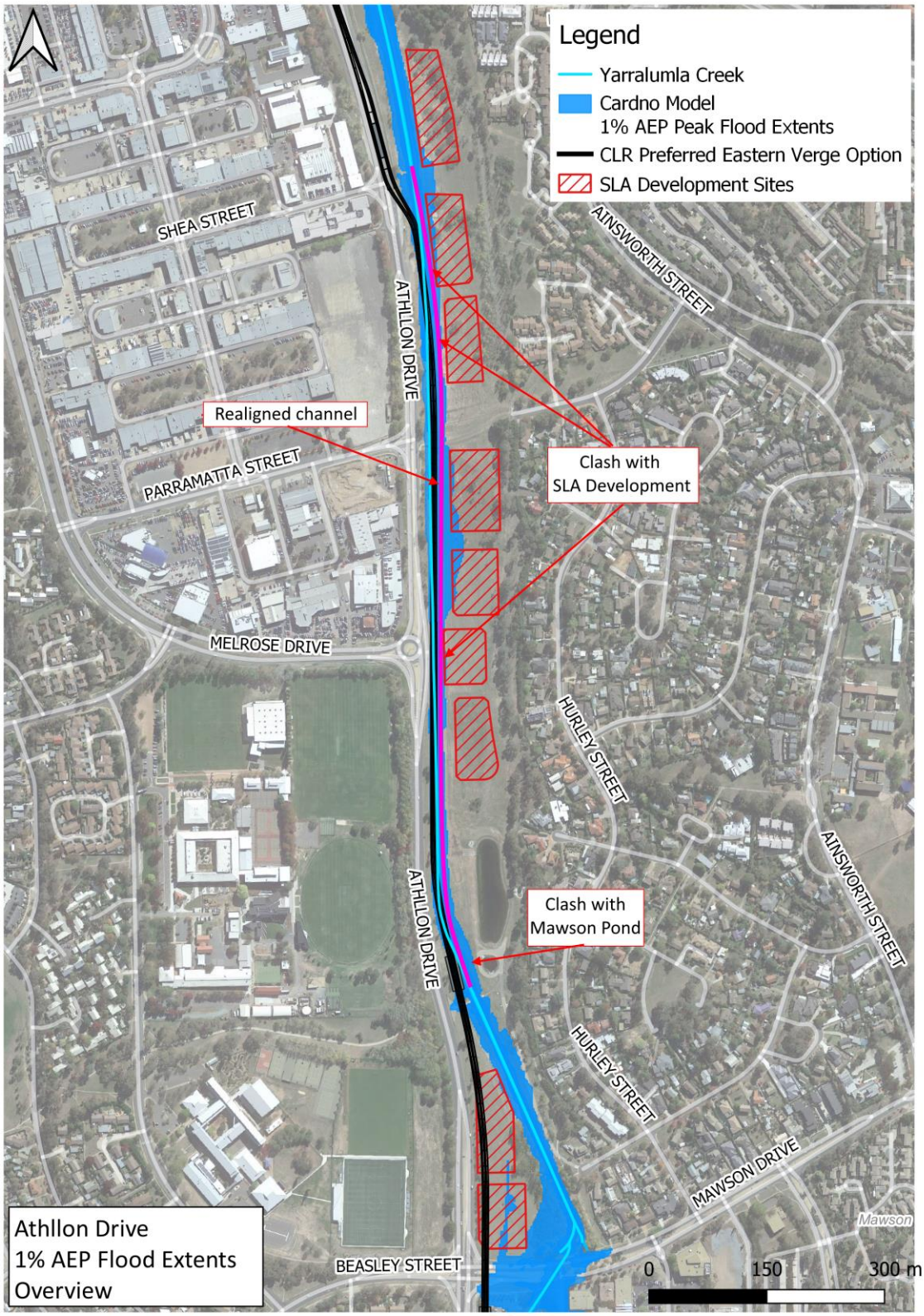

Figure 5: Flooding constraints

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6.2 Yarralumla Creek Realignment Options

Due to the constrained corridor with the SLA development to the east and light rail alignment to the west, realignment options for Yarralumla Creek are constrained to a like-for-like replacement.

To ensure impacts from the realigned Yarralumla Creek are minimised, the hydraulic capacity of the existing waterway must be maintained, in particular:

- Hydraulic radius of the channel (i.e. the channel geometry may change however the total wetted perimeter should be maintained)
- Channel gradient
- Channel lining material (i.e. concrete)

Whilst a like-for-like realignment option should maintain similar hydraulic conditions to the existing, the works may result in impacts. It is therefore strongly recommended that any proposed realignment options are tested in a hydraulic model to ensure impacts are accounted for.

7 Model Review Findings

A high level review of the Athllon Drive duplication flood modelling completed by Cardno in 2020 has been completed. This review builds on the review which has previously been undertaken by Arup in *"Athllon Drive Infrastructure Study and Duplication: Review - Cardno Concept Design"*. The findings in the previous review have been re-evaluated in this document and any items which are considered to be major ongoing issues are summarised below. In addition, a review of the Mawson_GRC TUFLOW Model has been undertaken with the key review findings presented below. Note that a detailed comment register of both the report and model review is included in Appendix G2.

The review found that in its current form, the Mawson_GRC TUFLOW model is not suitable for predicting flood behaviour at the Athllon Drive site and the comments noted below should be addressed prior to any further modelling being conducted.

7.1 Boundary Conditions

The Mawson_GRC TUFLOW model utilises a fixed water level boundary condition for all flood events modelled. It is recommended that each event utilises a corresponding boundary level or an automatic slope is applied with sensitivity testing undertaken.

It is noted that regional flood modelling of Yarralumla Creek has previously been completed (*Yarralumla Creek and Long Gully Flood Study* (Jacobs, 2015)) and it would be suitable to extract boundary conditions from.

7.2 Hydrology

The hydrology standard adopted in the flood modelling is based on the ARR 2016 methodology. Australian Rainfall and Runoff (ARR) implemented a significant update to the methodologies in

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2019. Prior to this, the method was based upon 1987 and 2016 procedures. It is recommended that the current flood model (both amended existing and proposed design scenario) utilise the ARR2019 methodologies.

7.3 Climate Change

Climate change has not been addressed in the modelling. It is recommended that climate change be considered with respect to assessing the flood immunity and design of proposed infrastructure and for the sizing of new drainage infrastructure (pits, pipes, culverts etc).

7.4 Model Outputs

The model results provided at the time of writing appear to be output from a partially complete simulation and do not match the flood mapping provided in the Cardno report. The model was rerun by Arup for the purpose of reviewing for potential instabilities and the findings are summarised below.

7.4.1 Model Stability

Model instability is observed in the 1% AEP runs during both existing and proposed scenarios along the Yarralumla Creek reach between Hindmarsh Drive and Melrose Drive as seen in Figure 6. The instability is likely to result in inaccurate model outputs in this location.

It is noted that whilst the model mass balance is within acceptable range (<±1%) for the existing and proposed 1% AEP simulations, the instability observed is located at a critical location for the project and should be mitigated.

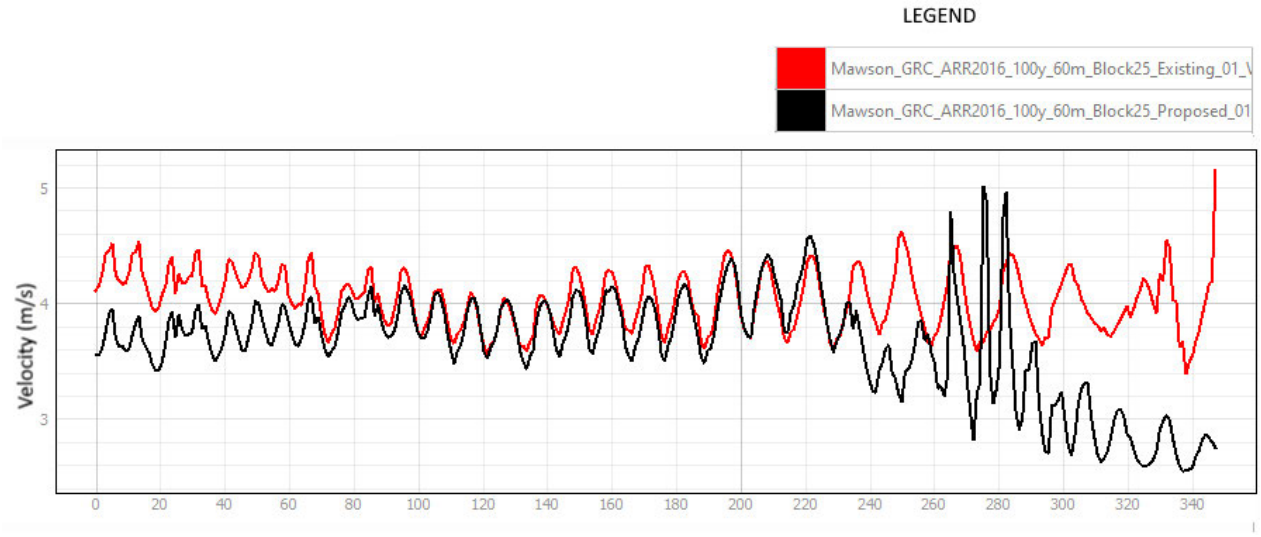

Figure 6: Peak flood velocity plot in Yarralumla Creek adjacent to Athllon Drive

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7.4.2 Impacts

Drawing 50520030-1104[C], Typical Sections sheet 5 of 5, indicates that the proposed Athllon Drive duplication works have a minor encroachment on Yarralumla Creek with the construction of the path and retaining wall at Chainage 720. At a similar location on the Cardno flood maps there is indication of newly dry areas which is a reflection of the retaining wall and path being built into the creek and raised above the flood levels. Although within the creek there is a reduction in flood levels which is converse to what would be expected from building into the floodway.

The Arup rerun of the proposed case 1% AEP event are shown in comparison with the Cardno flood mapping in Figure 7. This shows the proposed Athllon Drive duplication results in a larger increase in peak flood extent and flood level along Yarralumla Creek than was presented in the Cardno report.

It is acknowledged that as there was no model log file provided with the Mawson_GRC model handover, it is possible that the Arup rerun scenario may differ from the scenario used to produce the Cardno report flood maps. Further validation of the results is recommended to ensure consistency and that impacts from the proposed Athllon Drive duplication are adequately reported on.

Mapped results have only included 1% AEP. It is typical to assess flooding of several exceedance probabilities which usually include 5%, 10% and 20% AEP as a minimum.

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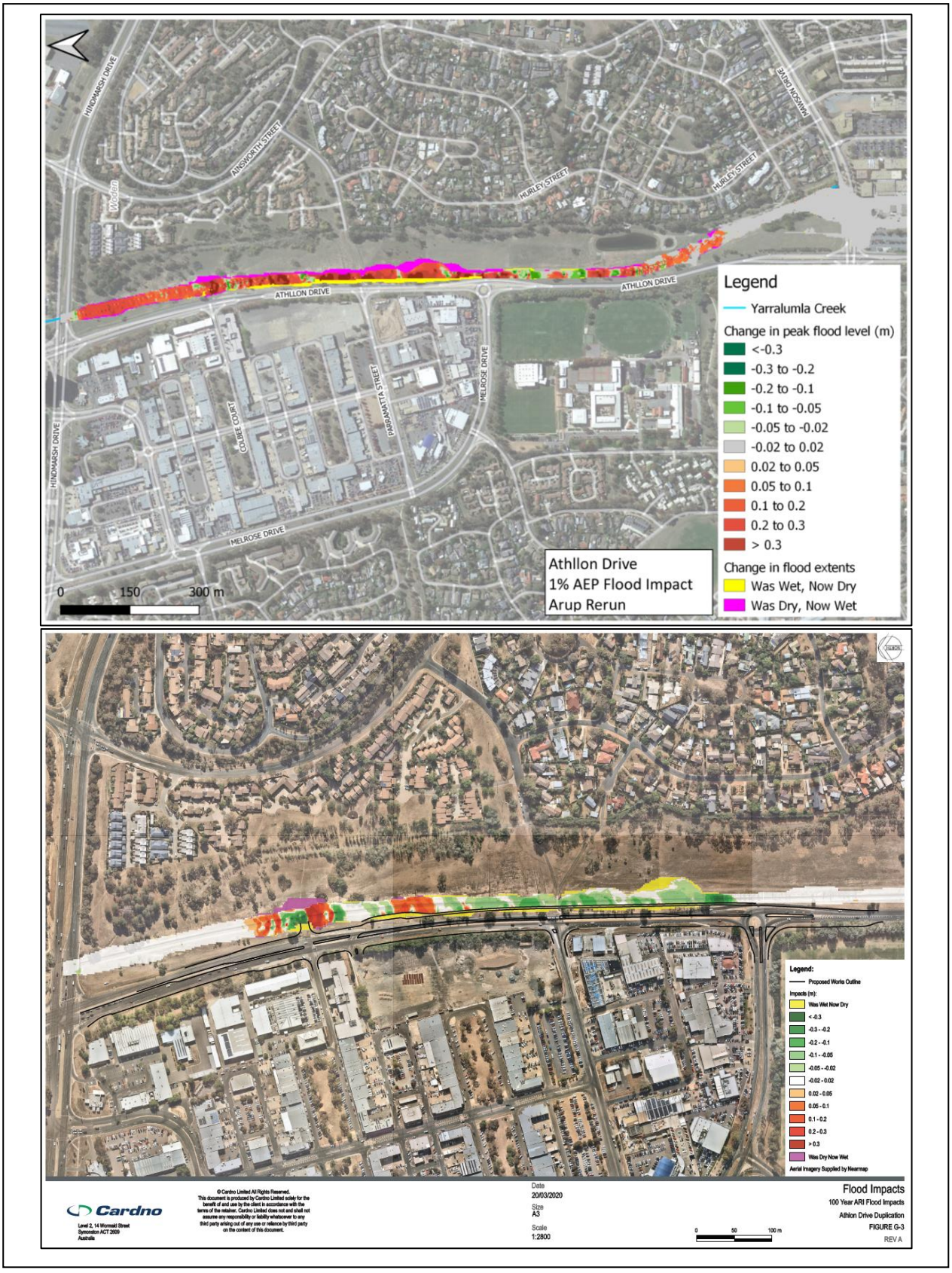

Figure 7: Comparison of impacts between Arup rerun and Cardno report

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7.4.3 Modelling of the Light Rail Alignment

Review of the model shows that the Light Rail alignment has not been tested in the flood model.

Due to the proximity of the proposed Light Rail alignment to the creek and floodway and the potential realignment of the creek, both of these items have potential for significant impact on flooding and the design.

7.4.4 Model Features

Mawson Ponds

A review of topography and historic aerial imagery within the vicinity of Athllon Drive indicates that a large water treatment pond was built in 2019 adjacent to Yarralumla Creek as shown in Figure 8. The ponds and the potential interaction with Yarralumla Creek have not been included in the Mawson_GRC TUFLOW model and may impact the model hydrological inflows.

The pond is captured in recent LiDAR topography however the geometry of the inlet/outlet structures are unknown. Any future modelling should consider the potential impact of the pond on the creek hydraulics.

Figure 8: Mawson Ponds

File Note

266938 4 June 2021

Athllon Drive Underpass

A review of aerial imagery shows that a pedestrian underpass is located beneath Athllon Drive as shown in Figure 9. This structure has not been included in the Mawson_GRC TUFLOW model. This underpass is likely to be utilised as a flow path during a flood event and should be included in future modelling.

Figure 9: Athllon Drive underpass near Lindwall Oval

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name	Toby Heading	Karen Seeto	Daniel Tadic
Signature			

G2 Athllon Drive flood model review comment register

ARUP

Design Checklist - Q&A

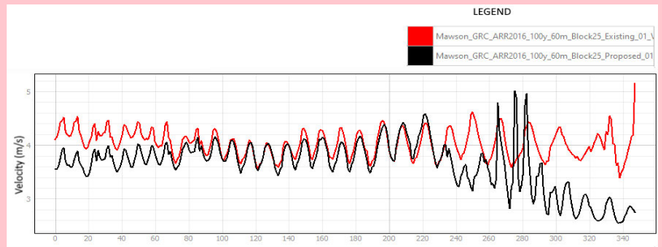
Job Title	Athllon Dr
Job Number	266938
Location	Mawson, ACT
Flood Modeller	Cardno
Date	Nov-20
Reviewed by	Toby Heading
Date	10/05/2021

Check Item	Reviewer Comments
Hydraulic Model Checklist	
Software	
Software used and version	TUFLOW 2016-03-AE-iDP-w64 used. Modeller should use latest version
Model extents	
Extents are consistent with project requirements	Model downstream boundary is located at Hindmarsh Drive. Proposed works to Athllon Dr extend to here and the Light Rail continues further north along Callam Street. **Action:** Model should be extended or sensitivity testing undertaken to show critical locations are not influenced by the boundary.
Area of interest is removed from boundary effects	As above.
Other comments/issues	
Model topography	
Resolution is appropriate	2m grid size appropriate for study.
Topography has been entered correctly (upper and lower limits are sensible)	Appropriate, DEM Z aligns with input data.
Key features have been identified	2015 LiDAR used when 2019/2020 LiDAR is publically available. Survey reasonable enough. Creek channel stamped. Mawson Ponds missing from 2015 LiDAR. **Action:** Use latest available LiDAR
Other comments/issues	Approach consistant with general practice.
Structures and Links	
Structure methods are appropriate	Bridges represented as LFCSH appears approriate. Major culverts upstream represented however no other drainage structures represented throughout model extent (e.g. pedestrian underpass beneath Athllon Dr near Melrose or stormwater pipes discharging into Yarralumla Creek near proposed site) Yarralumla Creek is adequately represented in 2D however due to the instability noted below, it is recommended that it is converted to a 1D channel. Beasley Street culvert appers to be drawn in wrong direction. **Action:** Include major drainage structures throughout model extent. Add drainage pipes near proposed site. Model Yarralumla Creek as a 1D Channel. Review Beasley St Culvert
Structure losses are appropriate	Yes appear so.
Structure data has been entered correctly	Cannot confirm
Links have been entered correctly (1D/2D and/or 2D/2D)	Yes.
Pit/pipe connectivity checked	N/A no pit pipes modelled
Design blockage has been incorporated/considered	Yes.
Other comments/issues	

Check Item	Reviewer Comments
Boundary conditions	
Boundary conditions are appropriate	Downstream boundary modelled as a constant tailwaterlevel. Inflows applied as 2d_sa polygons, distributing subcatchment flows along Yarralumla Creek. This is generally appropriate however approach does not capture potential surface water flood risk. **Action:** Downstream boundary should be extracted from regional flood model or HQ curve calculated. Inflow methodology to be reviewed to consider surface water flood risk
Value and locations have been entered correctly	Appears so.
Initial conditions are appropriate and correct	IWL not set so default automatically calculated. Creeks appear dry mostly so default IWL is appropriate. Note, if Mawson Ponds are included in next model iteration, IWL will need to be defined.
Other comments/issues	
Losses and other parameters	
Roughens values are appropriate	Material roughness is delineated quite roughly with generalisations around urban areas however as this model generally represents fluvial flooding which is confined to adjacent the main channels this is appropriate. Note if the model is converted to represent surface water flooding, it is recommended that the material layer is updated.
Spatial delineation of roughness is correct	As above.
Other parameters are appropriate	Appropriate no action requried.
Other comments/issues	
Runs and Results	
Run time step and duration are appropriate	Durations in TEF are appropriate. 2d timestep of 0.5s is appropriate however 1d timestep of 0.01s is very low and likely used to improve stability in large culverts upstream. Futher investigation into the low 1d timestep and potential instabilitiy is recommended,
Model input and output have been validated (eg. Hydrological inflows or rainfall matches runoff in hydraulic model, changes to terrain features match expectations)	Not completed
Results are stable and consistent (eg. mass balance, negative depths, control numbers)	Model appears unstable in the main channel of Yarralumla Creek adjacent to Athllon Drive. This is seen in the significant fluxuation in peak flood velocities & water levels in the channel. **Action:** Review model stability - suggest revising to 1D channel for Yarralumla Creek
Results fulfil the project objectives	As the model does not include the stormwater drainage network within the project area it is unlikely to provide useful outputs with regards to the potential impacts to surface water flooding.
Other comments/issues	

		Response Legend
	Project: Athllon Drive CLR Review	No comment / Not applicable
	JN: 266938	Minor issue, to be resolved at next stage of design
	Reviewer: Toby Heading	Moderate issue, further clarification/investigation required
	Date: 01/06/2021	Major issue, requires resolving before model is utilised
	Notes: This document provides a review of the Mawson Flood Model developed by Cardno and a response to the comments raised in CLR-ARU-C2W-01PLDE01-RPT-000001.pdf (Arup, Feb 2021) regarding the flood modelling reported on in the Athllon Dr- Northern Section_Concept Design Report_V04.pdf (Cardno, Jan 2021)	
ID	**Report Comment (Feb 21)**	**Response & Recommendation (June 21)**
1.0	**Design Criteria** Applicable design criteria are absent from the flood impact assessment. The flood impact assessment (Section 5.6.5) identifies an increase in water depths and extent which is has been determined by Cardno as being "not detrimental". It is recommended that design standards/ requirements be referenced and results quantified to confirm the project works are within the limits of the design criteria. Design criteria should address: · Design recurrence intervals; · Afflux criteria; and · Relevant standards.	To be reviewed/applied at next stage of design
2.0	**Boundary Conditions** Section 5.6.1 identifies that the existing TUFLOW model applies a downstream boundary condition with a constant water level of 585.0m. It is unclear what recurrence interval this applies to, and the reason behind the adoption of this level.	Currently fixed WL for all events modelled. Recommend updating for each event utilising levels extracted from regional Yarralumla Creek model.
3.0	**Landuse Types and Roughness Factors** A review of the land use types and the applicable roughness factors has been undertaken and are considered reasonable for modelling purposes. Typically, a roughness value of 0.02 can be adopted for a road surface, which would be more in line with the recommendation outlined in ACT's Municipal Infrastructure Standards 08 (2019) rather than the value of 0.025 adopted by Cardno.	Recommend undertaking sensitivity testing of modelled surface roughness values at next stage of design.
4.0	**Blockage Assumptions** A blockage factor of 25% has been adopted by Cardno for stormwater culverts and pipes. It is unclear the reason behind the adoption of this blockage factor. It is recommended that the Australian Rainfall and Runoff 2019 (ARR2019) risk-based approach and the ACT's Municipal Infrastructure Standards 08 (2019) be followed in determining suitable blockage factor to be adopted for drainage structures.	Recommend revising blockage assessment approach to be in line with MIS08 standards.
5.0	**Hydrology** The hydrology standard adopted in the flood modelling has not been identified in the reporting. Australian Rainfall and Runoff (ARR) implemented a significant update to the methodologies in 2019. Prior to this, the method was based upon 1987 and 2016 procedures. The modelling undertaken by Cardno was based upon a supplied SMEC flood model prepared in 2019 which was based upon an earlier model (date unknown) prepared by Jacobs. It is currently unclear which procedure (1987, 2016 or 2019) has been utilised in each of the various flood models, considering that the dates of flood model preparation span across the date of the ARR update to 2019. It is recommended that the current flood model (both amended existing and proposed design scenario) utilise the ARR2019 methodologies.	Recommend adopting ARR2019 approach. Note that ARR2016 methodologies used in Cardno model.
6.0	**Climate Change** Climate change has not been addressed in the Concept Design Report. It is recommended that climate change be considered with respect to assessing the flood immunity and design of proposed infrastructure and for the sizing of new drainage infrastructure (pits, pipes, culverts etc).	Climate change should be adopted therefore hydrology needs updating
7.0	**Proposed Drainage Infrastructure** The reporting indicates that the proposed Athllon Drive Duplication flood model has incorporated the design TIN and Shea Street Bridge structure. It would appear that the model has not incorporated the proposed drainage infrastructure. Therefore the impact of this infrastructure (either beneficial or adverse) has not been considered. Modelling of proposed drainage should also consider appropriate blockage factors in line with the recommendation outlined in ACT's Municipal Infrastructure Standards 08 (2019).	Proposed drainage structures are present in modelling directory however are not utilised for the runs reported on in the Cardno Report. Recommend utilising design drainage at next design stage

ID	Report Comment (Feb 21)	Response & Recommendation (June 21)
8.0	**Representation of Yarralumla Creek channel** The following statement found in Section 5.6.6: "It is noted that accurate impacts are difficult to predict due to the limited resolution of the flood model and the representation of the 2D channel on the two metre terrain grid. It is recommended that the existing Yarralumla Creek channel be represented as a 1D network at the detailed design stage." indicates that the current representation of the Yarralumla Creek channel in the flood model as inadequate. It is recommended that the channel be schematised in 1D to facilitate a more accurate simulation of the flow conveyance within the creek, and subsequently more reliable assessment of the impacts of the proposed works.	Recommend modelling Yarralumla Creek in 1D, regional model has been developed for CLR and includes the creek representation in 1D which can be utilised for the purpose of this study.
9.0	**Model Approach to Shea Street Bridge** In view of the critical nature of the bridge structure as a major constraint for Yarralumla Creek floodwater flows, it is recommended that an alternative software such as HEC-RAS be used to validate the afflux generated by the bridge structure as determined from TUFLOW. This would also provide confidence in the modelling of the bridge in light of the limitation described in the report pertaining to the model, i.e. representation of the channel in a 2 m terrain grid. The report provided details on the bridge span, deck level and thickness but there are no details on the form loss coefficient (resulting from any contraction or expansion losses) and blockage factor adopted for the bridge, both of which can significantly influence flow behaviour and afflux resulting from the bridge. It is recommended that the derivation of a suitable form loss coefficient and blockage factor for the bridge structure be discussed in detail.	Recommend testing sensitivity of bridge representation utilising a range of form loss coefficients at next design stage.
10.0	**Modelling of Light Rail Alignment** Reporting appears inconsistent as to the method of assessing flooding in relation to the light rail. *Section 5.3.3 Light Rail Alignment* , states "allowance for this future rail alignment and stop have been taken into consideration as part of the Athllon Drive duplication concept design". It also states that the "the existing Yarralumla Creek corridor, is anticipated to need to be realigned when light rail is constructed." The flood modelling methodology of the proposed scenario (Section 5.6.4) mentions the design TIN has been applied for the Athllon Drive duplication and the proposed bridge has been included in the model, but it does not indicate that the light rail and creek realignment has been captured in the modelling. The flood reporting is consistent with the flood maps (included in Appendix G) which do not indicate the light rail corridor or creek realignment. Therefore, it does not appear that the Athllon Drive duplication has 'considered' the light rail in the design and assessment of flood impact. Due to the proximity of the proposed light rail alignment to the creek and floodway and the potential realignment of the creek, both of these items have potential for significant impact on flooding and the design.	It appears that only the road design has been included in the Cardno Model. Recommend including Light Rail alignment

ID	Report Comment (Feb 21)	Response & Recommendation (June 21)
	Flood Maps (Appendix G)	
11.0	The following flood maps are included in Appendix G: · Existing Flood Extent 100 Year ARI Flood Event; · Proposed Flood Extent 100 Year ARI Flood Event; and · Flood Impacts 100 Year ARI Flood Impacts. The following comments are made in relation to these maps:	
11.1	Flood impact mapping indicates fluctuation between impact bands. For example, adjacent to Parramatta Street the impact bands fluctuate between green impact (-0.05 - -0.02 and -0.1 - -0.0.5) and white impact (-0.02 – 0.02). Similarly, downstream of the proposed Shea Street bridge the flood impact fluctuates between an increasing and decreasing flood impact. It is in our experience that such fluctuations may be an indication of model instability. However, this may only be confirmed by review of the flood model.	Model results supplied do not match report maps. It appears the at proposed grids are representing a partially completed model run rather than full modelled simulation. Model rerun by Arup shows significant fluxuation in peak flood velocity in Yarralumla Creek indicating that model is unstable. Instability observed in peak velocity outputs for both existing and design scenarios in Yarralumla Creek, see profile in figure. Instability extends to downstream boundary. Flood results are therefore unreliable where proposed development is located 
11.2	Flood impact mapping indicates afflux of >0.3m upstream of the Shea Street bridge and isolated locations up to 0.02 – 0.2m along the length of Yarralumla Creek. It is acknowledged that ACT's Municipal Infrastructure Standards 08 (2019) does not provide flood impact criteria for various landuse types. It is typical for an afflux criterion of ±10mm to be considered as a general design principle, which is the reported range of the accuracy of a TUFLOW model. This has not been achieved at several locations along the alignment. What is the basis of assessing the acceptability of the flood impact of the project?	Flood impact requirements to be confirmed for the project and proposed design to be reviewed to ensure compliance
11.3	Appendix G does not include velocity mapping. It is noted that ACT's Municipal Infrastructure Standards 08 (2019) requires that "any filling that is necessary in floodways should ensure both the 20% AEP and 1% AEP average flow velocities are not increased and should be accompanied by compensatory excavation so that the floodway is preserved". Current reporting is insufficient to determine if this criterion is met.	Velocity impact grids to be generated and mapped
11.4	Drawing 50520030-1104[C], Typical Sections sheet 5 of 5, indicates that the proposed works have a minor encroachment on Yarralumla Creek with the construction of the path and retaining wall at Chainage 720. At a similar location on the flood maps there is indication of newly dry areas which is a reflection of the retaining wall and path being built into the creek and raised above the flood levels. Although within the creek there is a reduction in flood levels which is converse to what would be expected from building into the floodway. Further review of the model results would be required to validate the results being reported in the mapping.	Arup rerun model results show an increase in peak flood levels and extent along the along the Yarralumla Creek reach between Hindmarsh Drive and Melrose Drive. This impact should be addressed.
11.5	Mapped results have only included 1% AEP. It is typical to assess flooding of several exceedance probabilities which usually include 5%, 10% and 20% AEP as a minimum.	Full suite of events to be modelled and reported on in next iteration

ID	Mawson Model Review (May '21)	Recommendation
12.0	**Application of hydrology:** Hydrology is applied at upstream bounds of model whilst previous CLR modelling shows that application of hydrology at sub-catchment level indicates extensive surface water flooding occurs.	Model hydrology should be revised to ensure all sources of flooding are considered
13.0	**CLR Modelling** It is noted that regional flood modelling completed for the Light Rail Stage 2 for Transport Canberra Light Rail (TCLR) in 2018, this model covers Yarralumla Creek and the	
14.0	**Mawson Ponds** The newly built Mawson Ponds (2018/19) are located adjacent to Yarralumla Creek and whilst their primary purpose appears to be for water quality purposes, the ponds and embankments are likely to impact the hydraulic behaviour of the creek during a flood event. The current flood model does not include the ponds as the LiDAR surface is dates 2015 and the topographic survey does not extend to the ponds. The pond outlet structure should also be included Note: Ponds generally appear to be located outside the 1% AEP fluvial flood extents and therefore may not impact the Yarralumla Creek flood behaviour	Use latest available LiDAR / Survey to include ponds in updated model
15.0	**TUFLOW Model Setup** See TUFLOW_QA Tab	**Summary:** - Use latest version of TUFLOW - Stormwater network should be included - Pedestrian underpass beneath Athllon Drive at Melrose to be included in model - Revise DS boundary - Use latest available LiDAR - Yarralumla Creek should be modelled in 1d - Instability in culverts to be reviewed and fixed

ACT LIGHT RAIL STAGE 2

MAWSON EXTENSION

PREPARED FOR

Major Projects Canberra

ACT Light Rail Stage 2: Mawson Extension

21-012

LIMITATION:

This report is confidential and has been prepared on behalf of and for the exclusive use of VLC's Client, and is subject to and issued in connection with the provisions of the agreement between VLC and its Client.

The purpose of the work remains as per the current contractual arrangement with the Client and is not varied by any statement contained herein.

The quality of the information contained in this report is on a best efforts basis and subject to the constraints of scope, budgets and the time allowed by the Client.

VLC accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

The output of the models used within this report are based upon reasonable assumptions and inputs agreed with the Client. They are not predictions or promises for the future but based on mathematical likelihoods and probabilities based on the data available at the time. As with any modelling effort unforeseen variables will affect the accuracy of the eventual outcomes.

The contents of this report are based upon reasonable assumptions and inputs agreed with the Client.

By issuing this report VLC is not recommending any course of action or investment undertaking.

Date	Version	Prepared by	Checked by	Approved by	Comments
28-05-21	Rev A	H. Smithers A. Bhutta S. Pang	R. Savedge	R. Savedge	
09-06-21	Rev B	H. Smithers	R. Savedge	R. Savedge	Updated cover, minor revisions

Table of contents

1.0 Introduction

This report outlines the analysis conducted on extending ACT Light Rail Stage 2 to Mawson. Analysis of existing travel behaviour in southern Canberra was undertaken using MyWay ticketing data and Location Based Services (LBS) mobile phone data. The ticketing data provides some insight into current public transport usage, while the LBS data captures a sample of total travel demand (all modes).

The way in which buses are integrated with the Mawson light rail extension will be an important factor in its success. A well-integrated solution will extend the catchment of the light rail and provide customers with a quality service. As such, we have considered how the bus network in southern Canberra might modified with the Mawson light rail extension, scoping out the potential strengths and weaknesses of various options.

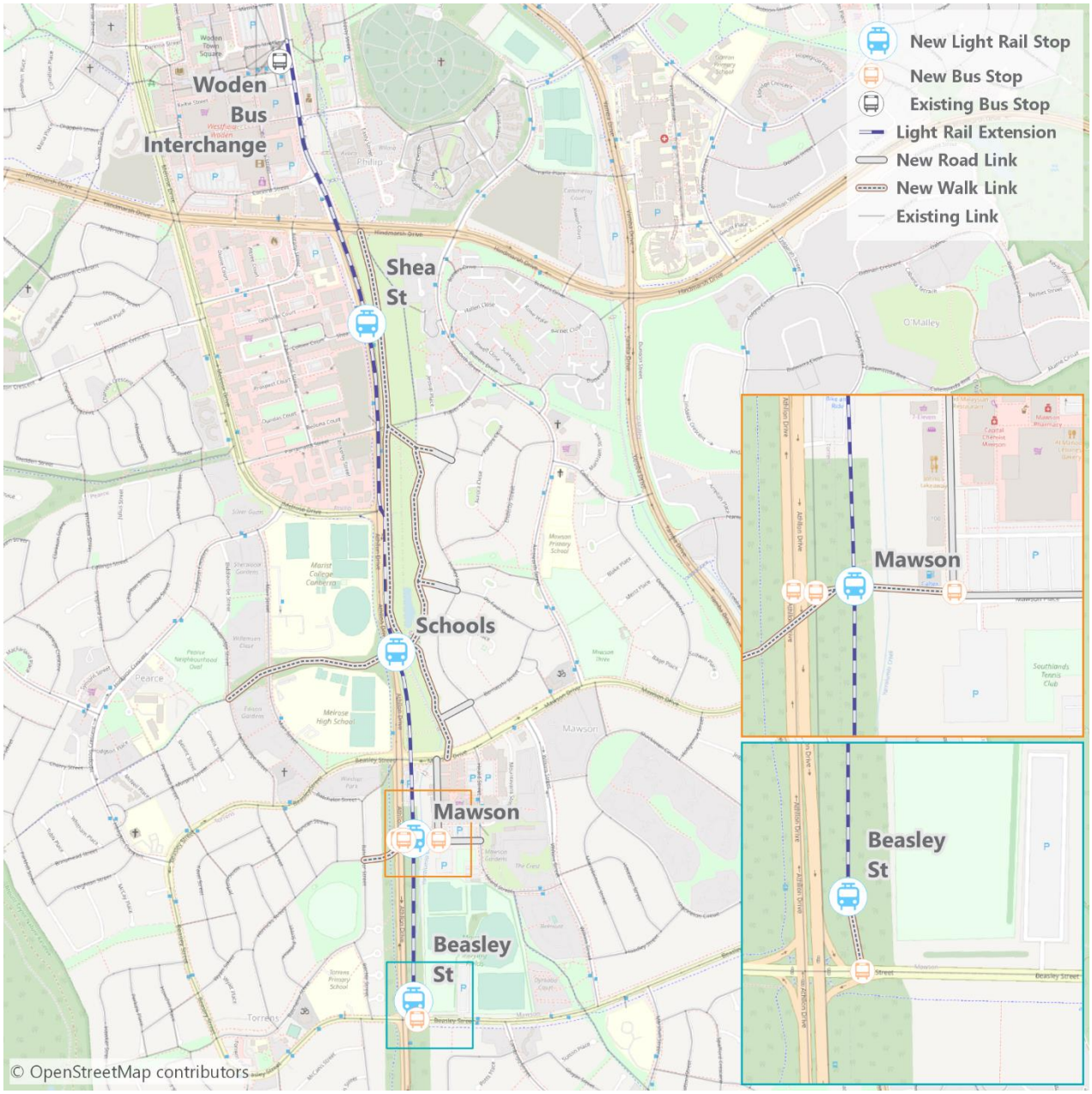
The Mawson light rail extension could significantly alter park and ride usage in southern Canberra, with the southern terminus of light rail likely to become a highly attractive destination for park and ride trips. As such we have anticipated the potential implications of the extension on park and ride facilities.

To provide insight into likely future demand, we have undertaken strategic transport modelling using the Zenith model of Canberra. In this report we detail the light rail patronage forecast by the model as well as the catchment of the Mawson extension.

In the modelling we have tested two Mawson extension scenarios.

1. The Mawson scenario - Extension from Woden to Mawson Town Centre, with stations at Shea Street, Schools, and Mawson Town Centre.
2. The Beasley scenario - Extension from Woden, stopping at Shea St, Schools, Mawson Town Centre, and Beasley Street.

In this exercise we have compared these extension scenarios to the State Circle alignment (run 249) from the modelling undertaken in June 2019. We refer to this as the State scenario.



2.0 MyWay Data Analysis

Canberra's public transport system has undergone significant reform in recent years. In April 2019, a new public transport network (Network 19) was implemented alongside ACT Light Rail Stage 1. In mid-2020 an update was made to Network 19 (Network 19 Update). To understand customer travel behaviour as each of these changes have been made, we have analysed ticketing data from:

- Before the implementation of Network 19, by analysing data from November 2018
- After the implementation of Network 19, by analysing data from November 2019, December 2019 and February 2020
- After the implementation of Network 19 Update, by analysing data from November 2020.

Our analysis focuses on the areas around Woden, Mawson, Wanniassa and Tuggeranong.

2.1 Mawson journeys

The Mawson light rail extension would be likely to capture public transport trips which currently use the bus stops between Hindmarsh Drive and Beasley Street on Athllon Drive (see inset in Figure 2-1). To understand usage patterns, we have extracted the MyWay journey data from December 2019 and February 2020. This was after the implementation of Network 19.

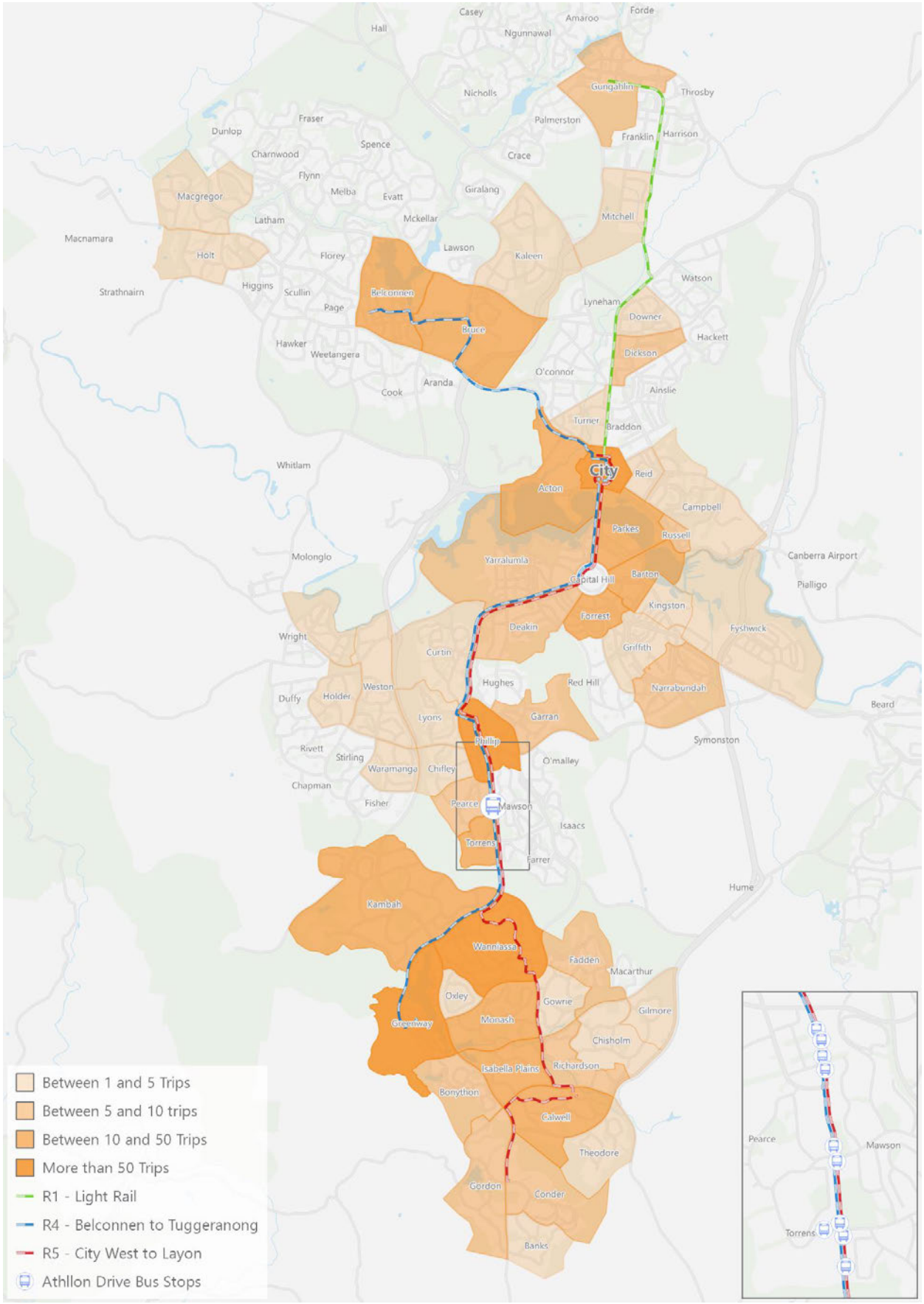
The MyWay data indicates that most customers travelled to or from suburbs north of these stops, particularly to the City or to Phillip (where the Woden Interchange is located). Almost one third of journeys beginning or ending on Athllon Drive had the CBD as their origin or destination (Table 2-1). Local journeys to or from Phillip made up the next most popular orgin/destination with about 90 journeys on an average weekday (a 10% share).

The MyWay data also indicates, travel to/from suburbs to the south such as Greenway and Wanniassa. This is likely to be driven by travel to schools along Athllon Drive and the Southlands Centre.

Table 2-1: Average weekday journeys to/from suburbs that begin/end their trip along Athllon Drive for the weeks beginning 2 December 2019 and 3 February 2020

Suburb (descending)	Journeys	Share	Suburb (continued)	Journeys	Share
City	**268**	**31%**	Deakin	9	1%
Phillip	**90**	**10%**	Pearce	9	1%
Greenway	**69**	**8%**	Conder	8	1%
Wanniassa	**54**	**6%**	Bonython	8	1%
Barton	33	4%	Fadden	8	1%
Belconnen	26	3%	Russell	7	1%
Bruce	20	2%	Gungahlin	7	1%
Torrens	19	2%	Richardson	6	1%
Calwell	19	2%	Dickson	6	1%
Parkes	16	2%	Narrabundah	6	1%
Forrest	16	2%	Gordon	6	1%
Kambah	14	2%	Garran	6	1%
Acton	14	2%	Chisholm	5	1%
Isabella Plains	12	1%	Gowrie	5	1%
Monash	11	1%	Other suburbs	<5	<1%
Yarralumla	10	1%			

Figure 2-1: Average weekday journeys to/from suburbs that begin/end their trip along Athllon Drive for the weeks beginning 2 December 2019 and 3 February 2020



2.2 Wanniassa journeys

The proposed Mawson light rail extension has the potential to impact customers who use stops in Wanniassa. To examine how this might impact these customers we have analysed MyWay data for journeys which start or end at stops in Wanniassa (see inset in Figure 2-2). The MyWay data is from December 2019 and February 2020 – after the implementation of Network 19.

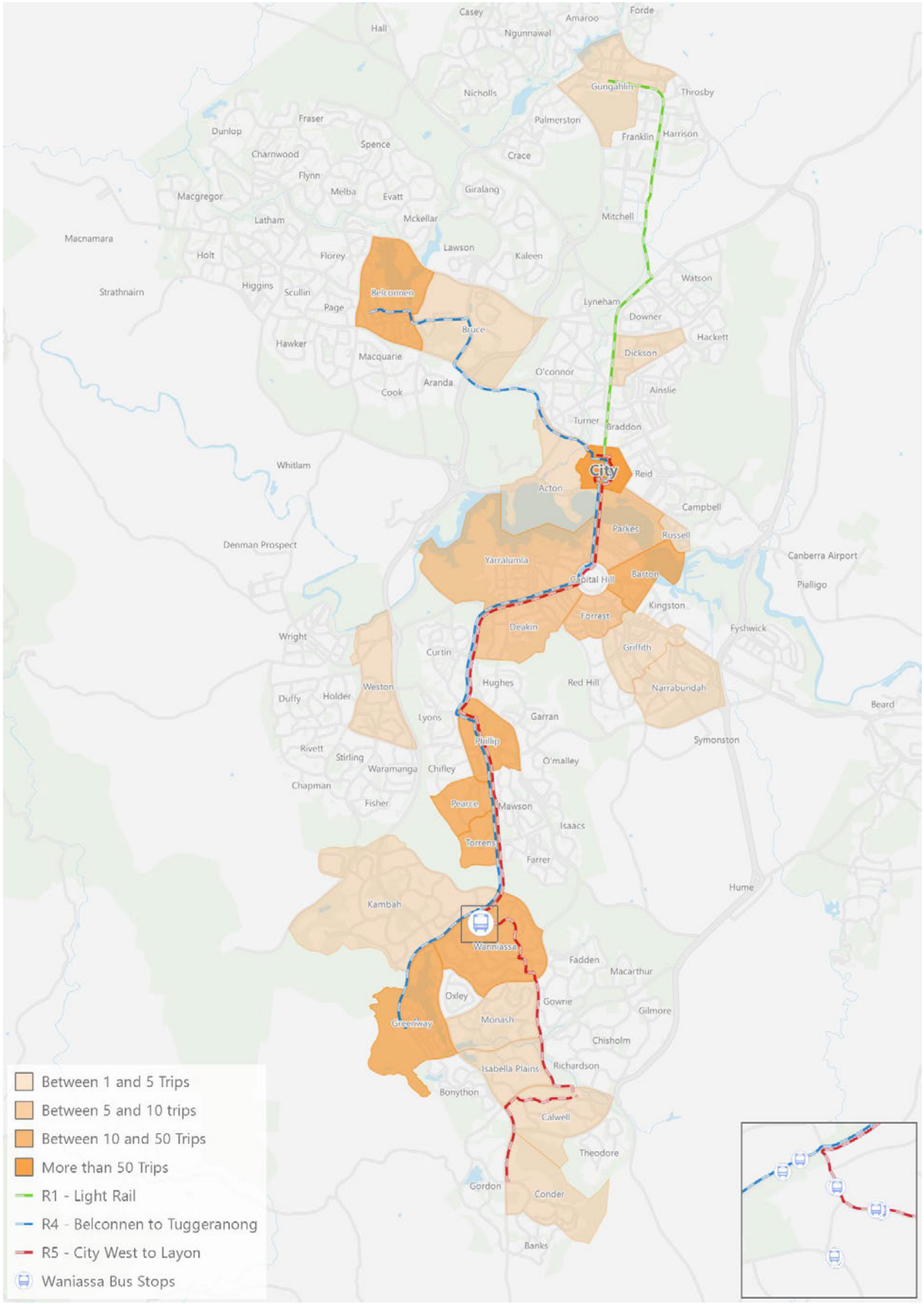
The MyWay data indicates a substantial amount of travel between Wanniassa and the City (about 38% of all journeys). The next most popular origin/destination was Phillip, with around 50 journeys between Phillip and Wanniassa on an average weekday. If buses were terminated at Mawson to meet the extended light rail, these customers would need to make an additional transfer to reach the Woden Town Centre. With light rail extension to either Woden or Mawson, city-bound passengers boarding in Wanniassa would need to connect from bus to light rail to reach the City.

The analysis also highlights travel to and from suburbs located reasonably close to Wanniassa such as Pearce and Torrens to the north and Greenway to the south (Figure 2-2).

Table 2-2: Average weekday journeys to/from suburbs that begin/end their trip in Wanniassa for the weeks beginning 2 December 2019 and 3 February 2020

Suburb (descending)	Journeys	Share	Suburb (continued)	Journeys	Share
City	149	38%	Kambah	5	1%
Phillip	47	12%	Calwell	4	1%
Greenway	31	8%	Griffith	4	1%
Barton	16	4%	Russell	4	1%
Wanniassa	14	4%	Narrabundah	4	1%
Pearce	14	4%	Weston	3	1%
Torrens	11	3%	Monash	3	1%
Belconnen	11	3%	Gungahlin	2	1%
Forrest	7	2%	Conder	2	1%
Parkes	7	2%	Turner	2	1%
Yarralumla	6	2%	Dickson	2	1%
Deakin	6	2%	Isabella Plains	2	1%
Bruce	5	1%	Other suburbs	<2	<1%
Acton	5	1%			

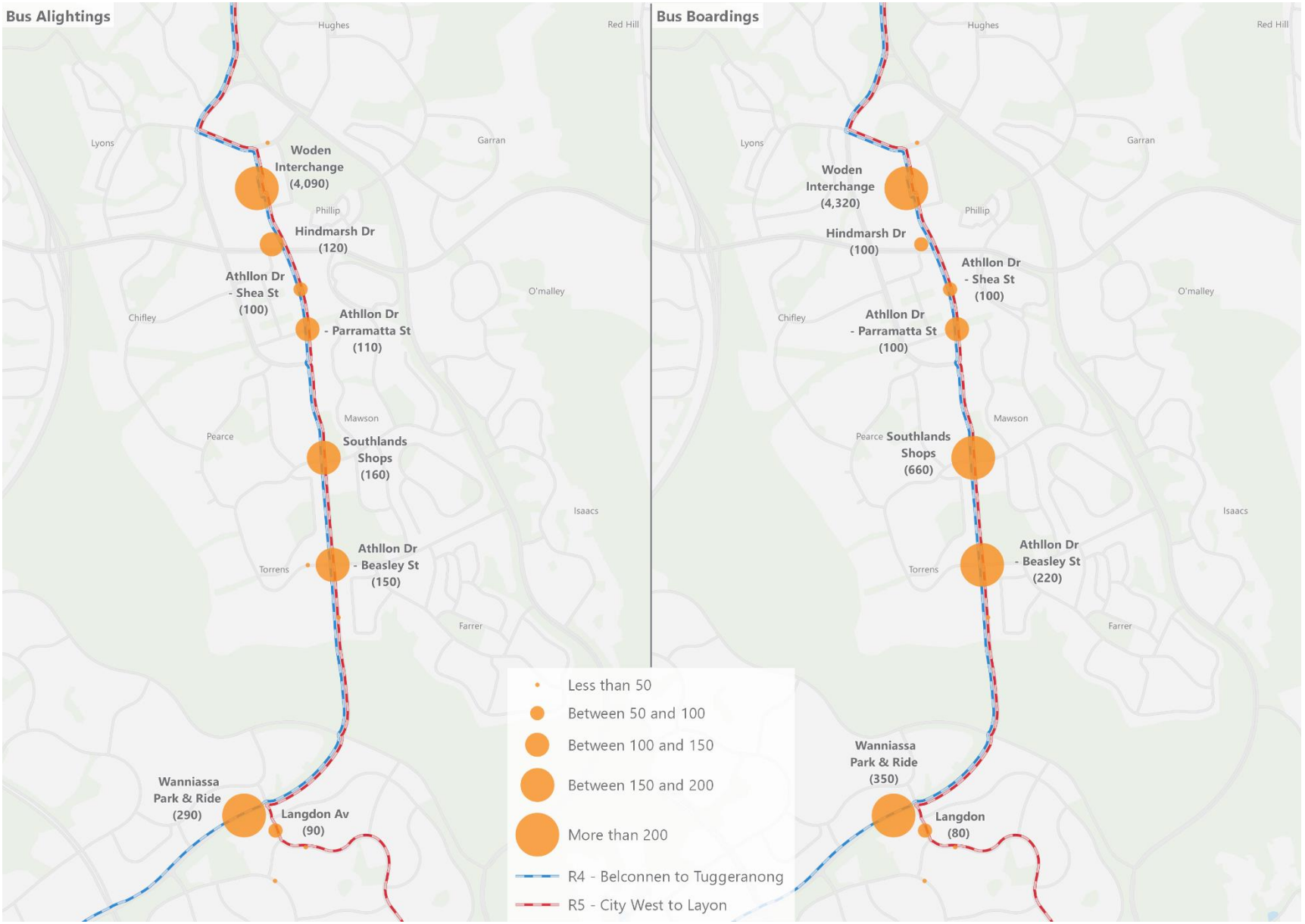
Figure 2-2: Average weekday journeys to/from suburbs that begin/end their trip in Wanniassa for the weeks beginning 2 December 2019 and 3 February 2020



2.3 Wanniassa to Mawson stop utilisation

To understand stop utilisation between Woden and Wanniassa, we have extracted MyWay ticket data for boardings and alightings at stops along Athllon Drive from December 2019 and February 2020 (Figure 2-3). The data indicates that on an average weekday over 4,000 boardings and alightings took place at Woden Interchange, in part this is likely to reflect customers transferring from local services onto Rapid routes. The other stops in the corridor were much less heavily used, of these stops, the largest number of boardings and alightings was observed to occur at the Wanniassa Park and Ride and Southland Shops / Mawson Park and Ride.

Figure 2-3: Average weekday alightings and boardings at stops along the R4 and R5 Bus routes for the weeks beginning 2 December 2019 and 3 February 2020



2.4 Boardings and Alightings at Canberra Hospital on Tuggeranong routes

In July 2020 the Network 19 Update was implemented. One of the changes made as a part of this process was to extend routes 72, 76 and 77 to Woden Interchange via Yamba Drive. This provides customers in Tuggeranong with a transfer free connection to Canberra Hospital.

To understand how many people are using the 72, 76 or 77 to access the hospital from the Tuggeranong Valley we have extracted the number of boardings and alightings being made at the Canberra Hospital stops on Yamba Drive. The MyWay data is from November 2020 which means that the COVID-19 pandemic will likely have had an impact on patronage.

The data suggests that on an average weekday, less than 20 customers boarded southbound 72, 76 or 77 services at stop number 2382 (Table 2-3). In the northbound direction (travelling to the hospital) less than 20 customers alighted at the Yamba Drive stop opposite the hospital (stop number 2095) on an average weekday (Table 2-4). While patronage in November 2020 was likely reduced by the COVID-19 pandemic, this data still indicates that use of routes 72, 76 and 77 to access the hospital direct from the Tuggeranong Valley is relatively low.

Nevertheless, total patronage on routes 72, 76 and 77 was also relatively low, and Table 2-3 and Table 2-4 indicate that boardings and alightings at the hospital accounted for approximately five per cent of total patronage. The data also suggests that the hospital stop is one of the busier stops on these routes, but with lower patronage than the major terminals such as Tuggeranong Bus Interchange, Erindale Bus Interchange and Woden Bus Interchange.

The use of routes 72, 76 and 77 to access Canberra Hospital should be viewed in the context of the hospital's expansion and equity considerations. The hospital is currently being expanded, which is likely to increase demand for travel to it. Canberra Hospital is also likely to be an important destination for disadvantaged groups, who may not have access to other forms of transport.

Table 2-3: Average weekday boardings at Canberra Hospital onto routes 72, 76 and 77, November 2020

Route	Boardings at stop number: 2382 Canberra Hospital Yamba Dr	Total southbound boardings	proportion
72	6	104	6%
76	6	172	3%
77	4	90	5%

Table 2-4: Average weekday alightings at Canberra Hospital from routes 72, 76 and 77, November 2020

Route	Alightings at stop number: 2095 Yamba Dr opp Canberra Hospital	Total northbound alightings	proportion
72	5	85	5%
76	9	164	5%
77	4	82	5%

2.5 Journeys from Tuggeranong

Athllon Drive is a key corridor for buses travelling to and from the Tuggeranong Valley and is used by the R4 and R5 (the two busiest routes in Tuggeranong). As such we have evaluated how changes to bus operations along Athllon Drive might impact Tuggeranong customers. In particular, we wanted to understand the potential impact of an additional transfer on patronage by looking at historical customer behaviour. Using MyWay ticket data, we have extracted the journeys originating in the Tuggeranong Valley (the orange suburbs in Figure 2-4) which finish in the blue area.

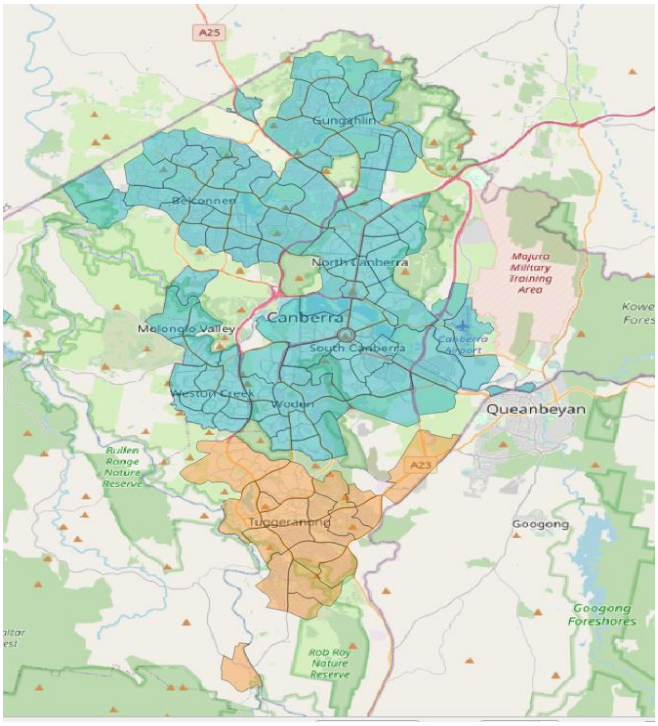
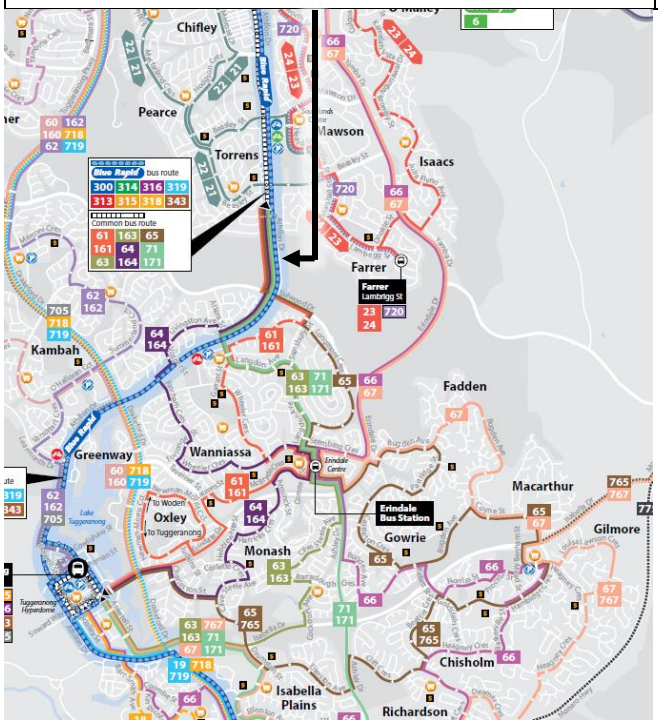


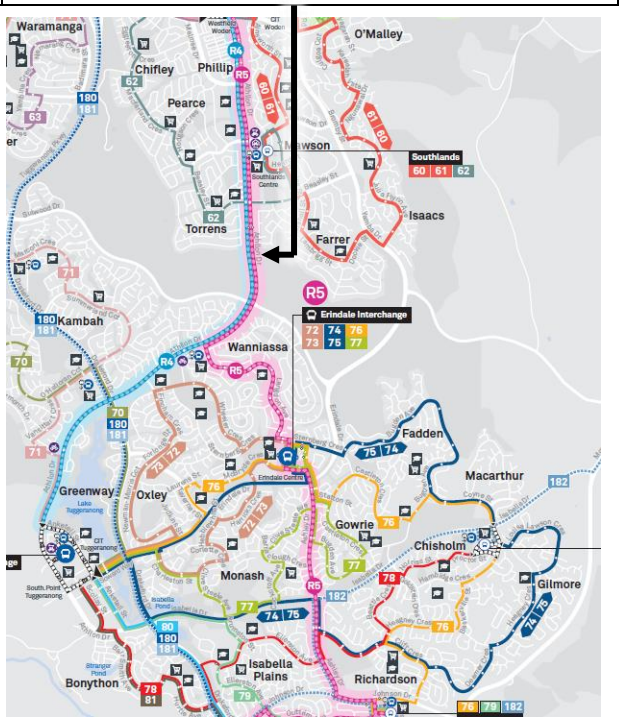
Figure 2-4: Origin suburbs (orange) and destination suburbs (blue) for Tuggeranong analysis

We have restricted our analysis to November 2018 and November 2019 – before and after the implementation of the new 'Network 19' in April 2019. For some customers in Tuggeranong, Network 19 introduced an additional transfer to reach destinations like the Woden and the City (Figure 2-5).

Figure 2-5: Old network (left) v Network 19 (right)

2018 network – many routes use Athllon Drive and provide direct access to Woden and the City.	Network 19 – only the R4 and R5 use Athllon Drive and provide direct access to Woden and the City.





In both 2018 and 2019 the data indicates that the three most popular destinations for customers beginning their journeys in Tuggeranong were: the City, Phillip and Pearce (Table 2-5). While total patronage northbound from

the Tuggeranong Valley declined slightly with the introduction of the new network (a four per cent decline). Patronage to the City was resilient, increasing slightly. Nevertheless, the number of journeys to Pearce and Phillip declined by 20 per cent and 14 per cent respectively. This might be related the additional transfer that some users were required to make after the introduction of Network 19.

Table 2-5: Destination suburbs for journeys from the Tuggeranong area (average weekday in November)

	Pearce	Phillip	City	Other suburbs	Total
Old network (2018)	366	634	731	1,245	2,977
New Network (2019)	295	543	764	1,242	2,844
Change	-20%	-14%	+4%	0%	-4%

One explanation for the seemingly mixed response to the network change is the differing proportion of total journey time that a transfer accounts for. Transfer time will be a smaller proportion of total journey time for City bound customers than for those travelling the shorter distance to Woden. In addition, it is possible that a high proportion of customers travelling to the City are commuting to work, while Woden might attract a higher share of discretionary journeys (such as shopping). Customers might be more willing to accept a transfer to get to work in the City than they are to go shopping in Woden.

2.6 Recent changes to the R5

In July 2020 the R5 had its alignment shortened as a part of the Network 19 Update. While the November 2019 alignment saw the R5 diverge from the R4 at Capital Hill to serve Barton and Russell (see Figure 2-6), the Network 19 Update removed this diversion and today the R5 follows the R4 direct to the City via Commonwealth Avenue. This change has decreased the R5's travel time to the City. Customers in Tuggeranong now benefit from a more direct journey to the City on the R5, which has the potential to increase patronge even in the wake of Covid-19.

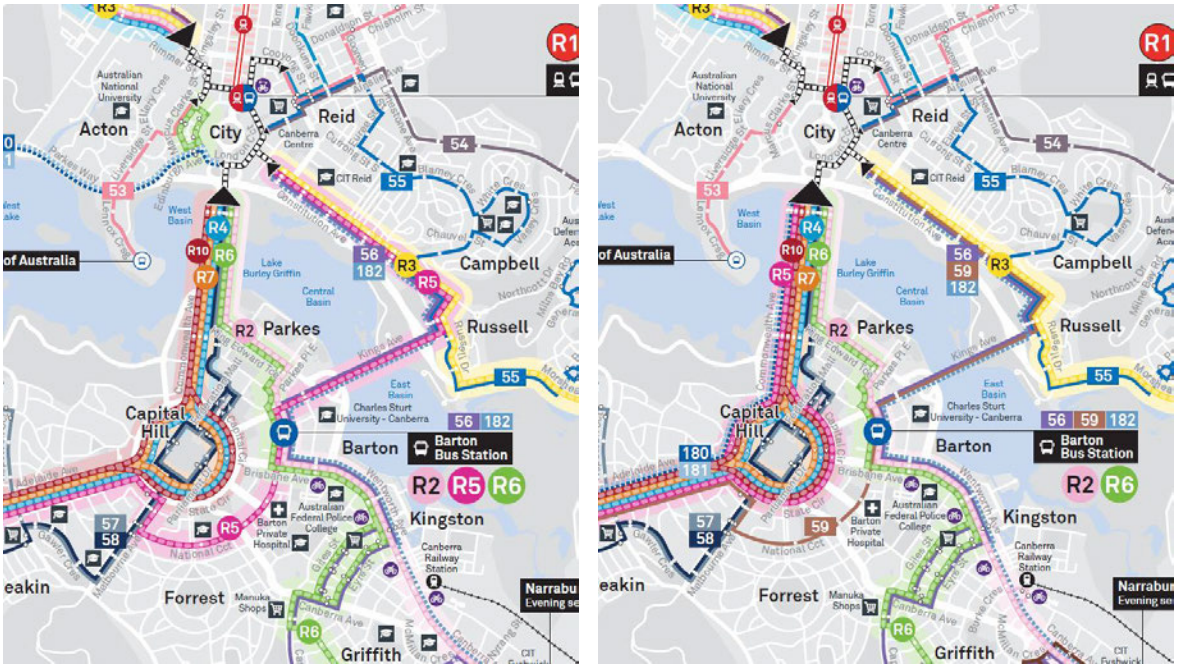


Figure 2-6: Network 19 (left) v the Network 19 Update (right)

2.7 Conclusions

- Our analysis of MyWay ticketing data from late 2019 / early 2020 confirms that Woden and the City are the major destinations for bus trips from Athllon Drive and the Tuggeranong area.
- Canberra Hospital is another key destination; however, patronage data from late 2020 indicates limited use of routes 72, 76 and 77 for travel directly between the hospital and the Tuggeranong Valley.
- Comparing data from before and after the implementation of Network 19 (November 2018 vs. November 2019) suggests that the introduction of a transfer has had a mixed impact on patronage. Journeys from Tuggeranong to the City increased slightly between 2018 and 2019, despite the introduction of an additional transfer for some passengers. In contrast, the number of journeys to Woden from Tuggeranong decreased after an additional transfer was introduced.

3.0 Smart Phone Data Analysis

Location based services (LBS) data is gathered from smart phone applications (apps) that use sensors within the phone including Global Positioning System (GPS) to estimate the location of the smart phone. App publishers enter into commercial agreements with data aggregators who combine data from multiple publishers and license the combined dataset under strict conditions to organisations which analyse the data.

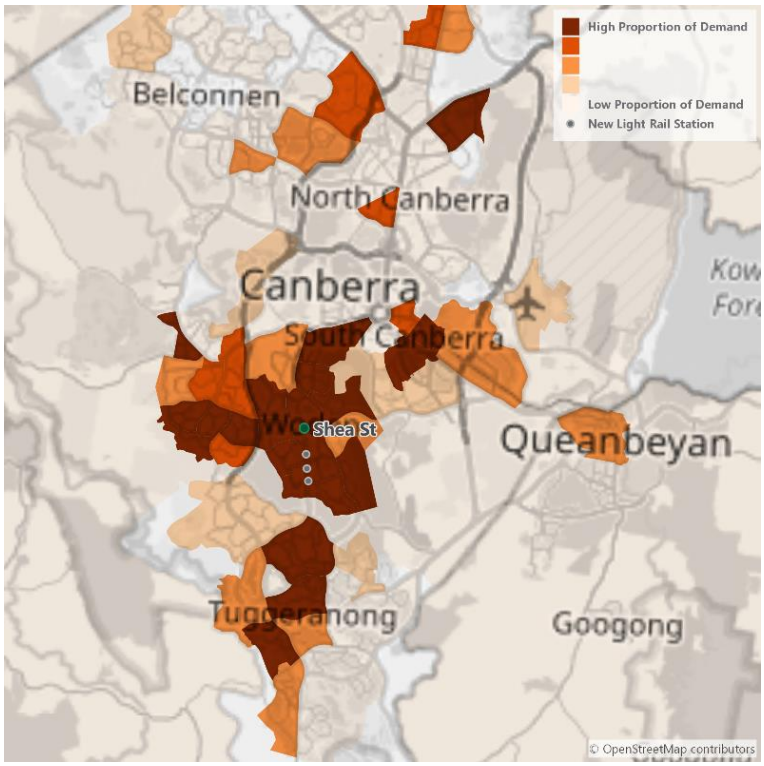
VLC has licensed this data and processed the raw location trace level containing billions of data points into useful project deliverables. All LBS data is de-personalised, meaning there is no data component that can directly identify an individual (such as name, phone number or address). Further, outputs provided for use in the project are anonymised through aggregation which ensures the integrity of project data.

The LBS data used comes from 2019 – after the changes to the Canberra bus network, and before the impacts of Covid-19. It is not mode specific and captures the location data of contributors regardless of whether public transport or a private vehicle was used in the journey. Using a one-kilometre catchment around each of the proposed station locations (Shea Street, Schools, Mawson Town Centre and Beasley Street), we have filtered the data to those who have either started or completed their journey within this catchment during the AM peak of 6am to 9am (note the three-hour peak period as opposed to the two-hour peaks used in the modelling). The analysis of LBS data has been focused towards understanding the movements of potential Mawson light rail extension users, including whether forcing a connection between bus and light rail at Mawson would inconvenience people.

3.1 Shea Street

The LBS analysis indicates a large proportion of trips to the Shea Street stop area were made from the Woden Valley, while there was also a sizable proportion travelling from the Tuggeranong Valley (Figure 3-1). Public transport trips to Shea Street from Tuggeranong are currently served by the R4, R5 and 73 bus routes. The truncation of these routes at Mawson with light rail extension would sever the direct bus service between the Tuggeranong Valley and Shea Street, with customers required to transfer at Mawson. This will likely inconvenience a substantial portion of the Shea Street's potential customer catchment.

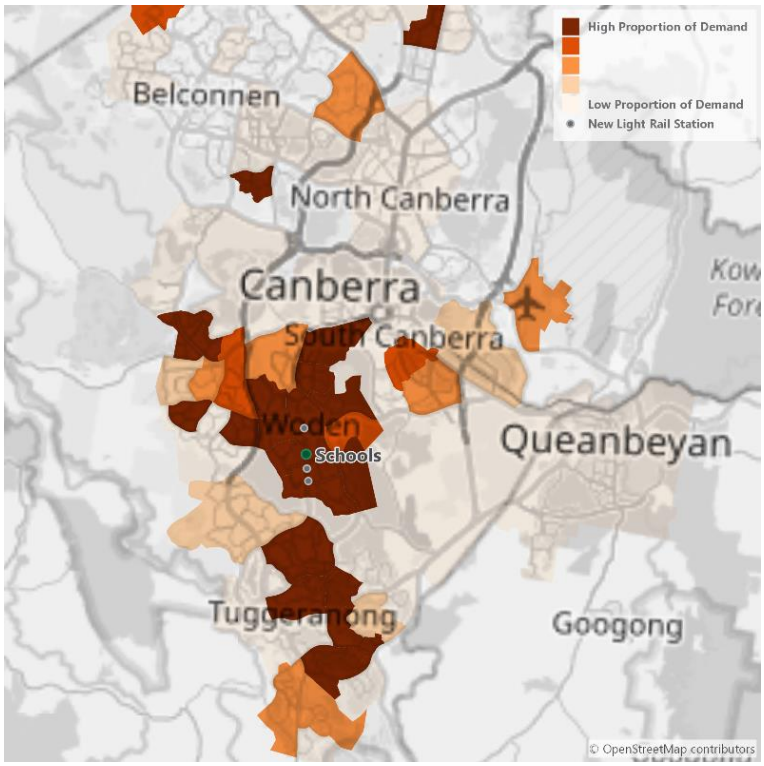
Figure 3-1: Origin of trips that are destined for Shea Street during the AM peak



3.2 Schools

According to the LBS data, most trips destined for the Schools catchment area originated from within local suburbs (Figure 3-2). The data also indicates some longer trips from Coombs in the west, and Wanniassa, Monash, and Callwell in the Tuggeranong Valley. The Schools catchment area includes two large schools (Melrose High School and Marist College), which mean a substantial proportion of trips to the catchment area during the AM peak would be school children, who would be largely reliant on an effective public transportation service . Trips to the Schools catchment area that begin in Tuggeranong are currently served by the R4, R5 and 73 bus routes. The truncation of these routes would require customers (including presumably a large number of students) to either walk the last 500 metres of their journey or change to the light rail service at Mawson Town Centre.

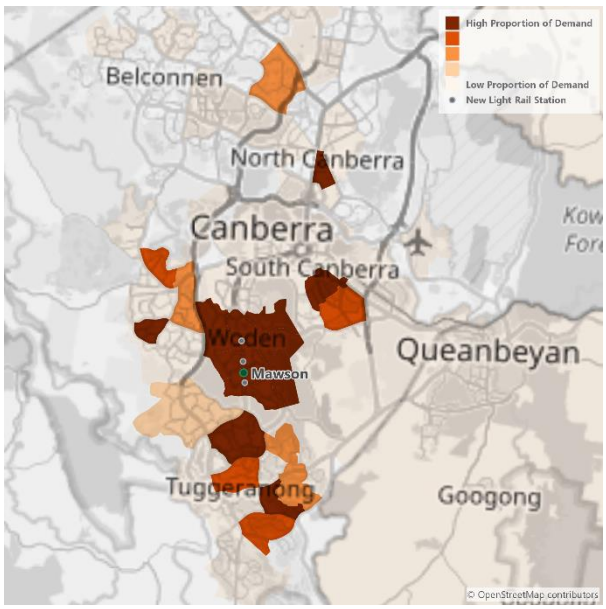
Figure 3-2: Origin of trips that are Destined for Schools during the AM peak

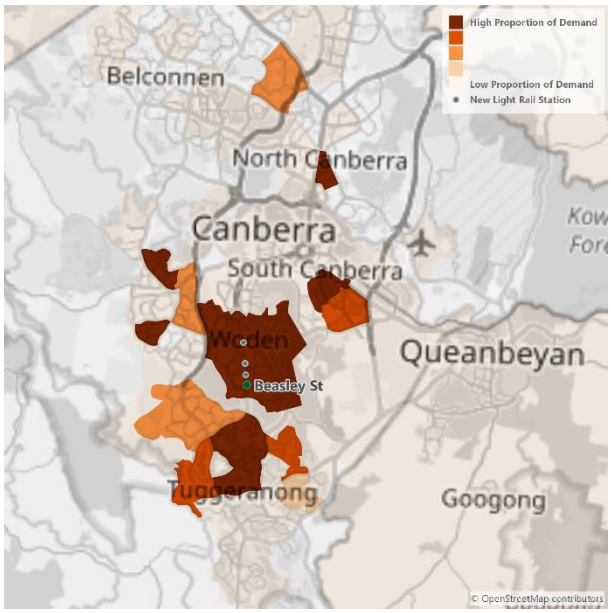


3.3 Mawson Town Centre and Beasley Street

The sites for the Mawson Town Centre and Beasley Street stations both drew similar origin profiles (Figure 3-3), largely attracting local trips from the surrounding suburbs, as well as a sizable proportion of trips from Wanniassa and Kambah in the Tuggeranong Valley. These trips would be largely unaffected by any truncation in the R4, R5 and 73 bus routes, as users currently making these trips will still be able to do so should these routes be shortened to Mawson.

Figure 3-3: Origin of trips that are Destined for Mawson (left) and Beasley Street (right) during the AM peak

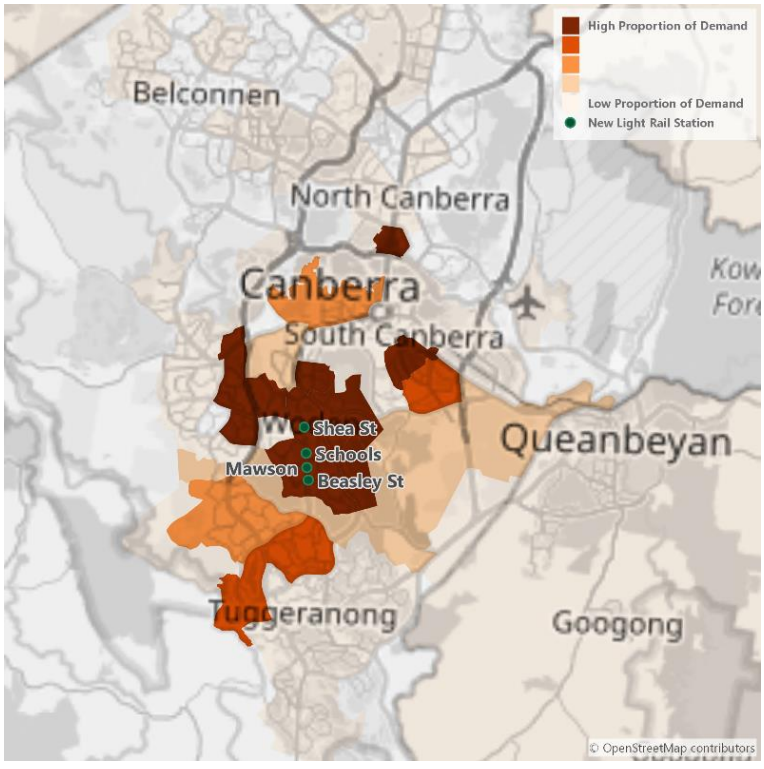




3.4 Journey destinations

The LBS data indicates that high proportion of local travel from each of proposed light rail stations, with journeys destined for the surrounding suburbs in the Woden Valley (Figure 3-4). There was also demand for travel to destinations along the light rail corridor towards Capital Hill, with high proportion of journeys to the City. The data suggests that there was a substantial amount of travel to Narrabundah (in the east) and Kambah, Greenway, and Wanniassa within the Tuggeranong Valley.

Figure 3-4: Destination of trips that Originate from one of the slated Light Rail stations during the AM peak



3.5 Conclusions

Our LBS analysis of current travel demand around the four planned stations provides some insight as to how residents, workers and other customers travelling to/from the station catchment areas move in the AM peak. While it is not clear what mode is used, movements between the Tuggeranong Valley and Shea Street have the potential to be served by the existing R4, R5 and 73 bus routes, and would be negatively impacted by the severing of routes at the Mawson Town Centre. This could limit overall patronage on the public transport network. Therefore, it is suggested that with light rail extension to Mawson, these routes continue to serve the corridor and terminate at Woden Town Centre.

The LBS trip destination analysis for the proposed stations (Figure 3-4) indicate strong demand for destinations along the light rail corridor and particularly for journeys to the city. These journeys would be well served by the Mawson light rail extension.

4.0 Bus Network Integration

This section considers the potential bus network changes that could be implemented with the extension of the light rail from Woden to Mawson.

The key considerations for integrating the bus network with the light rail extension are:

- Which (if any) routes will be truncated in Mawson and
- How buses will connect with the extended light rail.

The new station locations proposed as a part of the extension of light rail to Mawson are currently proposed to be at Shea Street, Schools, Mawson Town Centre and at the southern intersection of Beasley Street and Athllon Drive.

4.1 Bus route alignment changes

This section considers the options for realigning bus routes with the Mawson light rail extension. The main consideration is which routes (if any) will terminate at Mawson instead of continuing onto the Woden Interchange. The main reasons for considering truncating routes at Woden are the cost savings that could be achieved through decreasing service kilometres as well as reducing the number of buses that the Woden Interchange will have to accommodate. Previous work has indicated that Woden Interchange could approach capacity as service frequency is increased.

In this study we have considered options for realigning the bus routes impacted by the extension of light rail to Mawson (specifically the R4, R5, 60, 61, 62, 72, 73, 76 and 77). One option would be for all routes coming from the south (the R4, R5, 72, 73, 76 and 77) to terminate at the new Mawson interchange (Option A). To avoid an additional transfer for R4 and R5 customers travelling to Woden, another option (Option B) would be for the R4 and R5 to continue running to Woden, duplicating a small section of the light rail corridor. The third option would be to continue running all services from the south to Woden (Option C),

Bus priority infrastructure is planned for Athllon Drive; however, it is currently unclear if the 72, 76 and the 77 (which currently use Yamba Drive) will be re-aligned north of Wanniassa to take advantage of this infrastructure. As such we have developed two sub-options for each of the main options. In the first set of sub-options (Option A1, B1 and C1) the 72, 76 and 77 will be re-aligned to use Athllon Drive instead of Yamba Drive. In the second set of sub-options (Option A2, B2 and C2) the 72, 76 and 77 remain on Yamba Drive as they do today.

There are advantages of the 72, 76 and 77 using Athllon Drive:

- The 72, 76 and 77 will be able to use bus priority infrastructure on Athllon Drive.
- The upgraded Woden Interchange has been designed for Tuggeranong Valley buses to approach from the south, via Athllon Drive.
- Moving the 72, 76 and 77 from Yamba Drive to Athllon Drive will reduce the length of these routes, decreasing service kilometres.

The disadvantage of realigning these routes to Athllon Drive is that it will remove the direct connection between the Tuggeranong Valley and Canberra Hospital. The situation would be slightly better with Option C1, because the retention of the Woden terminus for routes 72, 76 and 77 will mean only one transfer (rather than two) will be required to reach Canberra Hospital for customers in the catchment of the 72, 76 and 77.

OPTIONS

The options considered in this exercise are:

- Option A1 and A2: All routes (R4, R5, 73, 72, 76 and 77) terminate just north of Mawson (Figure 4-2 and Figure 4-3).
- Option B1 and B2: The R4 and R5 continue running to Woden, but routes 72, 73, 76 and 77 terminate at Mawson (Figure 4-2 and Figure 4-3).

- Option C1 and C2: All routes (R4, R5, 73, 72, 76 and 77) continue running to Woden (Figure 4-2 and Figure 4-3).

In Option C the route 73 could be realigned north of Mawson to provide additional coverage in Pearce, following the alignment of the old 21 and 22 from the 2018 network (see Option C in Figure 4-2).

In this exercise we have also considered the opportunities for having local routes connect with light rail in a similar way to which routes 18, 21 and 22 currently operate in Throsby, Harrison and Mitchell in Canberra's north (Figure 4-1). In these areas, buses connect with light rail at intersections along Flemington Road. However, unlike in the north, most of the stations on the Mawson light rail extension would not be located at major intersections, making integration of perpendicular bus routes more challenging.

Figure 4-1: Current route alignments around the light rail in Flemington Road

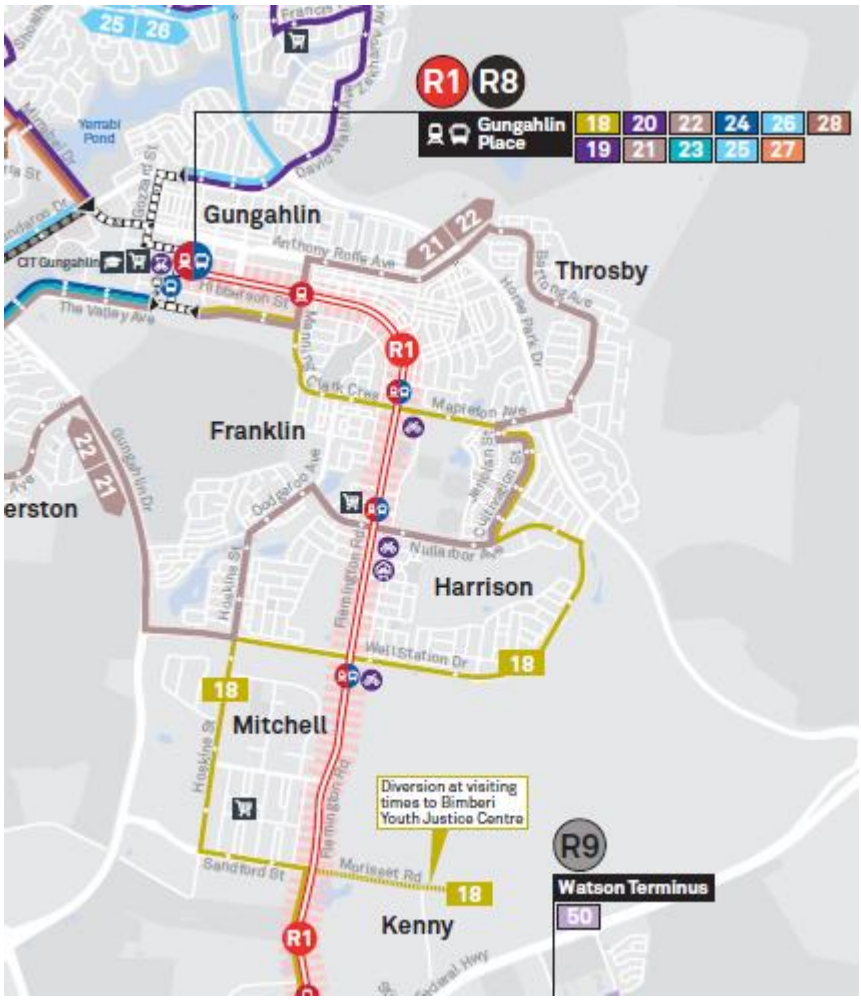


Figure 4-2: Options A1 (left), Option B1 (centre) and Option C1 (right)

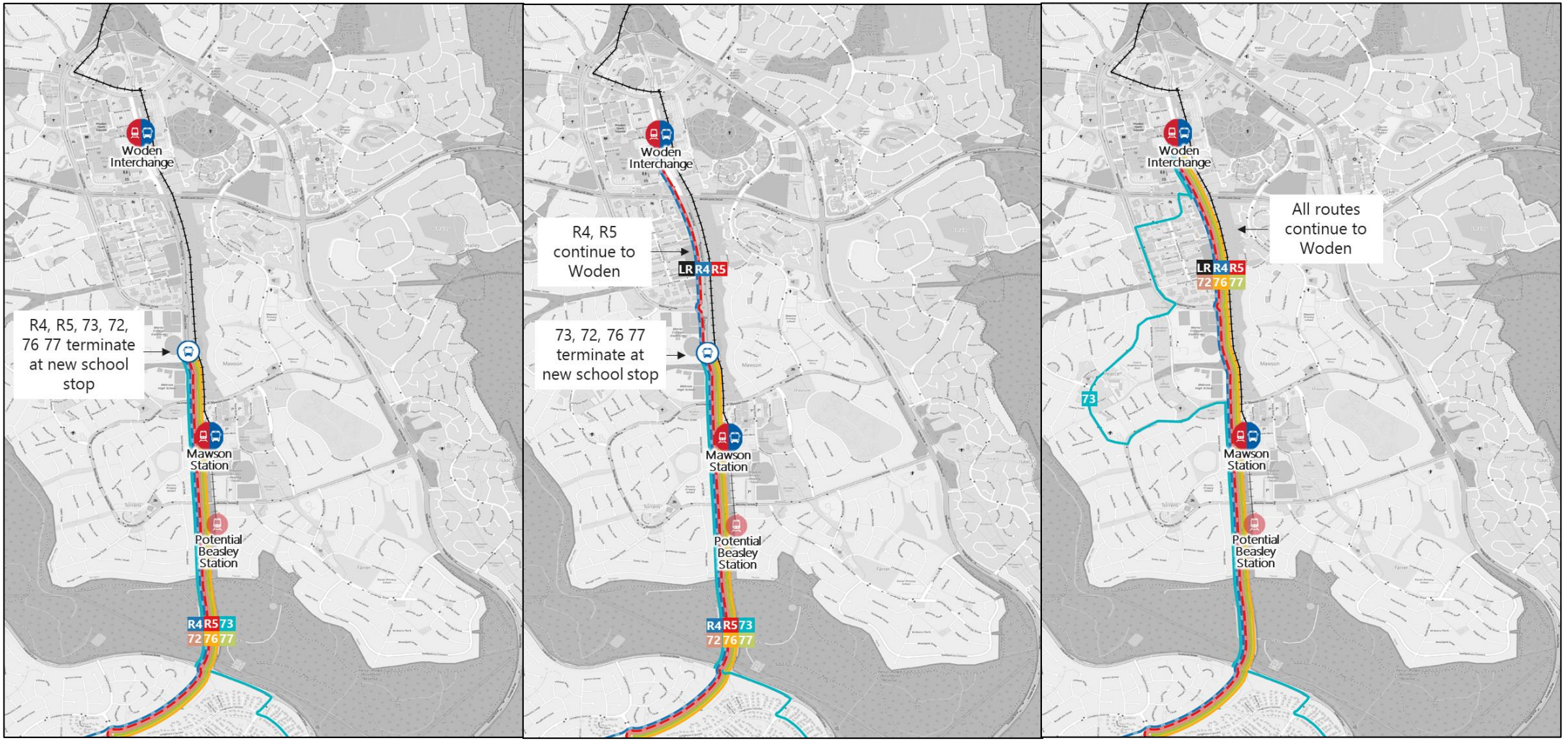
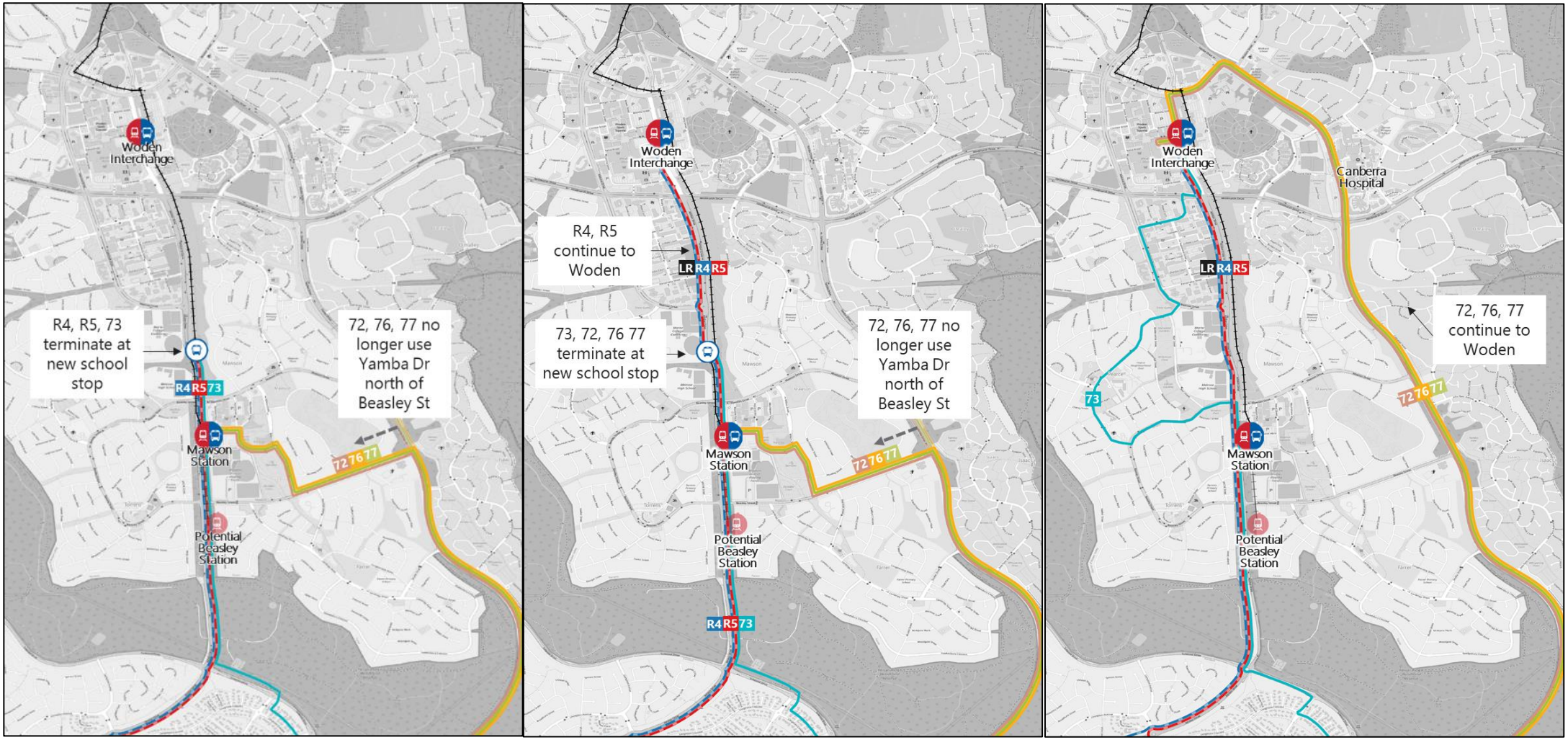


Figure 4-3: Options A2 (left), Option B2 (centre) and Option C2 (right)



We consider the potential advantages and disadvantages of Options A, B and C below.

OPTION A

In Option A, all routes (R4, R5, 73, 72, 76 and 77) would be truncated as close to the end of the light rail as possible. While Mawson Town Centre is the closest stop to the end of the light rail, there is not likely to be enough room for buses to layover or to turn around at the Town Centre. Instead, buses would likely have to layover at the Woden Depot, which would see them dead run past Melrose High School and Marist College. Thus, adding a new stop outside these schools would improve accessibility while not substantially increasing costs. As such, in Option A, we envisage that buses would be truncated at the new schools stop.

Option A would enable a substantial reduction in costs through a reduction in service kilometres, however it would significantly impact customers travelling between Woden and the Tuggeranong Valley by introducing an additional transfer approximately 2 kilometres from their destination. Some Tuggeranong customers would have to make *two* transfers to reach Woden (one from their local bus onto an R4 or R5 and then another onto light rail at Mawson). Historical data (section 2.0) indicates that this has the potential to decrease patronage for Woden-Tuggeranong journeys. A further drawback of option A is that the Mawson Town Centre is a much weaker anchor than Woden. Best practice public transport planning principles would generally call for rapid routes (including the R4 and R5) to terminate at strong anchor points.

Table 4-1: Advantages and disadvantages of Option A

Advantages	Disadvantages
• Reduced service kilometres • Reduced pressure on Woden Interchange	• Introduction of an additional transfer for those travelling to Woden • Weaker anchor for buses from Tuggeranong

OPTION B

Option B retains the direct R4 and R5 connection to Woden, removing the requirement for Woden bound R4 and R5 customers to transfer at Mawson. This could largely mitigate the risk of decreased use of these services.

Another advantage of Option B is that it gives the R4 and R5 a strong anchor at the Woden Interchange. While these routes would physically duplicate light rail on Athllon Drive, they would serve different markets, with the Rapid routes providing access to Woden from the Tuggeranong area, and the light rail providing access to the city from the southern Woden Valley and the park and ride facilities.

While Option B retains the R4 and R5 connection to Woden, the 72, 73, 76 and 77 would be truncated at the Mawson schools stop. This would reduce service kilometres and costs, however this saving would not be as large as in Option A and it would come at the expense of direct access to Woden for 72, 76 and 77 customers who live outside the catchments of the R4 and R5.

Table 4-2: Advantages and disadvantages of Option B

Advantages	Disadvantages
• Some reduction in service kilometres (but not as much as Option A) • Maintains R4 and R5 connection to Woden	• Some Tuggeranong Valley customers would need to make an additional transfer to reach Woden

OPTION C

In Option C the 72, 73, 76 and 77 would all continue running to Woden. For customers living in the catchment of the 72, 73, 76 or 77 but outside that of the R4 and R5, Option C would retain a direct connection to Woden. It would also maintain a strong northern anchor for the 72, 73, 76 and 77.

In addition, Option C enables the 73 to run through Pearce, returning coverage to an area where it was removed in Network 19 (which previous analysis suggested resulted in decreased patronage). This re-alignment would slightly increase the 73's travel time from Wanniassa to Woden. Nevertheless, 73 customers could avoid the Pearce section of the route by transferring to light rail at Mawson.

Of the options considered here, Option C would have the highest cost in terms of service kilometres. However, this cost would only be marginally higher than that of Option A and B and provide much better connectivity for customers. Option C would only add around one or two extra kilometres of running per trip, with buses remaining in service until Woden before laying over at Phillip Oval (just north of Woden Interchange). In this way, Option C would be more efficient than Options A and B, as buses would be able to layover much closer to their terminal stop (in Options A and B buses would have to dead run the substantial distance to Woden Depot).

Table 4-3: Advantages and disadvantages of Option C

Advantages	Disadvantages
• Maintains R4, R5, 73, 72, 76 and 77 connection to Woden • Stronger anchor for R4, R5, 73, 72, 76 and 77 • Re-aligned 73 provides additional coverage in Pearce	• Limited reduction in service kilometres (less than Options A and B)

4.2 Bus-light rail connectivity

The main opportunities for connecting buses with light rail will be at Mawson Town Centre (labelled as Mawson Station in Figure 4-4 and Figure 4-5) and at the southern intersection of Beasley Street (Beasley Station). The new Mawson Station will likely be located between Athllon Drive and the Southlands Shopping Centre. This would see the existing Mawson Town Centre stops on Athllon Drive moved to the south with a new pedestrian underpass built adjacent to Mawson Station (Figure 4-5). New bus stops would also likely be required near Melrose High School and Marist College.

High-quality connections between buses and light rail will maximise the investment in the Mawson light rail extension. At Mawson Town Centre, routes 60, 61 and 62 currently have stops on Heard Street, approximately 250 metres walk from where the Mawson Light Rail Station will be. To provide a high-quality connection between light rail and the 60, 61 and 62, a shorter transfer distance will be required. There are two main options for achieving this:

1. A new off-street facility could be built at the end of Mawson Place with routes 60, 61 and 62 taking a short diversion off Heard Street to access this new stop. This would likely reduce the transfer distance to less than 100 metres.
2. New bus stops could be provided at Beasley Station for routes 60, 61 and 62. This would require the 60 and 61 to be realigned and could only be done if the light rail is extended to the southern intersection of Beasley Street and Athllon Drive.

The off-street facility would require space for buses to layover—likely at least one space per terminating route, plus an additional space or two to accommodate longer breaks. Such a facility could take some pressure off of the Woden Interchange in terms of laying over, with routes 60, 61 and 62 taking layover / recovery time at Mawson rather than Woden.

In the second set of sub-options (the 72, 76 and 77 terminate at Mawson) the Mawson Place off-street facility will need to be expanded to cope with the higher volume of buses (Figure 4-4). This expansion could be avoided if the 72, 76 and 77 were realigned to use Beasley Street and Athllon Drive, allowing customers to connect with light rail at Beasley Street or Mawson before terminating at the new schools stop and laying over at Woden Depot.

Figure 4-5: Bus light rail connectivity at Mawson with first set of sub-options (Option A1 shown)

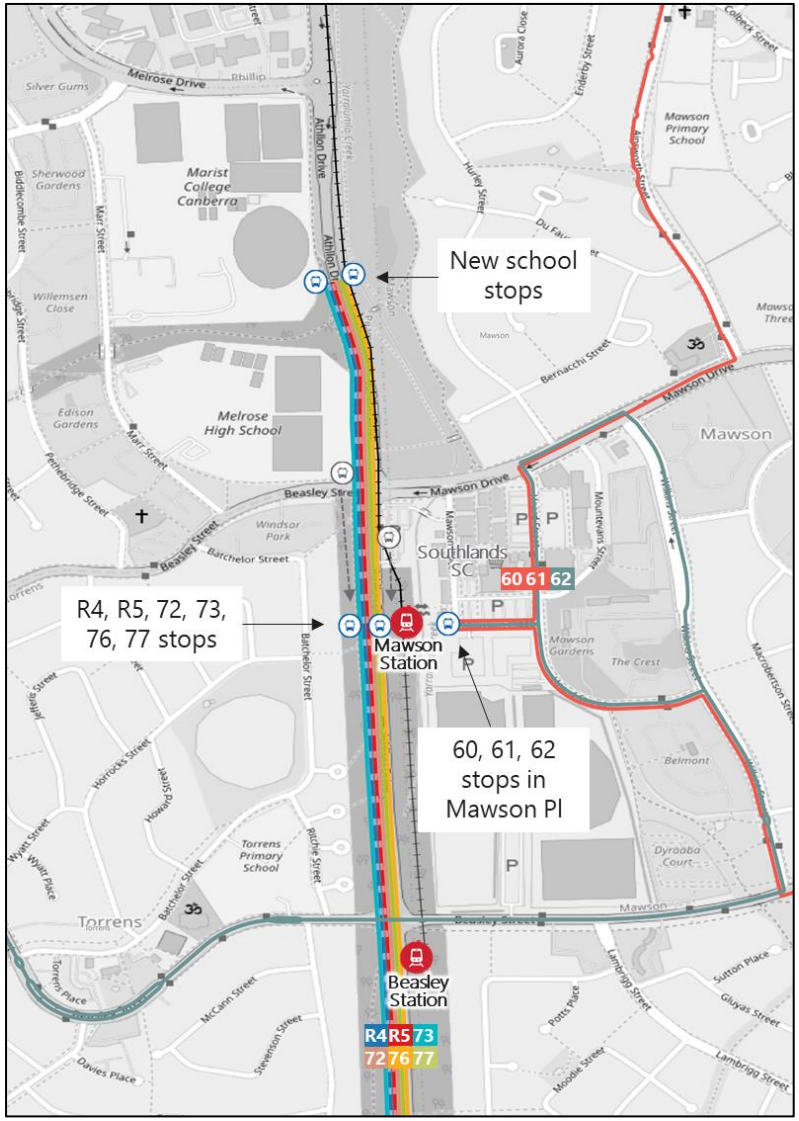
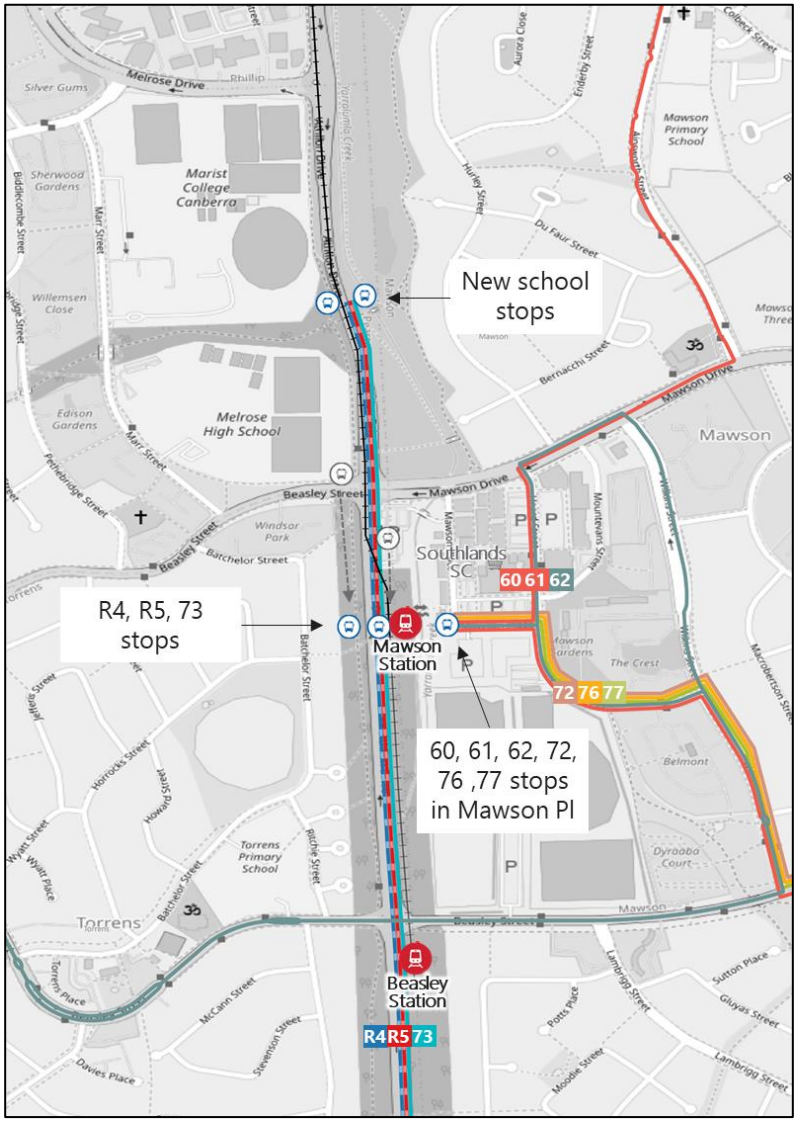


Figure 4-4: Bus light rail connectivity at Mawson with second set of sub-options (Option A2 shown)



4.3 Options Summary

The main considerations for integrating the bus network with the Mawson light rail extension are: connectivity with Woden, network kilometres, the capital costs of a new bus facility at Mawson Place and connectivity with Canberra Hospital.

Option A will have a substantial negative impact on customers, with an additional transfer added for all customers travelling from the Tuggeranong Valley to Woden. This would be partially mitigated in Option B, by maintaining the R4 and R5 connection to Woden. Option C would retain all existing bus connections to Woden.

Option A will have the lowest number of network kilometres, however, because buses would still layover at the Woden Depot it is only marginally fewer kilometres than Options B or C.

The sub-options (A2 and B2) in which the 72, 76 and 77 terminate and layover at Mawson Place will have the highest additional capital costs. Nevertheless, all options are likely to require some additional investment to facilitate high quality connections between light rail and the 60, 61 and 62.

Only Option C2 maintains the existing direct connection between Canberra Hospital and the Tuggeranong Valley, with Option C1 the next best (only requiring one transfer).

Table 4-4: Options summary

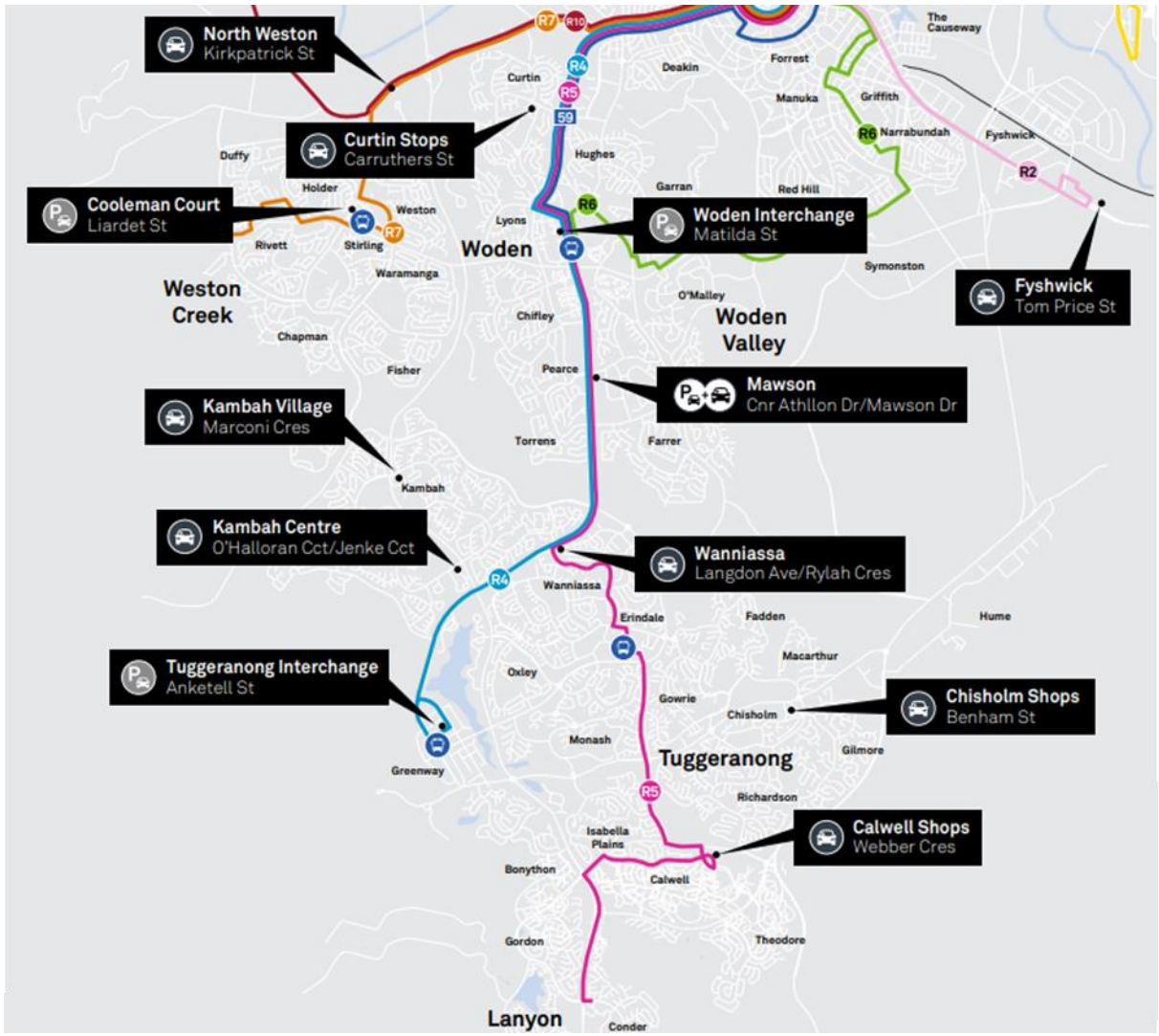
	Option A1	Option A2	Option B1	Option B2	Option C1	Option C2	
Connectivity with Woden	🔴	🔴	🟠	🟠	🟢	🟢	
Network kilometres	🟢	🟢	🟠	🟠	🔴	🔴	
Capital costs	🟠	🔴	🟠	🔴	🟠	🟠	Relative to the other options, Options A2 and B2 will require a larger Mawson Place facility.
Connectivity with Canberra Hospital	🔴	🔴	🔴	🔴	🟠	🟢	Only option C2 will maintain a direct connection between Tuggeranong and Canberra Hospital. C1 means more of Tuggeranong can access hospital through single transfer.

5.0 Park and Ride Considerations

In this section we consider the how the Mawson Light rail extension might impact usage of park and ride facilities in southern Canberra (Figure 5-1). We examine how new park and ride facilities at Mawson Town Centre and Beasley Street could allow for the consolidation of the Woden and Wanniassa Park and Rides.

Wherever the light rail is extended to will likely see an increase in demand for commuter parking, as customers will value having a higher probability of securing a seat on the light rail.

Figure 5-1: Park and Ride locations in southern Canberra



5.1 Woden

The extension of light rail to Woden is planned to support the creation of a high amenity urban centre, with the new CIT Woden Campus integrated with the new Woden bus and light rail interchange. The Woden Town Centre is set to undergo significant development over the coming decades and parking is likely to become more constrained. Extending the light rail to Mawson would further leverage the investment in light rail and the Woden Town Centre by enabling some park and ride capacity to be shifted to Mawson. This would likely make it easier for commuters to secure a parking space and enhance the amenity of the Woden Town Centre.

5.2 Mawson Town Centre

Extending the light rail to Mawson Town Centre will likely see it become a highly attractive park and ride location, potentially replacing the Woden Park and Ride. Mawson will also likely draw demand from the Wanniassa Park and Ride as it could become more attractive for city bound commuters to drive slightly further (approximately 3 kilometres) to Mawson and eliminate a transfer. (By driving to Mawson, city bound commuters will be able to board the light rail directly rather than boarding a bus at Wanniassa and then transferring to light rail).

An advantage of having a park and ride facility at the Mawson Town Centre is that it would enable customers to access the existing shopping centre to perform tasks before, after or during their journeys. Activity at the Mawson Town Centre could also improve safety at the park and ride through passive surveillance.

A disadvantage of the Mawson Town Centre location is the space constraint, which could limit the capacity for expanding the park and ride facility. As such, in this exercise we explore providing an additional park and ride facility at Beasley Street.

5.3 Beasley Street

Extending the light rail to the southern intersection of Beasley Street would present the opportunity for a purpose-built park and ride facility to be built on land which currently has limited usage. This would relieve some of the pressure on the Mawson Town Centre park and ride.

A Beasley Street Light Rail Park and Ride would likely draw a substantial number of commuters – particularly from Tuggeranong and would be likely to replace the Wanniassa Park and Ride.

5.4 Wanniassa and other Park and Ride facilities

As outlined above, the Wanniassa Park and Ride would become less attractive with the extension of light rail to Mawson Town Centre or Beasley Street. Mawson is only a short distance (approximately three kilometres) north of the Wanniassa Park and Ride and it is likely that a significant number of customers would be willing to drive the extra distance to avoid a bus to light rail transfer. As such, it may be possible to consolidate the Wanniassa Park and Ride into the Beasley Street and/or Mawson Town Centre Park and Ride.

New park and ride facilities in Mawson, would also be likely to draw some demand from the Tuggeranong Park and Ride. However, since the Tuggeranong is further away (approximately 7 kilometres) from Mawson, the impact would likely be small.

The impact of an extension to Mawson on demand on other park and ride facilities in Southern Canberra (including Chisholm, Calwell and Kambah) would also likely be fairly limited as they are served by direct bus connections to Woden and a small number of peak express services to the city.

6.0 Modelling

This section details the key model assumptions and contains the results of the model runs.

6.1 Assumptions

SCENARIOS

The modelling scenarios are based on the State Circle alignment and Parliament-East land use from the latest set of modelling runs in June 2019 (run 249 referred to as the State scenario). Two scenarios were run as per Table 6-1.

Mawson scenario - Extension from Woden, stopping at Shea Street, Schools, and Mawson Town Centre.

Beasley scenario - Extension from Woden, stopping at Shea Street, Schools, Mawson Town Centre, and Beasley Street Park and Ride.

Table 6-1: Light rail scenarios

Scenario	Run ID	Shea St	Schools	Mawson Park and Ride	Beasley St Park and Ride
Mawson	274	✓	✓	✓	×
Beasley	275	✓	✓	✓	✓

LIGHT RAIL ALIGNMENT

The modelled alignment can be seen in Figure 6-1. Additional walk connectivity has been added to integrate with the new light rail stations.

Figure 6-1: Mawson right rail extension alignment as coded in the model

LIGHT RAIL TRAVEL TIMES

The assumed travel times between the additional stops are listed in Table 6-2. An assumed dwell time of 0.5 minutes at light rail stations is included in the travel time.

Light rail speeds replicate similar sections from Stages 1 and 2 along Adelaide Avenue (45 kph) from Beasley Street to Parramatta Street, and Flemington Road (40 kph) from Parramatta Street to Woden Interchange.

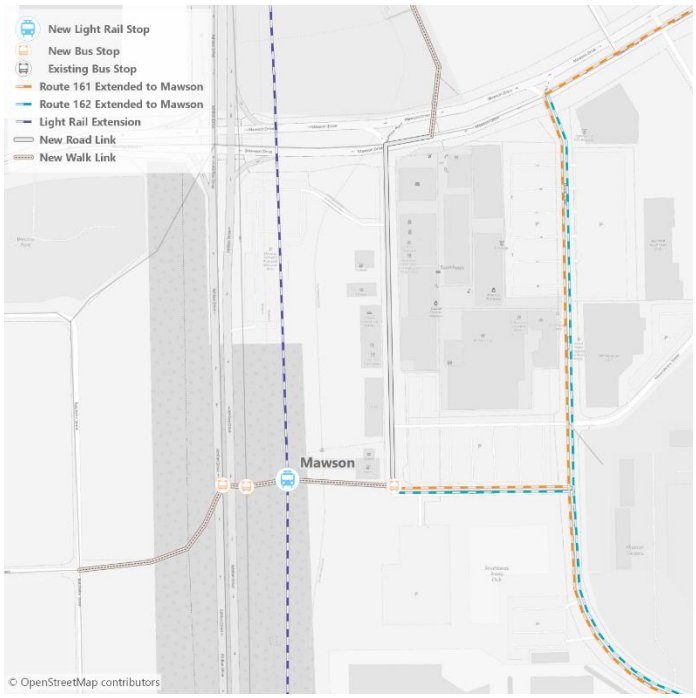
Table 6-2: Light rail travel times (including dwell times)

Section	Length (km)	Cumulative Time (min)	Travel Time (min)	Average Speed (kph)
Beasley St – Mawson	0.52 km	1.20 min	1.20 min	45.0 kph
Mawson - Schools	0.61 km	2.51 min	1.31 min	45.0 kph
Schools - Shea St	1.07 km	4.49 min	1.98 min	43.4 kph
Shea St - Woden	0.96 km	6.43 min	1.94 min	40.0 kph

BUS NETWORK

The bus network was unchanged from the previous run except for the provision of extra connectivity to Mawson and Beasley Street Stations. At Mawson Town Centre an off-street bus interchange was assumed (Figure 6-2). At Beasley Street Station, stops on Athllon Drive and Beasley Street were repositioned to be closer to the light rail station (Figure 6-1).

Figure 6-2: Mawson bus connections



STREET NETWORK (PEDESTRIANS)

Additional network connectivity was added around the Mawson Town Centre Station to link residential areas to the west of Athllon Drive, and around the Schools stop to better connect with the residential areas to the east and to the schools in the west, as shown in Figure 6-1. Pedestrian links were also added to connect the Beasley Street stop with nearby bus stops and the (proposed) park and ride.

PARK AND RIDE

The light rail station at Mawson Town Centre is adjacent to the existing Mawson Park and Ride, with which the station was connected via a pedestrian link. Additionally, a park and ride was added at Beasley Station in the Beasley Street scenario. In the modelling, the capacity of park and ride facilities were not constrained to provide insight into the latent demand.

6.2 Model Results

This section outlines model outputs and provides analysis of public transport patronage forecast in each scenario.

The Mawson light rail extension is expected to result in a modest increase in public transport usage in Canberra, with the number of public transport journeys predicted to increase by approximately one per cent in both the Mawson and Beasley scenarios (Table 6-3). The modelling indicates that the extension will facilitate a slight shift from buses to light rail.

The Mawson extension will expand the catchment of light rail, with customers walking to the new stations (Figure 6-3). As a result, over 2,000 additional walk access trips are expected on an average weekday (an increase of eight and nine per cent in the Mawson and Beasley scenarios respectively). The modelling also indicates that the extension could slightly increase bus access to light rail.

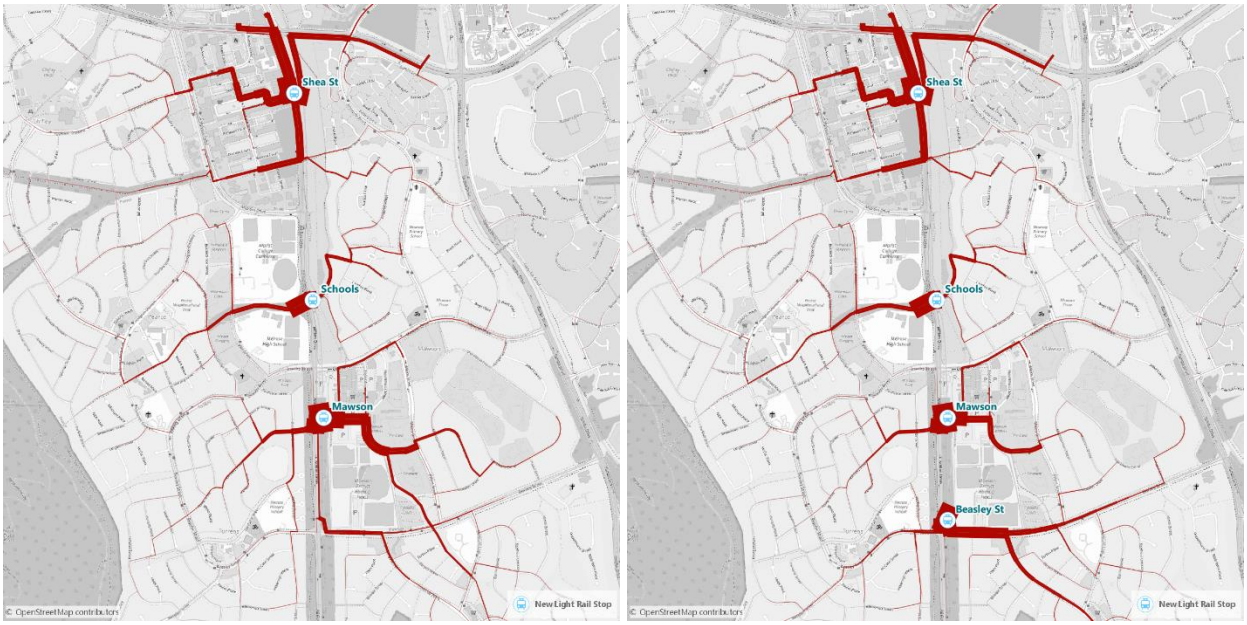
Overall, the extension is not expected to materially affect the number of customers accessing light rail by car. However, as is outlined below, the extension is predicted to substantially change the distribution of car access, with park and ride access at Woden expected to decrease.

The extension is also forecast to result in slightly more kilometres travelled on public transport, with an increase in the number of kilometres travelled on the light rail more than offsetting a slight decrease in bus kilometres.

Table 6-3: Model wide statistics in 2036 scenarios, (with per centage difference compared to State scenario)

Metric	State	Mawson		Beasley	
Public transport journeys	136,000	137,000	+1%	137,000	+1%
Public transport boardings	157,000	159,000	+1%	159,000	+1%
- Bus boardings	119,000	117,000	-2%	117,000	-2%
- Light Rail boardings	38,000	41,000	+8%	41,000	+8%
Light Rail Access Mode Trips					
- Walk	27,700	30,000	+8%	30,200	+9%
- Bus	5,800	6,400	+10%	6,400	+10%
- Car	3,200	3,100	-3%	3,200	-%
Public transport passenger Kms	1,203,000	1,223,000	+2%	1,226,000	+2%
- Bus	922,000	903,000	-2%	902,000	-2%
- Light Rail	281,000	320,000	+14%	324,000	+15%

Figure 6-3: Walk access to light rail, Mawson (left) and Beasley (right) scenarios



LIGHT RAIL BOARDINGS

The Mawson extension is predicted to significantly decrease the number of light rail boardings at Woden compared to the State Circle scenario (Figure 6-4). In the Mawson scenario approximately 4,500 boardings are forecast at the new stations (spread across the Mawson Town Centre, Schools and Shea Street stops). Extending the light rail to Beasley Street further increases patronage, with about 4,800 daily boardings expected at the new stations (spread across the Beasley Street, Mawson Town Centre, Schools and Shea Street stops). The additional boardings in both these scenarios more than offset the decreased number of boardings at Woden.

In both the Mawson and Beasley scenarios, Mawson Town Centre Station is expected to be the busiest on the extension. However, in the Beasley scenario around 1,300 daily boardings are predicted to occur at Beasley Street Station and around 1,000 fewer at Mawson Town Centre Station. North of Woden, the impact of the extension on boardings on the remainder of the light rail line is expected to be small (Figure 6-5).

In the south bound direction, the extension is predicted to slightly increase boardings from Alinga Street south (Figure 6-6). The impact of the extension on stops north of Alinga Street is expected to be immaterial.

Figure 6-4: North bound daily light rail boardings on Mawson light rail extension (plus Woden)

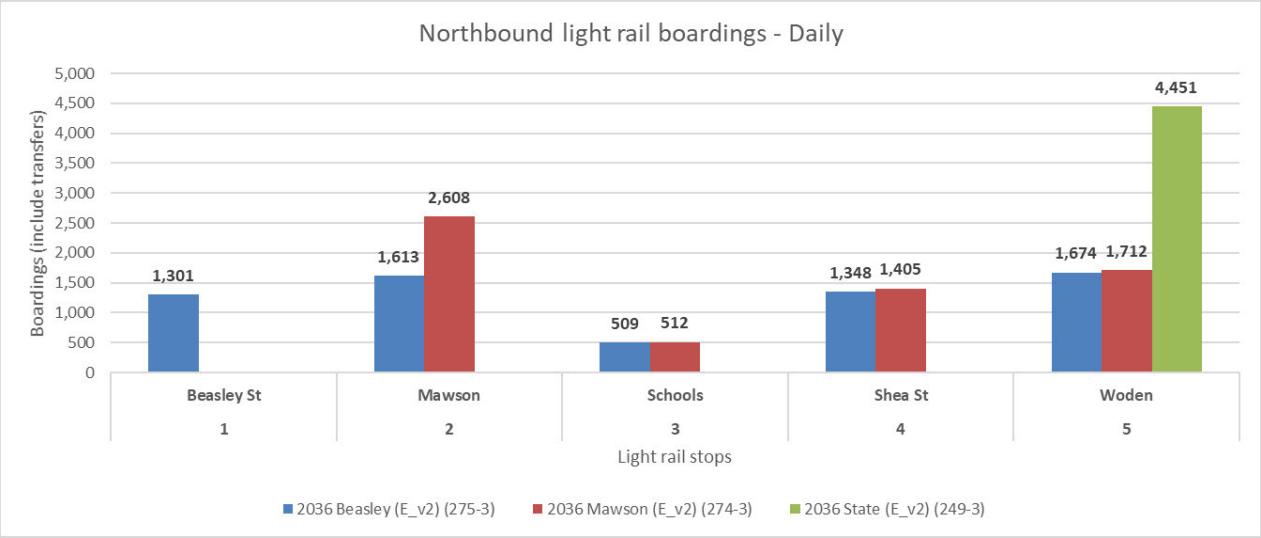


Figure 6-5: North bound daily light rail boardings on full light rail line

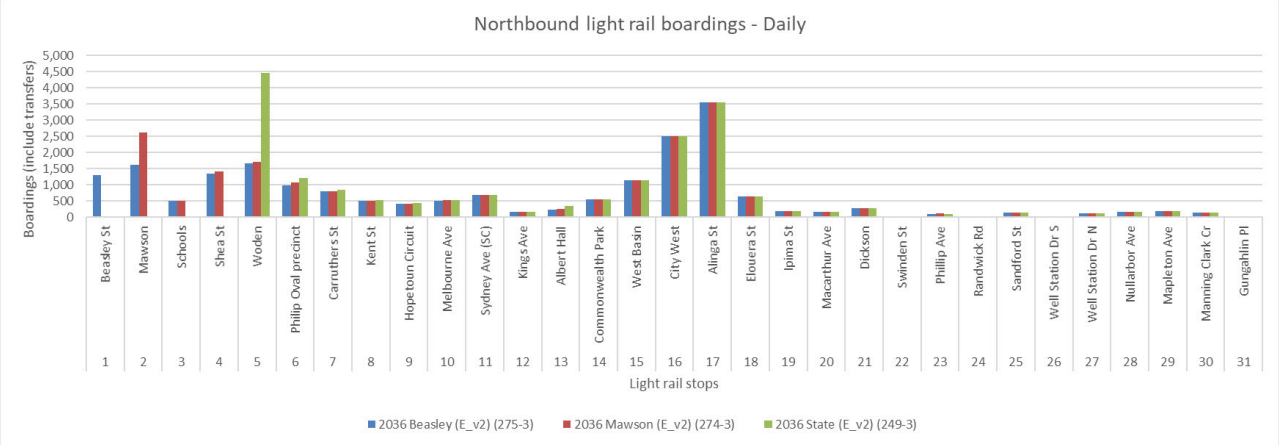
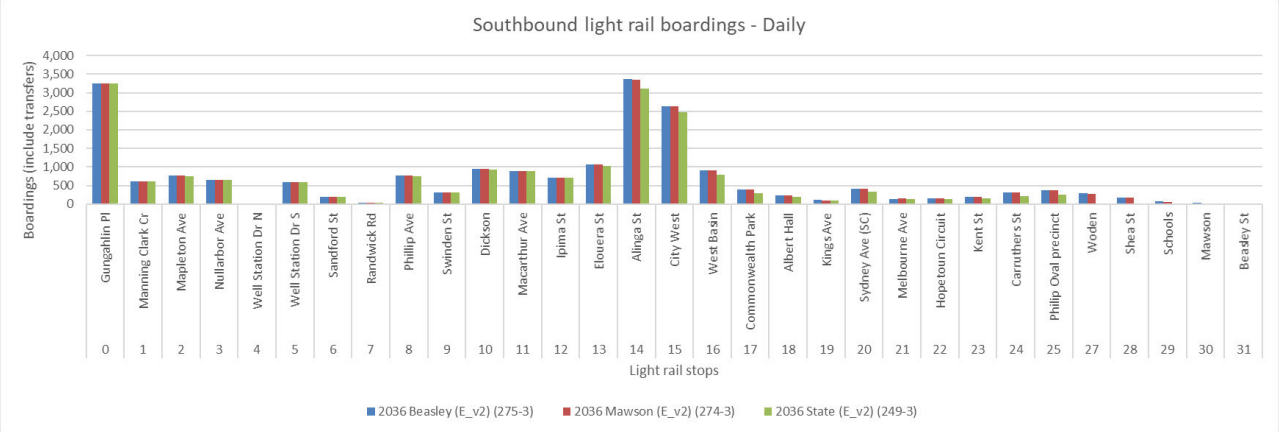


Figure 6-6: South bound daily light rail boardings on full light rail line



Park and ride access

The modelling suggests that the Mawson extension will significantly reduce the number of people driving to Woden to board light rail, with northbound car access trips to Woden expected to nearly halve in the Mawson scenario and decline by even more in the Beasley Street scenario (Figure 6-9).

In all three scenarios, a substantial proportion of the park and ride trips are expected to originate in the Tuggeranong Valley (Figure 6-7 and Figure 6-8). In the extension scenarios (Figure 6-8), the number of customers driving from the Tuggeranong Valley all the way to Woden is expected to decrease.

The modelling indicates that the light rail terminus in each scenario (Woden Station for the State, Mawson Station for the Mawson scenario and Beasley Street Station for the Beasley Street scenario) will attract a substantial amount of park and ride access. In the Beasley Street scenario there is less pressure on the Mawson Town Centre facility, with more customers parking at Beasley Street.

Figure 6-7 : Car access to light rail, State scenario

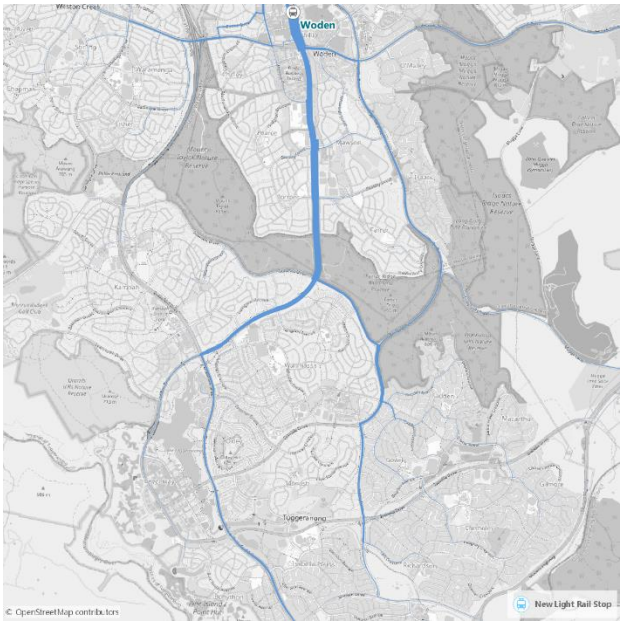
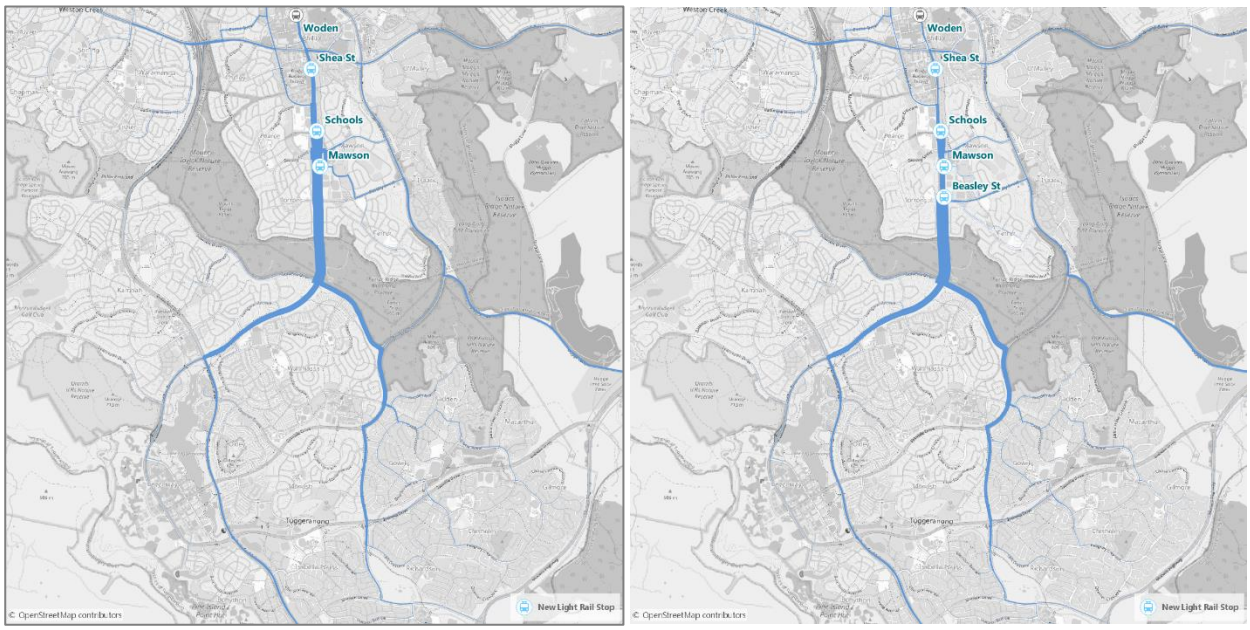


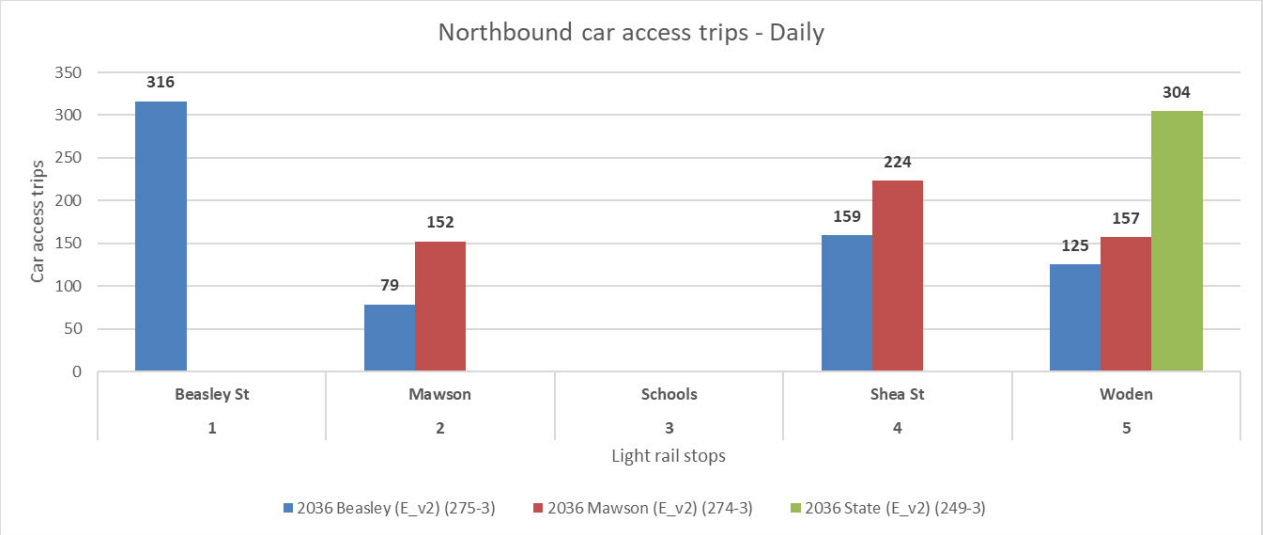
Figure 6-8: Car access to light rail, Mawson (left) and Beasley (right) scenarios



In this project the model was run with no limit on the parking at light rail stations (except for stations only connected to the walk network – such as the Schools stop – where no parking is allowed). As such, the outputs give an idea of the latent demand at each stop without taking into consideration the constraint imposed by the limited supply of parking. Thus, even with an unlimited supply of parking at Woden, the model suggests that a substantial number of customers are expected to park and ride at the new stations on the Mawson extension instead of at Woden Town Centre.

Because parking has not been constrained in the modelling, there is park and ride demand at Shea Street. If parking supply were constrained, the limited supply of on-street parking at Shea Street would cap the number of customers parking there.

Figure 6-9: Northbound car access trips to Mawson light rail extension stations (plus Woden)



Bus access to light rail

Given the option, the model suggest that some customers will transfer from buses to light rail before Woden Interchange, with the most popular transfer point expected to be Mawson Town Centre (Figure 6-10 to Figure 6-12)

Figure 6-10: Bus access to light rail, State scenario

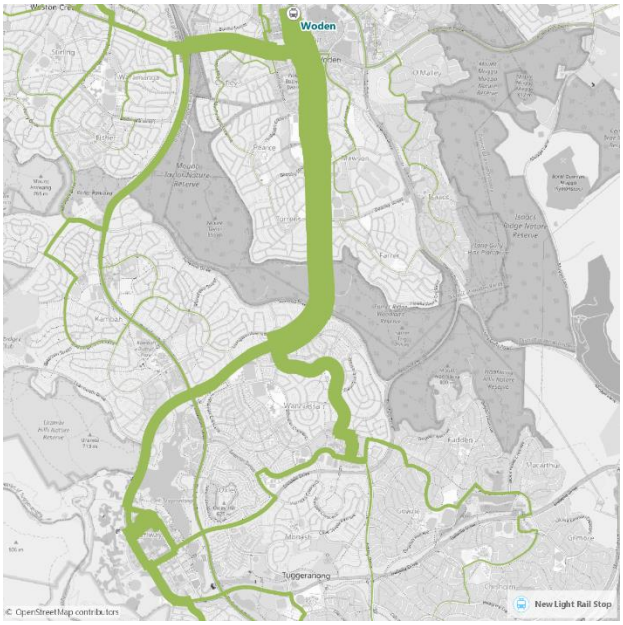


Figure 6-11: Bus access to light rail, Mawson (left) and Beasley (right) scenarios

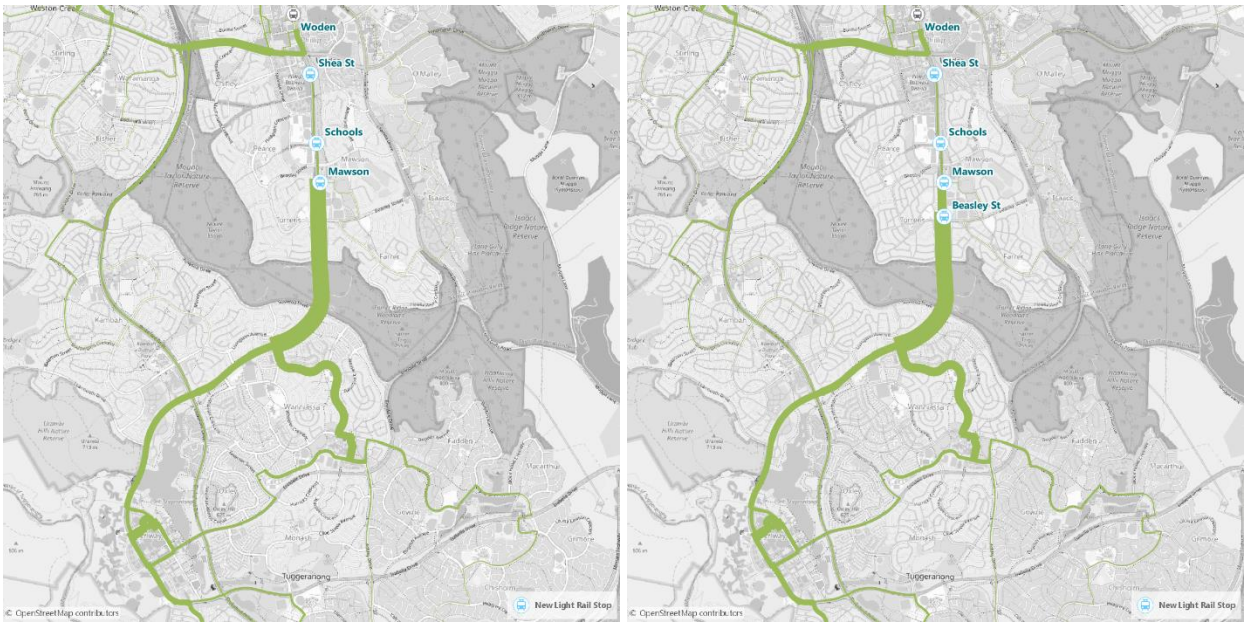
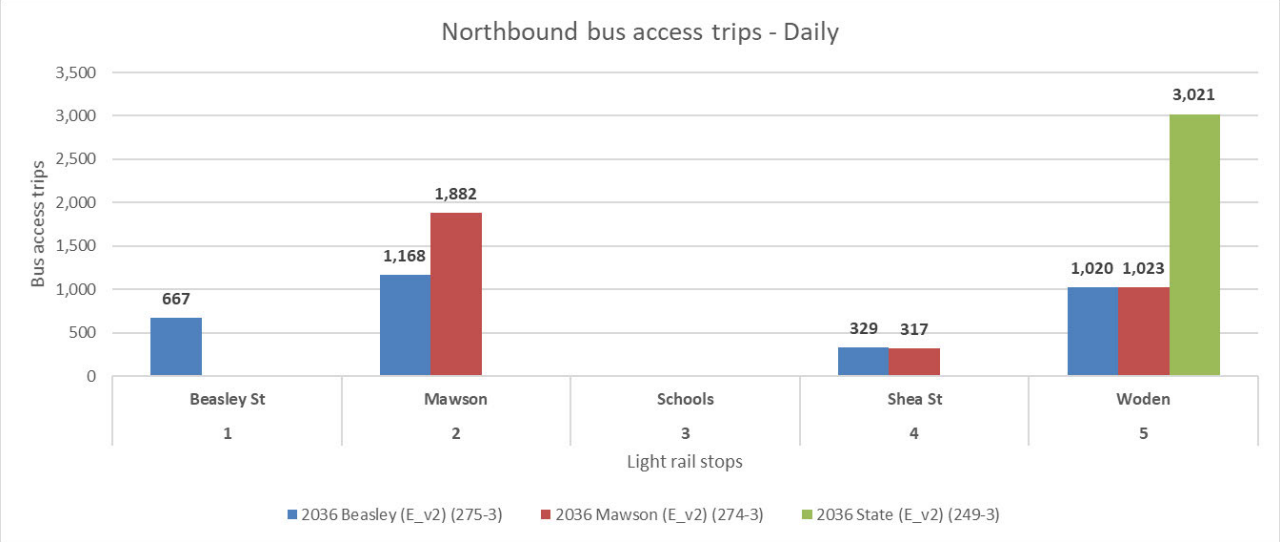


Figure 6-12: Northbound bus access trips to Mawson light rail extension stations (plus Woden)



LIGHT RAIL LOADINGS

The Mawson extension is expected to increase passenger loadings on the light rail, with the model indicating higher loads between Mawson and the City in both northbound and southbound directions (Figure 6-13 and Figure 6-14).

Figure 6-13: Daily load profile northbound

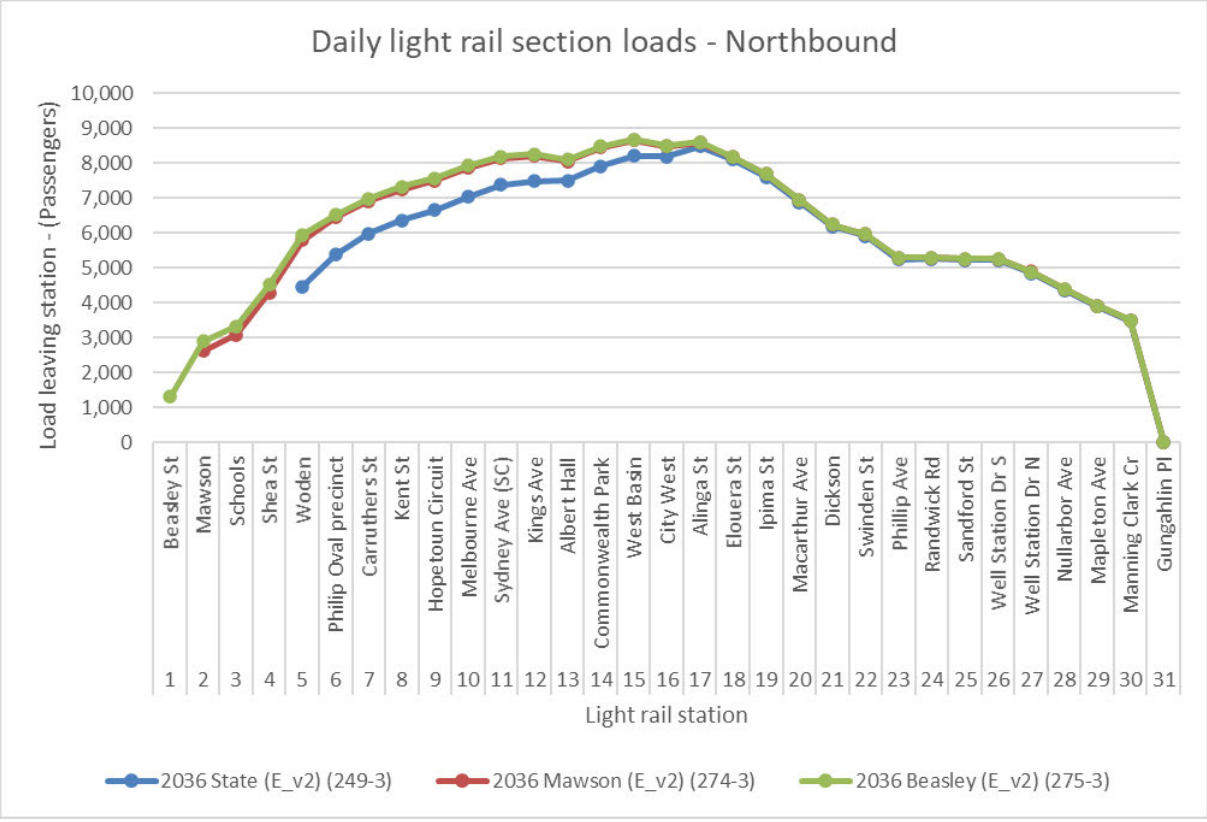
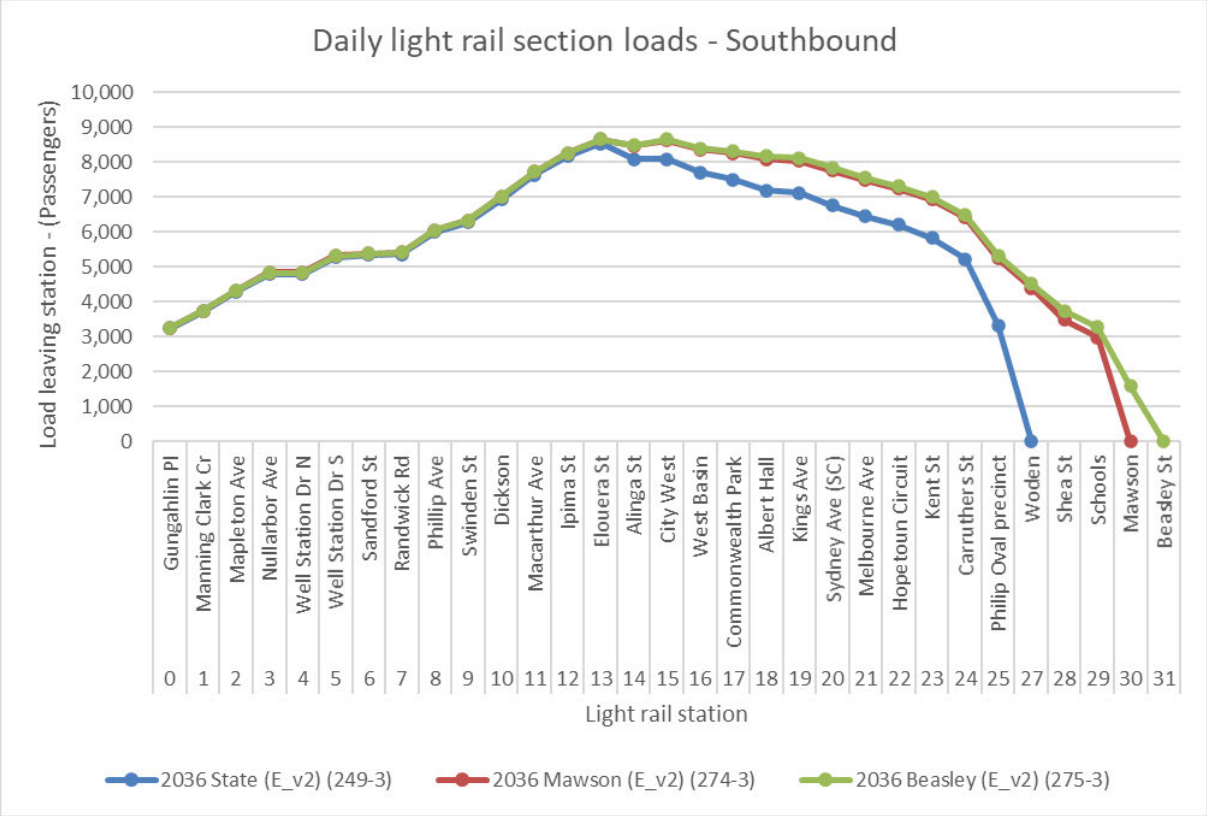


Figure 6-14: Daily load profile southbound



7.0 Summary and Conclusions

Modelling and data analysis

The Mawson light rail extension has the potential to further leverage investment in ACT Light Rail Stage 2 by expanding its catchment, increasing patronage, and enabling commuter parking to be shifted away from the Woden Town Centre. The extension is forecast to increase public transport usage very slightly in the ACT, but its main benefits are likely to be an improved customer experience and higher levels of amenity at the Woden Town Centre. The modelling undertaken in this exercise predicts the extension will result in around 3,000 additional boardings onto light rail on an average weekday in 2036, with the majority of these additional boardings being walk access.

LBS data indicates Woden and the city were major journey destinations for those living in the prospective walk catchments of the new stations, by providing these customers with a direct rail connection with Woden, South Canberra and the City, the Mawson extension will likely improve their travel experience.

The modelling also suggests that the terminus of the light rail will be a substantial attractor for park and ride commuters. Given the urban renewal slated for Woden Town Centre, including a large park and ride at this location would be incompatible with plans for the precinct—it would be preferable to locate a park and ride facility farther south, outside of the town centre. Extending light rail to Mawson would provide an opportunity for commuter parking to be shifted away from Woden, improving urban amenity and reducing congestion at the Woden Town Centre, while also making it easier for park and ride commuters to find a space at purpose-built facilities in Mawson.

Extending the light rail to Beasley Street would leverage further benefits from the extension, with the model indicating higher patronage and less pressure on parking at Mawson Town Centre. Additionally, extending light rail to Beasley Street would be likely to make future extensions to Erindale or Greenway less costly.

Bus network integration

The way in which the Mawson light rail extension is integrated with bus routes will be an important factor in its success. A well-integrated solution will extend the catchment of the light rail and enable higher levels of bus access to light rail. Nevertheless, given that the introduction of the light rail will require more transferring (such as R4 and R5 customers who currently have a direct connection to the city), the impacts of network changes should be carefully considered. In this paper we have identified three options for the bus routes connecting the Tuggeranong Valley to Woden (the R4, R5, 72, 72, 76 and 77).

Truncating all routes at the Mawson light rail terminus will add and additional transfer to the journeys of the substantial number of customers travelling to Woden. Because many of these trips are relatively short and likely to be made for a variety of purposes (such as shopping and recreation) they may be sensitive to the additional transfer, with historical data showing a drop in patronage last time an additional transfer was added. In contrast to the significant customer impact, the cost saving of truncating all routes at Mawson would be modest, as these routes would most likely need to layover at the Woden Depot (which is only one kilometre south of the Woden Interchange). Truncation at Mawson would also have the disadvantage of being a weak terminus for these routes.

A preferable solution would be to have some or all these routes continue running to Woden. As the 'premium' services, preference should be given to retaining a strong anchor at Woden for the R4 and R5. Nevertheless, the best outcome for customers would be for all routes to continue running to Woden. If all routes were to continue running to Woden, this would enable the 73 to be re-aligned through Pearce, returning service to an area where it was lost with the introduction of Network 19.

Another consideration for the future bus network is whether the Tuggeranong Valley to Canberra Hospital connection should be retained. Patronage data indicates that relatively few customers have taken advantage of this connection since it was introduced. With Athllon Drive to become a bus priority corridor, it may make sense to realign the 72, 76 and 77 from Yamba Drive to Athllon Drive. This change would retain a direct connection to Woden but require a transfer onto the R6 to reach Canberra Hospital.

Additional infrastructure

Aside from light rail infrastructure, the Mawson extension will likely require new interchanges to integrate it with the bus network as well as new park and ride facilities. The key interchange point on the extension will be at Mawson Town Centre, with routes using Athllon Drive (e.g. the R4 and R5) to be connected to the light rail station via a new set of stops, and a new pedestrian path and underpass. On the eastern side, the local routes (including the 60, 61 and 62) should ideally be connected to the light rail station through a new facility (potentially off street) adjacent to the Caltex Woolworths on Mawson Place. This facility would also require space for buses to layover, functioning as the new terminus for routes 60, 61 and 62.

It would be ideal to have park and ride facilities at both Mawson Town Centre and at Beasley Street. Space at the existing Mawson Town Centre site is more limited and additional demand for parking could conflict with shopping centre activity. Thus, the optimal solution would be to retain the existing park and ride at Mawson Town Centre and provide a larger dedicated park and ride at Beasley Street. Note these facilities would also likely replace the Wanniassa park and ride, as people parking at that facility who wish to travel to the city would have to transfer between bus an light rail with the extension of light rail to either Woden or Mawson.