New Richmond Bridge Stage 2 Concept Design and REF

Traffic and Transport Assessment

Transport for New South Wales

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1 Introduction

1.1 Proposal identification

Transport for NSW (Transport) proposes to upgrade Bells Line of Road / Kurrajong Road between Crooked Lane, North Richmond and Old Kurrajong Road, Richmond and construct a new bypass south of Richmond town centre. This is known as New Richmond Bridge and traffic improvements – Stage 2 (the proposal). The new route between Richmond and North Richmond would provide a minimum five per cent annual exceedance probability (AEP) flood resilience (equivalent to the 1 in 20 chance per year flood event). The proposal is about 50 kilometres north-west of the Sydney Central Business District (CBD) and about 33 kilometres north-west of Parramatta. It is in the Hawkesbury City Council local government area (LGA).

The proposal would be delivered in two stages, known as Stage 2A and Stage 2B. Should this REF be determined, and the already committed funding by the Australian Government and NSW Government released, Stage 2A would be constructed. This is expected to be complete by 2029. The timing of Stage 2B would be subject to available funding and Transport will continue to seek funding in upcoming State and Federal budgets to deliver the rest of the upgrades.

Stage 2A of the proposal includes a new four-lane bridge over the Hawkesbury River about 30 metres downstream of the existing Richmond Bridge, widening of Bells Line of Road through North Richmond to provide two lanes in each direction between the new bridge and the Terrace Road / Grose Vale Road intersection and a new bypass to the south of the Richmond town centre. The bypass would extend about 1.7 kilometres across the floodplain between the Kurrajong Road / Old Kurrajong Road intersection and Castlereagh Road / Inalls Lane / Southee Road intersection. Stage 2A of the proposal would also provide an active transport corridor between North Richmond and Richmond. This would include a new shared path on the southern side of Kurrajong Road between Old Kurrajong Road and Chapel Street and the conversion of the existing Richmond Bridge into an active transport connection across the Hawkesbury River.

Stage 2B of the proposal includes widening of Bells Line of Road between the Terrace Road / Grose Vale Road intersection and west of Charles Street and at its intersection with Crooked Lane. The bypass would also be extended 1.3 kilometres east from Castlereagh Road to Londonderry Road and would be a new road alignment to the south of Southee Road. Southee Road would connect to the bypass opposite Valder Place. The Londonderry Road / bypass / Vines Drive intersection would also be upgraded.

1.1.1 Proposal background

Richmond Bridge is currently operating at capacity during peak periods and future traffic demand in the area will increase, driven by residential development west of the Hawkesbury River and background traffic growth. This is expected to further increase congestion and travel times along this arterial corridor.

Richmond Bridge is closed in moderate flood events when flood levels reach about eight metres Australian Height Datum (AHD), which is at about the 50 percent AEP flood level. Since 2020, Richmond Bridge has closed multiple times due to flooding. The closure of this bridge results in disruption to travel between North Richmond and Richmond and disrupts regional traffic using the Bells Line of Road corridor.

The Australian Government and NSW Government are funding traffic improvements between North Richmond and Richmond including a new bridge over the Hawkesbury River. This initiative is part of a wider program of traffic improvements between North Richmond and Richmond which includes previous intersection improvements at three key intersections on the approach to the existing Richmond Bridge, including Bells Line of Road / Grose Vale Road intersection in North Richmond as well as Kurrajong Road / Old Kurrajong Road intersection and March Street / Bosworth Street intersection in Richmond. The proposal builds on the previous intersection improvements and is being carried out as part of a wider program of traffic improvements between Richmond and North Richmond which is being delivered in two stages (Stage 1 and Stage 2). They are:

- **Stage 1** involves upgrading The Driftway between Londonderry Road and Blacktown Road to improve safety and flood resilience. This project has been separately determined by Transport and is being delivered separately to the proposal.

- **Stage 2** is the proposal and it aims to improve traffic efficiency, flood resilience, active transport connections and safety of the road network between Richmond and North Richmond.

1.1.2 Proposal description

The key features of Stage 2A of the proposal would include:

- a new four-lane bridge over the Hawkesbury River (about 360 metres long) about 30 metres downstream of the existing bridge, with two eastbound and two westbound lanes and the road level at a height to provide a five per cent AEP flood immunity
- widening of Bells Line of Road and Kurrajong Road to two lanes in each direction from the Terrace Road / Grose Vale Road intersection in North Richmond to just east of the Kurrajong Road / Old Kurrajong Road intersection in Richmond
- a new two-lane bypass south of Richmond town centre (one lane in each direction) between the Kurrajong Road / Old Kurrajong Road intersection and just east of the Castlereagh Road / Inalls Lane / Southee Road intersection, including:
  - a three-way signalised intersection connecting Kurrajong Road and the new bypass, including closure of the existing northern and southern legs of Old Kurrajong Road at Kurrajong Road
  - a two-way gated emergency driveway access connecting the northern leg of Old Kurrajong Road and Kurrajong Road, to be opened during flood evacuation events
  - a 150-metre-long bridge over a tributary to Mareh-Mareh Lagoon (near Inalls Lane)
  - a 120-metre-long bridge over the floodplain parallel to Inalls Lane
  - a roundabout at the Castlereagh Road / Inalls Lane / bypass intersection, with a local road connection to Southee Road
  - local road connections to Yarramundi Lane and Victoria Place from the bypass
  - truncation of Inalls Lane near Mareh-Mareh Lagoon, with local road connections to Inalls Lane from the bypass via Yarramundi Lane and near Drift Road
  - closure of the existing Drift Road intersection with Inalls Lane, with a new local road connection to Drift Road from the bypass
  - footpaths along the southern side of the of the bypass between Drift Road and Castlereagh Road and on each side of the roundabout
- an upgraded active transport network between Richmond and North Richmond, including:
  - a new shared path along the southern side of Kurrajong Road between the existing Richmond Bridge and Chapel Street, Richmond, a distance of about two kilometres, connecting to existing paths along March Street, Richmond
  - conversion of the existing Richmond Bridge and approaches into an active transport only connection
  - active transport connections from the existing Richmond Bridge through Hanna Park to an upgraded shared path on the northern side of Bells Line of Road until east of the Bells Line of Road / Terrace Road / Grose Vale Road intersection
- retention of bus stops along Bells Line of Road and Kurrajong Road
- new drainage infrastructure, including swales and water quality basins
- utilities connections and upgrades (including electrical, gas, water and telecommunications)
- new intelligent transport systems including closed-circuit television (CCTV) cameras to monitor traffic flow and assist with emergency management
- new maintenance access to the three new bridge structures
- permanent retaining walls near the approach to the new four-lane bridge in North Richmond and along Kurrajong Road near the new shared path

- driveway adjustments and tie-ins, including along Bells Line of Road, Beaumont Avenue, Kurrajong Road, Old Kurrajong Road, Inalls Lane, Drift Road and Castlereagh Road
- eight new parking spaces on the northern side of Beaumont Avenue, near its intersection with Terrace Road to replace parking spaces removed on Bells Line of Road
- finishing works, including kerb and gutters, signs, landscaping, lighting and line marking
- construction activities, including:
  - early work, including the establishment of a new compliant handrail on the existing Richmond Bridge
  - geotechnical, contamination and utility investigations which may be carried out as early work
  - a temporary roundabout at the Kurrajong Road / Chapel Street intersection
  - civil earthworks, bridge structural works, retaining walls, drainage work, utilities relocations and tie-in work and adjustments to adjoining sections of road
  - establishment of temporary ancillary facilities to support construction, including compound sites, site offices, stockpile and laydown locations, temporary access tracks and water quality devices
  - demolition work for structures and property features that fall in the proposal area.

The key features of Stage 2B of the proposal would include:

- localised widening of Bells Line of Road to provide a dedicated right-turn lane into Crooked Lane
- widening of Bells Line of Road to two lanes in each direction from west of Charles Street to the Terrace Road / Grose Vale Road intersection in North Richmond
- additional capacity improvements to the Bells Line of Road / Terrace Road / Grose Vale Road intersection, including an additional eastbound through lane at the intersection
- an upgraded shared path on the northern side of Bells Line of Road from west of Charles Street to the Terrace Road / Grose Vale Road intersection in North Richmond
- extension of the bypass (one lane in each direction) between the Castlereagh Road roundabout and just south of the Londonderry Road / Southee Road intersection, including:
  - a new signalised intersection at the junction of Londonderry Road, the new bypass and Vines Drive
  - closure of the Southee Road local road connection from Castlereagh Road and closure of Southee Road at Londonderry Road
  - a new local road connection to Southee Road opposite Valder Place, with left and right turn lanes provided at this intersection.
  - two new bus stops along the bypass near Hill Avenue (one eastbound and one westbound), with a footpath connection to Southee Road
- retention of bus stops along Bells Line of Road and Londonderry Road
- new drainage infrastructure, including swales and a water quality basin on Londonderry Road
- noise screening mounds, walls and/or additional attenuation between the bypass and Southee Road along the extended section of the bypass between Castlereagh Road and Londonderry Road
- utilities connections and upgrades (including electrical, gas, water and telecommunications)
- new intelligent transport systems at the Londonderry Road / bypass / Vines Drive intersection including closed-circuit television (CCTV) cameras to monitor traffic flow and assist with emergency management
- driveway adjustments and tie-ins, including along Bells Line of Road, the bypass and Londonderry Road
- finishing works, including kerb and gutters, signs, landscaping, lighting and line marking
- construction activities, including:
  - geotechnical, contamination and utility investigations which may be carried out as early work

- civil earthworks, retaining walls, drainage work, utilities relocations and tie-in work and adjustments to adjoining sections of road
- establishment of temporary ancillary facilities to support construction, including compound sites, site offices, stockpile and laydown locations, temporary access tracks and water quality devices
- demolition work for structures and property features that fall in the proposal area.

An overview of the proposal (Stage 2A and 2B) is provided in Figure 1-1a-b.

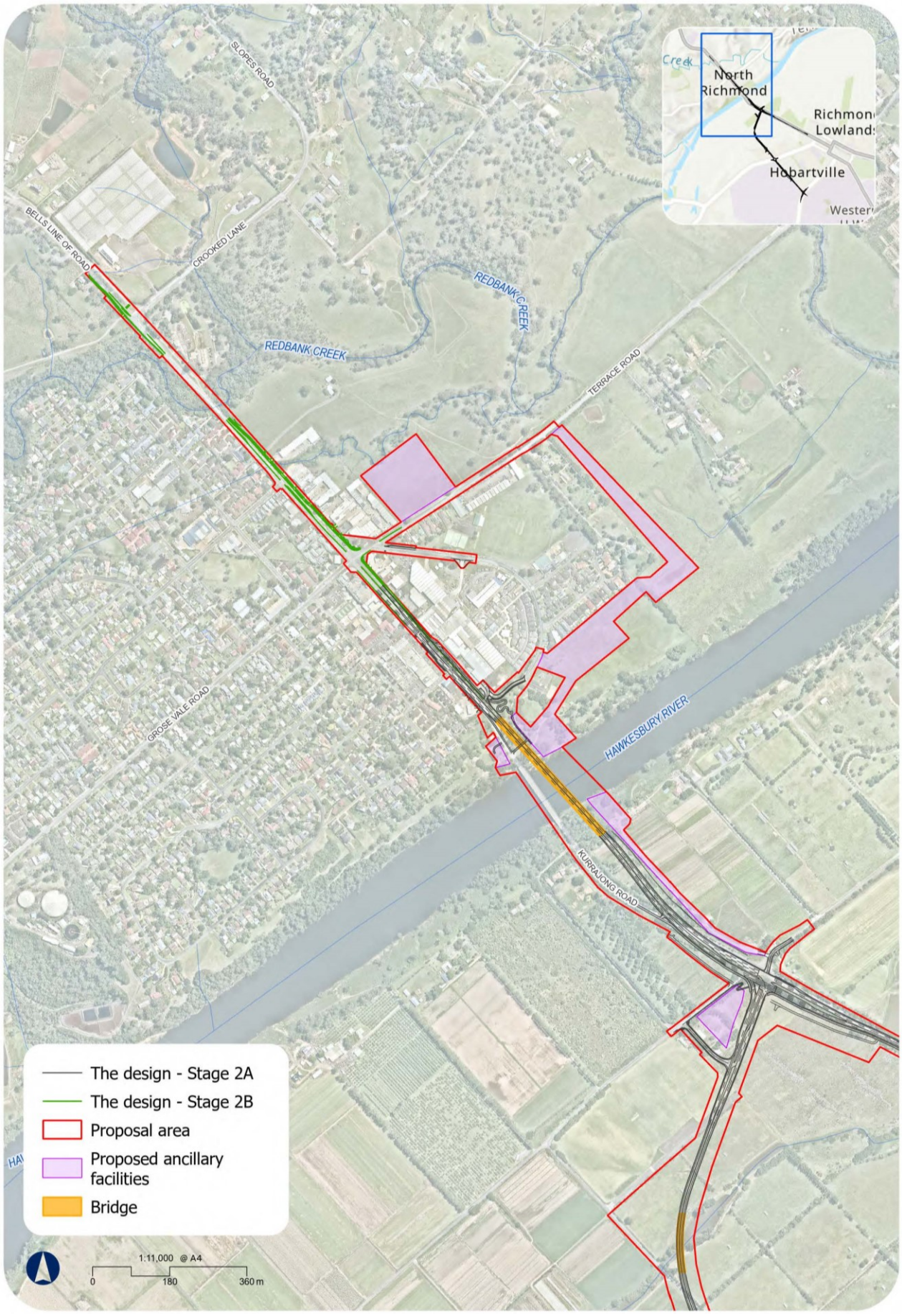


Figure 1-1a The proposal

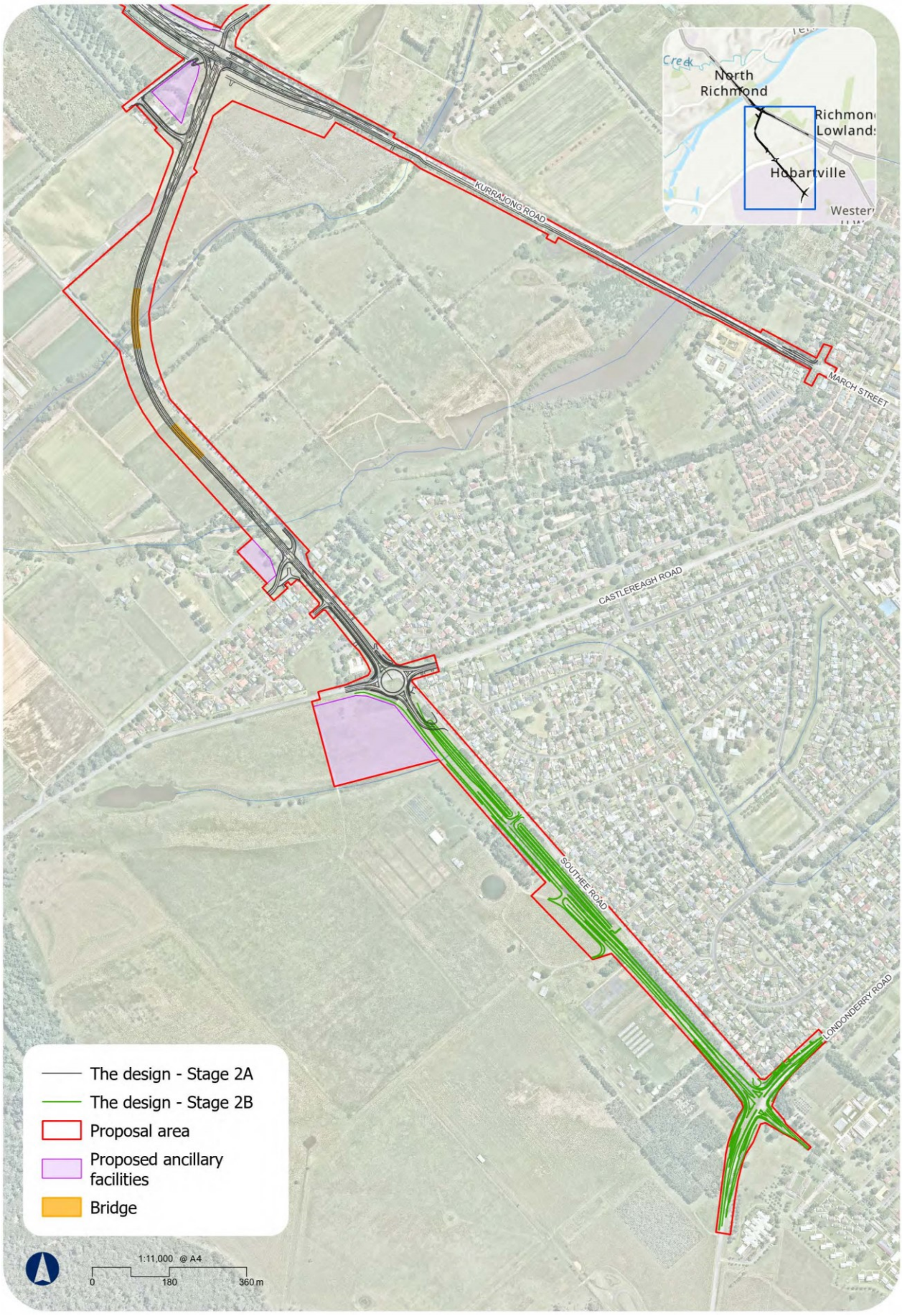


Figure 1-1b The proposal

1.2 Purpose and scope of this report

The proposal is subject to environmental assessment under Division 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), which requires Transport to prepare a Review of Environmental Factors (REF) for the proposal. The purpose of this report is to assess the traffic and transport patterns for the proposal and identify the potential traffic and transport impacts of the proposal during construction and operation to support the REF. The assessment considers the traffic and transport impacts during construction and operation of both Stage 2A (opening in 2029) and Stage 2B (opening in 2039).

2 Methodology

2.1 Study process

The methodology for this traffic and transport assessment consisted of:

- reviewing the existing and future conditions of the transport network within and surrounding the proposal using publicly available information, as well as data that had been previously collected for the proposal
- preparing a microsimulation traffic model for the concept design of the proposal using the Aimsun software
- modelling the traffic performance of the concept design for several scenarios within the study area
- assessing the impacts of the proposal on traffic and transport performance during operational stages
- recommending management measures to minimise potential traffic or transport impacts from the proposal.

Further details on the methodology are provided in the following sections. The base model calibration and validation report is provided in Appendix A.

2.2 Study area

The traffic and transport study area adopted for this assessment consists of the following key road corridors:

- East-west corridors, including:
  - Hawkesbury Valley Way / Windsor Street / Kurrajong Road / Bells Line of Road, extending from Richmond to North Richmond
  - Blacktown Road / Lennox Street, in Richmond
  - Southee Road, south of Richmond
  - The Driftway, south of Richmond
- North-south corridors, including:
  - Londonderry Road, south of Richmond
  - Castlereagh Road / Bosworth Street, south of Richmond
  - Old Kurrajong Road / Yarramundi Lane, west of Richmond
  - Grose Vale Road / Terrace Road, in North Richmond

Figure 2-1 shows study area used for this assessment and the road network included in the traffic model.

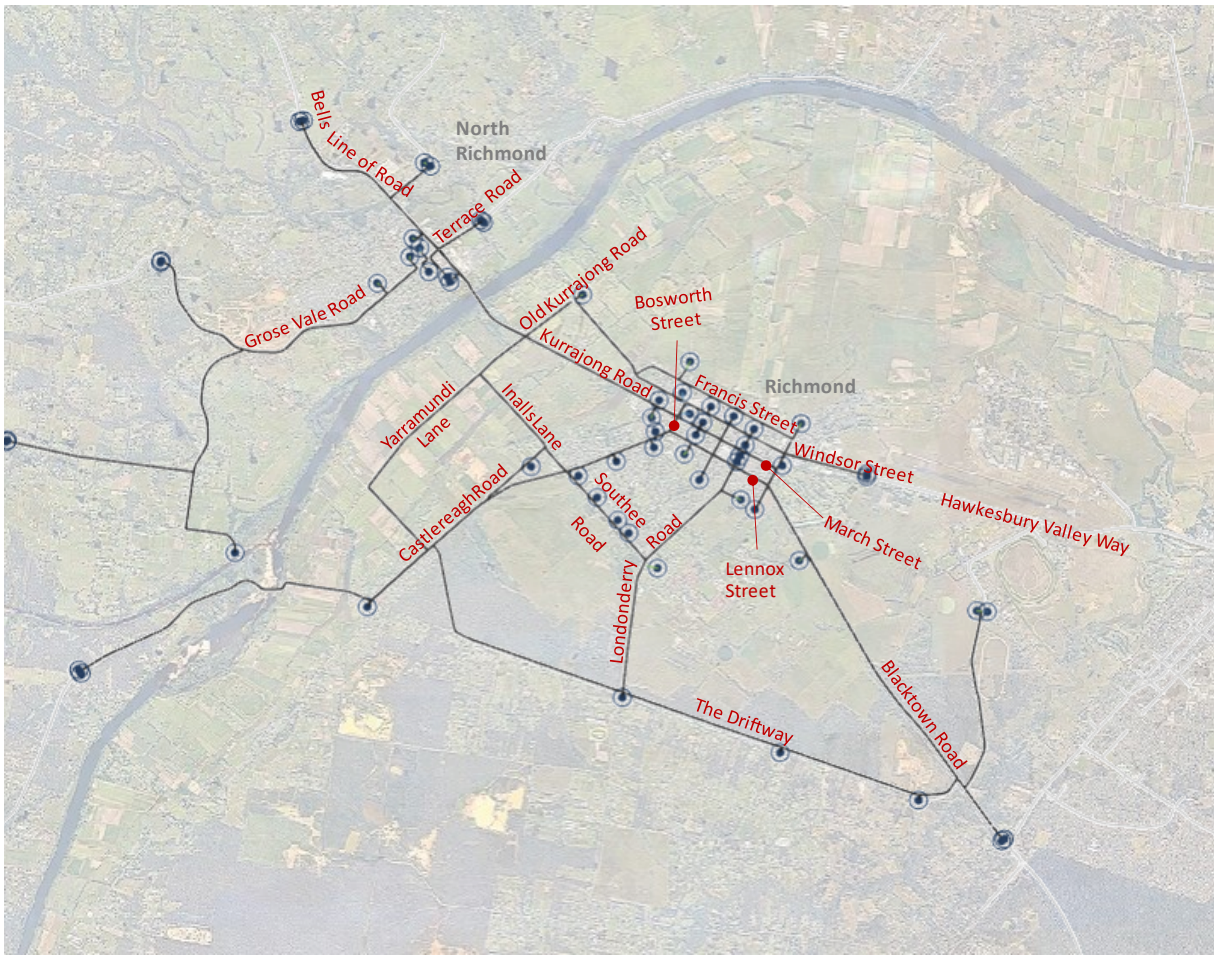


Figure 2-1 New Richmond Bridge Stage 2 modelled study area (Background image source: Nearmap)

2.3 Modelling methodology

Aimsun was used to carry out microsimulation modelling for the proposal. The modelling provided details on reporting of flows, delays, queuing and travel times at intersections and along road segments in response to travel demand and geometric conditions.

The traffic modelling for the proposal comprised of two development stages, being:

- The development of a calibrated and validated existing traffic base (2023) model that accurately represents base traffic conditions observed within the study area. This model is suitable for analysing network performance and acting as a benchmark to evaluate the performance of future year scenarios.
- The development of future year scenario traffic models that draw on the base model and the Sydney Strategic Traffic Forecasting Model (STFM) to compare the expected traffic conditions with and without the proposal under forecasted traffic volumes.

The following future year modelling scenarios were developed for both the AM and PM peak periods with the proposed upgrades outlined in Section 2.3.3:

- 2029 'Without proposal'
- 2029 Stage 2A Proposal Case
- 2039 'Without proposal'
- 2039 Stage 2B Proposal Case.

For the purposes of traffic modelling, Stage 2A has been assumed to be constructed for the Opening Year (2029) and Stage 2B has been assumed to be constructed for the +10 Year (Year 2039).

The traffic demands for the future years (2029 (opening year) and 2039) were developed for the future AM and PM peak periods by adding the predicted traffic growth to the current 2023 calibrated demand. The traffic growth, per forecast year, was developed from the STFM sub area matrices and link volume plots provided by Transport. In addition, traffic to and from the expected new developments (namely, the Redbank development at Grose Vale Road, Vineyard residential development and Glossodia residential development) were also added to the current 2023 calibrated demand. The future year demand development process is discussed in detail in Appendix B.

2.3.1 Traffic monitoring and existing data

The data used during both the base model development (including validation and calibration), as well as future year scenario traffic model development, are presented in Table 2-1.

Table 2-1 Traffic model development data

Data Type	Item	Source	Collection date	Application
Network geometry	Existing traffic model (2018)	Transport	March 2023	Used as the starting point for model network development
	Nearmap aerial imagery	Nearmap, Transport	May 2023	Latest aerial imagery – used for network refinement and coding
	Imagery, street views, site visit	Google Earth, Google Maps	May 2023	Posted speed limits, road network geometry, school zones, etc.
		Open Street Maps		
		Site visit		
Traffic signals	SCATS phasing plots and history data	Transport	February 2023	For model signal coding including, phasing, coordination
Public transport	Bus routes, stops and timetables	https://transportnsw.info/	February 2023	Public transport network coding
Heavy vehicle access routes	Freight routes	Transport	February 2023	Network coding and traffic assignment
Traffic count data	Intersection classified traffic counts	Video surveys by Matrix Traffic and Transport Data, Transport	Tuesday, 7 February 2023	Model recalibration and demand estimation
	Mid-block counts	Automatic traffic counts (ATC) by Matrix Traffic and Transport Data, Transport	Tuesday, 7February 2023 to Monday, 13February 2023	
	SCATS detector counts	Transport	Tuesday, 7February 2023	Count verification
Traffic distribution - Origin Destination (OD) data and Zoning	OD survey data	Vehicle number plate survey by Matrix Traffic and Transport Data, Transport	Tuesday, 7February 2023	Trip distribution and demand estimation
	OD demand data	Existing 2018 traffic model	March 2023	
Travel time	Travel time and speed data	Floating car travel time survey by Matrix Traffic and Transport Data, Transport	Tuesday, 7February 2023	Model revalidation
Intersection congestion conditions	Intersection approach queue lengths	Queue length survey by Matrix Traffic and Transport Data, Transport	Tuesday, 7February 2023	Model revalidation
Future year demand	STFM	Transport	August 2023	Future Year Matrices
	Latest Land Use Data, Population Projections	Hawkesbury City Council	August 2023	Future Year Development Traffic Matrices

Data Type	Item	Source	Collection date	Application
Future network geometry	Drawings	Transport	June 2023	Committed projects geometry
		Aurecon design team	January 2024	Proposal geometry

2.3.2 Development of the base case traffic model

The base traffic model was developed using Aimsun Next version 22.0.2 to replicate 2023 base year traffic conditions for the two-hour AM (7.30–9.30am) and PM (3.30–5.30pm) peak periods. The model reflected existing lane configurations, intersections, gradients, lane and turn restrictions, turning lanes and reduced speed areas within the study area.

The *Traffic Modelling Guideline, Version 1* (Roads and Maritime, 2013) was used as the main guideline for the base year model development, calibration and validation process. The calibration of the base model involved network verification, demand calibration and route choice calibration. This included development of accurate origin-destination (O-D) matrices calibrated against the intersection turn count data, origin destination data, aerial imagery and other background data collected for the proposal. The model was then validated against travel time, queue lengths and signal time data, which confirmed the accuracy of the model.

Both AM and PM peak models of the 2023 existing conditions traffic model and future microsimulation models were found to be acceptably calibrated and validated against the required Roads and Maritime Services Traffic Modelling Guidelines, 2013 criteria.

The recalibrated and revalidated AM and PM peak microsimulation traffic models have been reviewed and verified internally by Aurecon, in accordance with the Roads and Maritime verification standards.

Appendix A contains the Calibration and Validation Report, which includes a full breakdown of the base case development process.

2.3.3 Development of assessment scenarios for the proposal

The future year models were undertaken to assess the proposal and related network upgrades, which also consider several other committed projects.

To allow for the distinction between the impacts of the committed projects and the proposal, these network upgrades were phased into the future years scenario traffic models by firstly introducing all committed projects (termed the ‘Without proposal’ scenario) followed by adding the proposal network upgrades (termed the ‘With proposal’ scenario).

The proposal network upgrades were introduced through two stages (as discussed in Section 1.1). For the purposes of traffic modelling, Stage 2A has been assumed to be implemented for the Opening Year (2029) and Stage 2B has been assumed to be implemented for the +10 Year (Year 2039).

‘Without proposal’ network changes

The ‘Without proposal’ scenario consists of network upgrades near the proposal that have been assumed to be completed prior to this proposal. This scenario includes the strategically important confirmed projects in the modelled area that were applied in the STFM (including the new Grose River Bridge). The following upgrades were therefore applied under the ‘Without proposal’ scenario (refer to Figure 2-2 for locations):

- Location 1: Londonderry Road and The Driftway intersection upgrade
- Location 2: Blacktown Road, The Driftway and Racecourse Road intersection upgrade
- Location 3: Grose River Bridge.

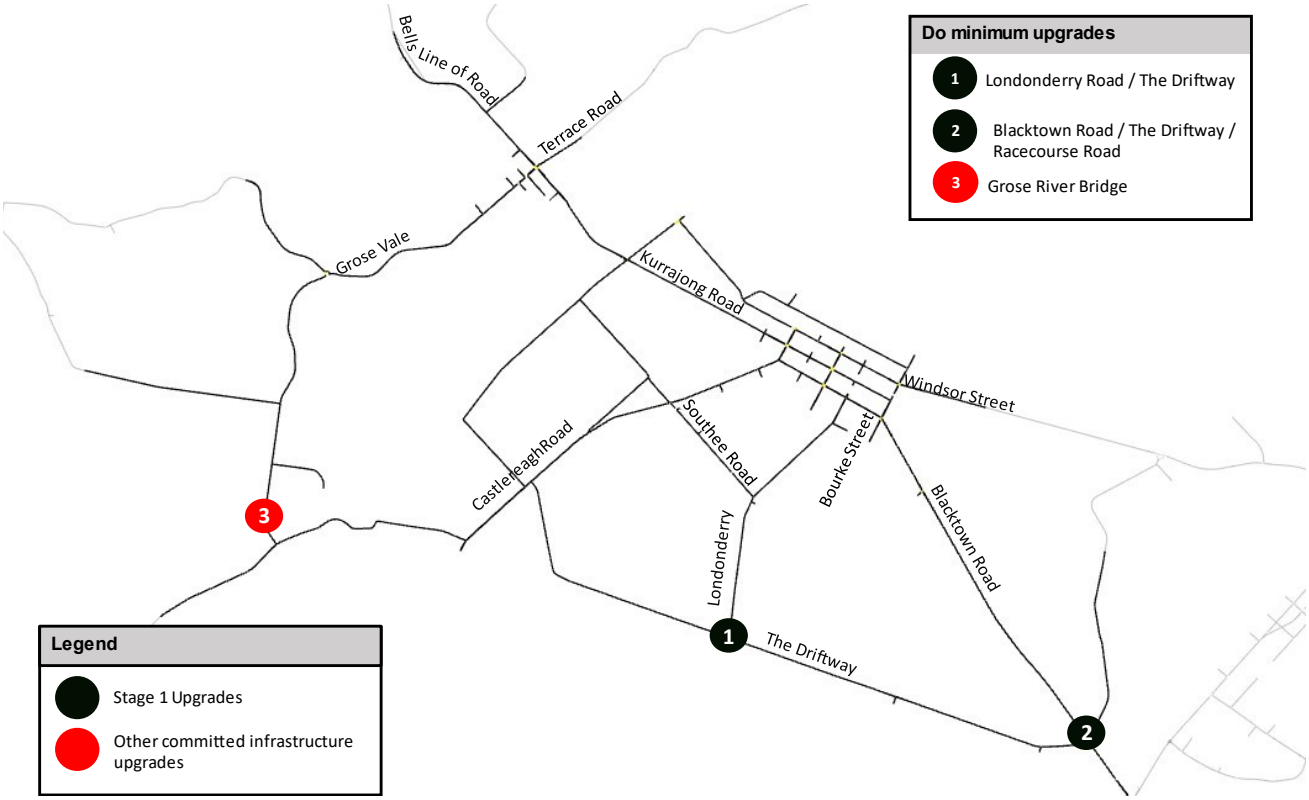


Figure 2-2 Future year traffic model network – 'Without proposal'

The Londonderry Road and The Driftway intersection (Location 1) is being upgraded to a roundabout. The roundabout includes a single lane on all approaches, apart from the north to south movement on which two lanes are planned as part of flood evacuation upgrades. Figure 2-3 shows the existing layout (left) and the proposed upgrade (right).

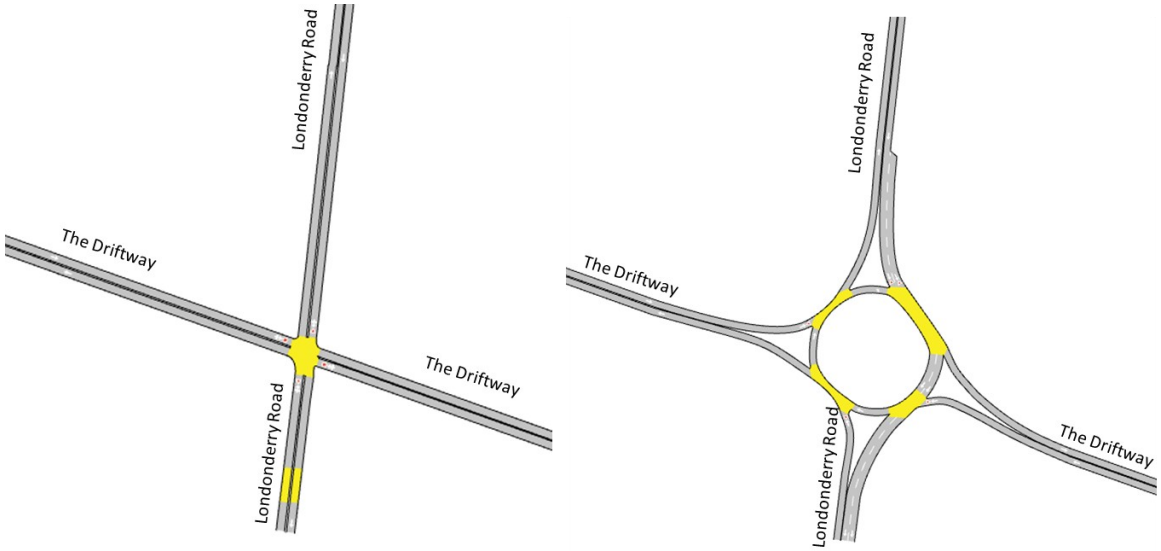


Figure 2-3 Londonderry Road and The Driftway intersection (Location 1) – Existing layout (left) and proposed upgrade (right)

The upgrade of Blacktown Road, The Driftway and Racecourse Road intersection (Location 2) includes the following changes (refer to Figure 2-4 for existing layout (left) and the proposed upgrade (right)):

- merging of Blacktown Road and The Driftway Road intersection and Blacktown Road and Racecourse Road intersection as a single lane roundabout intersection
- realignment of 230 m of The Driftway to the east.

Figure 2-4 Blacktown Road, The Driftway and Racecourse Road intersection (Location 4) – existing layout (left) and proposed upgrade (right)

The Grose River Bridge (Location 3 on Figure 2-2) includes the building of a new bridge, providing an additional connection over a tributary of the Hawkesbury River.

With proposal (Stage 2A) (Opening year – 2029)

The 'With proposal (Stage 2A)' scenario consists of the committed projects described under 'Without proposal', as well as the network upgrades outlined in Figure 2-5 to be implemented for the Opening Year (2029). These upgrades are as follows:

- provision of four lanes on Bells Line of Road and Kurrajong Road from the Bells Line of Road/Terrace Road/Grose Vale Road intersection to the Kurrajong Road intersection with the new Richmond bypass (Location 1)
- new four-lane bridge over the Hawkesbury River, located north of the existing bridge, with two eastbound lanes and two westbound lanes (Location 2)
- conversion of the existing Richmond Bridge and approaches into an active transport only connection new signalised intersection at Kurrajong Road, Old Kurrajong Road and Richmond bypass intersection, with the northern approach of Old Kurrajong Road being a gated access with emergency use only (Location 3)
- new Richmond bypass with one lane in each direction to the south of Richmond town centre with connections to Kurrajong Road, Inalls Lane and Castlereagh Road (Location 4)
- new single lane roundabout at the intersection of Castlereagh Road and Richmond bypass (currently Inalls Lane) (Location 5)
- relocation of bus stops throughout the proposal area.

Refer to Figure 2-5 for locations of these changes.

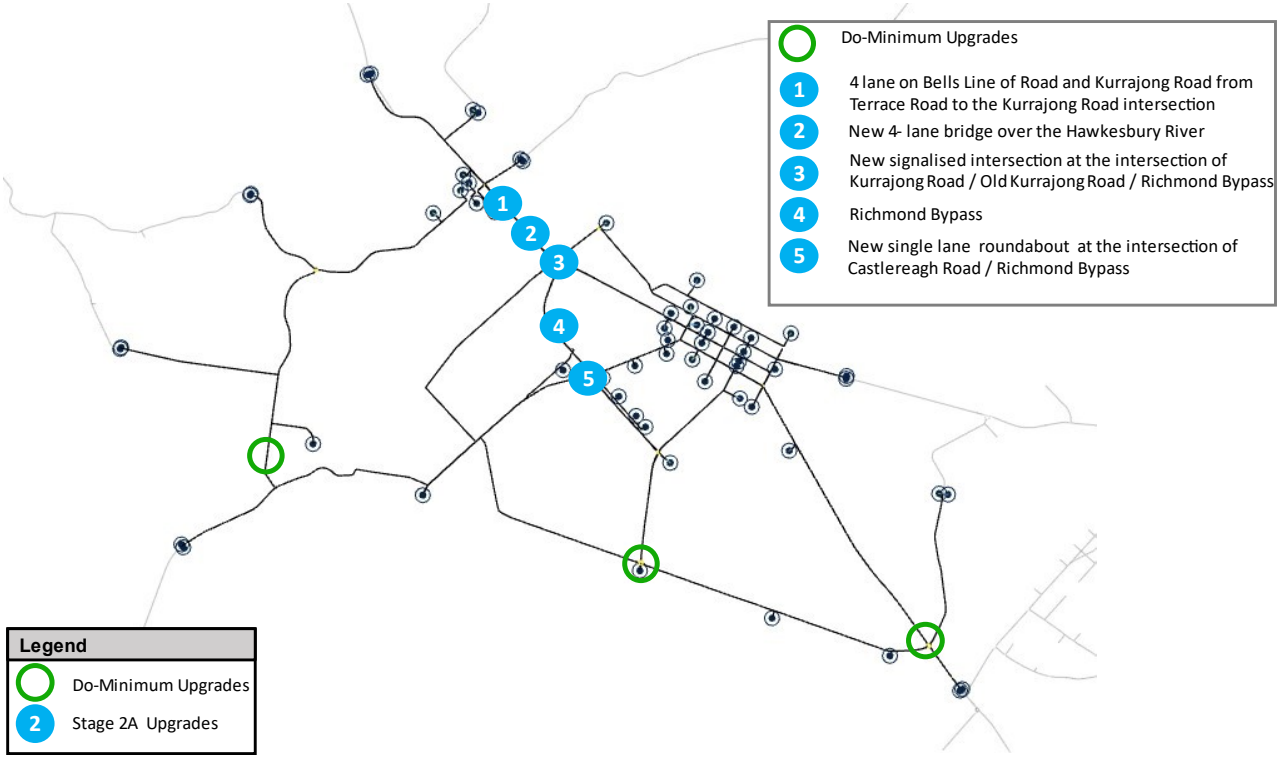


Figure 2-5 Future year traffic model network – Stage 2A (Opening year – 2029)

Figure 2-6 shows the alignment of the new four-lane bridge (Location 2) over the Hawkesbury River (right) compared to the existing bridge alignment (left).

Figure 2-6 Existing Richmond Bridge alignment (left) and the new 4-lane Bridge over Hawkesbury River (right) (Location 2)

The Bells Line of Road, Kurrajong Road and Old Kurrajong Road intersection (Location 3) would be upgraded from a priority-controlled intersection to a signalised intersection, connecting Richmond bypass to Bells Line of Road. The upgrades include:

- Conversion to a signalised intersection.
- Western approach: Provision of two dedicated right turn lanes with lengths of about 120 metres and 135 metres, respectively. Provision of two through traffic lanes and about 55 metres long left turn lane, which also serves as a reserved public transport lane through lane.
- Eastern approach: Provision of a 90 metre long dedicated right turn lane, two through lanes and a 90 metre long left turn lane, which also serves as a reserved public transport lane through lane.

- Southern approach: This approach connects Richmond bypass with Bells Line of Road. As a result, the proposal includes the provision of two dedicated left turn signalised slip lanes, and two right turn lanes, of which one is a shared right and through lane.
- Northern approach: This approach would be converted to a gated access for emergency use only and as such was not considered in the traffic model for normal daily operations.

Figure 2-7 shows the existing layout (left) and the proposed upgrade (right).

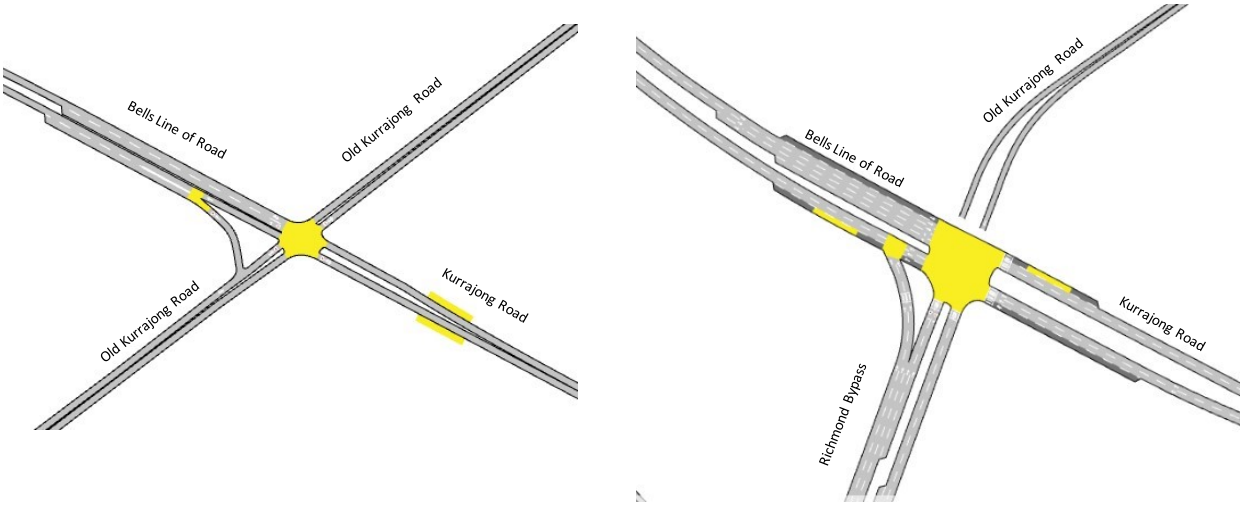


Figure 2-7 Bells Line of Road, Kurrajong Road and Old Kurrajong Road intersection (Location 3) – existing layout (left) and proposed upgrade (right)

Figure 2-8 presents the proposed alignment of the new Richmond bypass, as well as the existing network between the new Richmond Bridge and Inalls Lane (Location 4). Richmond bypass would include one lane in each direction and provide connections to Kurrajong Road, Yarramundi Lane, Inalls Lane, Drift Road, Victoria Place, Castlereagh Road.

Figure 2-8 Existing network (left) and proposed Richmond bypass (right) (Location 4)

A new intersection at Richmond bypass and Castlereagh Road (Location 5) is proposed to be built with a single lane roundabout configuration with the south-eastern leg connecting to the existing Southee Road, as shown in Figure 2-9.

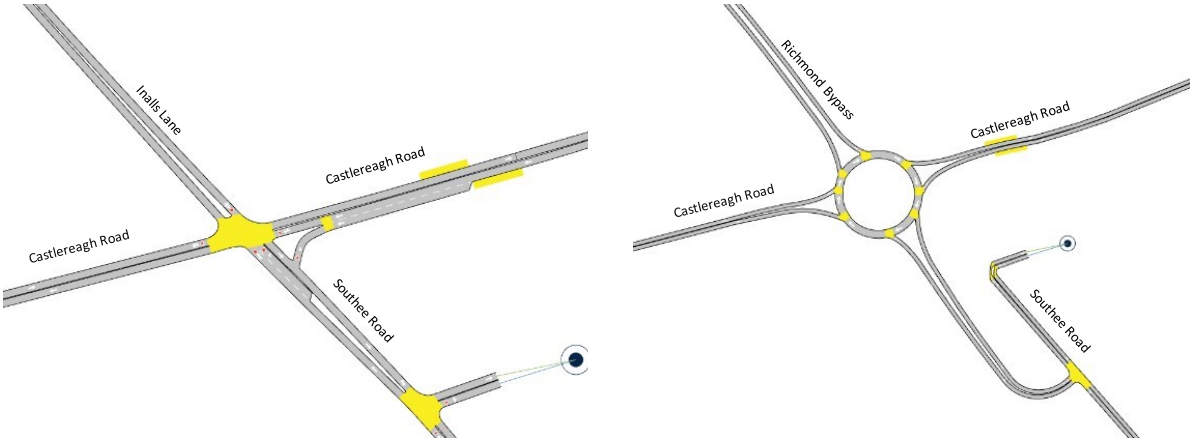


Figure 2-9 Richmond bypass and Castlereagh Road intersection (Location 5): existing layout (left) and proposed upgrade (right)

With proposal (Stage 2B) (+10 Year (2039) projections)

The 'With proposal (Stage 2B)' scenario considered the following network upgrades (refer to Figure 2-10), which would open to traffic in 2039 (10 years after opening of the proposal):

- Committed projects described under the 'Without proposal' scenario
- 'With proposal (Stage 2A)' network changes
- 'With proposal (Stage 2B)'
  - Bells Line of Road and Crooked Lane intersection upgrade (Location 6)
  - Bells Line of Road, Terrace Road and Grose Vale Road intersection upgrade (Location 7)
  - Castlereagh Road and the Richmond bypass intersection upgrade to a dual lane roundabout (location 8)
  - continuation of the bypass between Castlereagh Road and Londonderry Road, parallel to Southee Road (Location 9)
  - new signalised intersection at Londonderry Road, Richmond bypass and Vines Drive intersection (Location 10).
- Other upgrades
  - The Driftway and Luxford Road intersection upgrade (Location 11)
  - The Driftway and Reynolds Road intersection upgrade (Location 12).

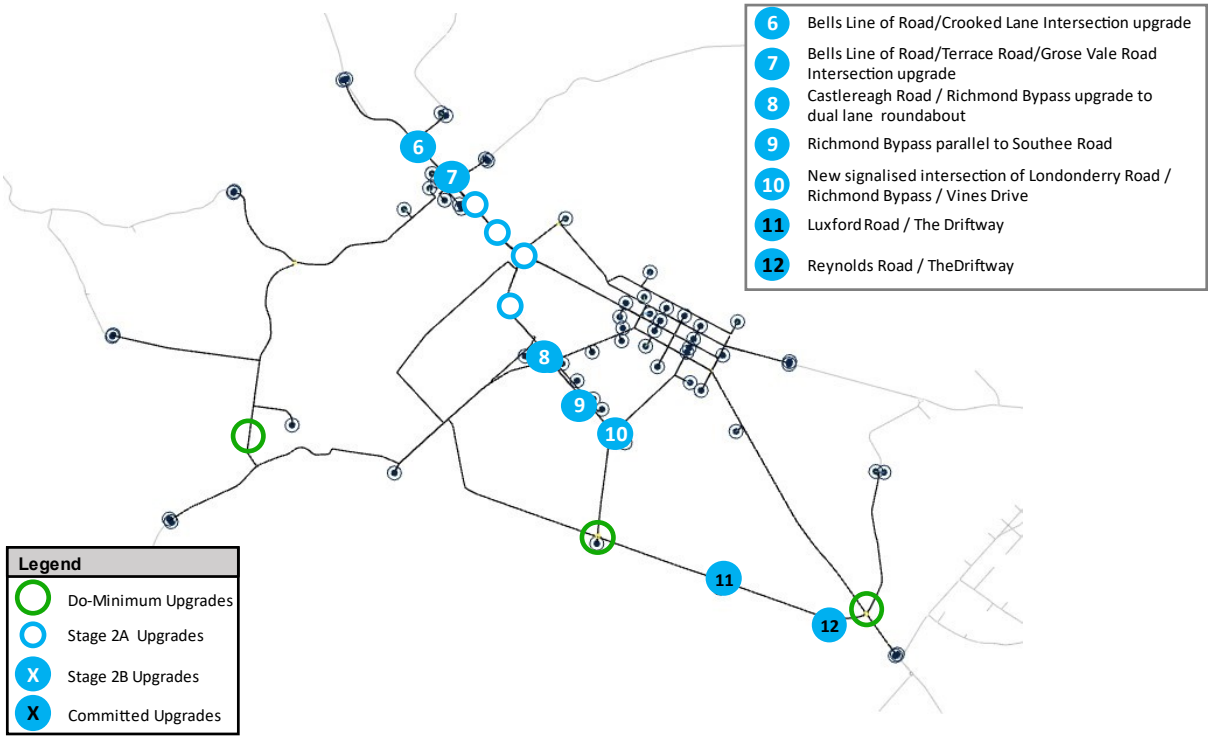


Figure 2-10 Future year traffic model network – Stage 2B (+10 Year (2039)

The intersection upgrade of Bells Line of Road and Crooked Lane (Location 6) includes a right turn bay on the eastern approach. Figure 2-11 shows the existing layout (left) and the proposed upgrade (right).

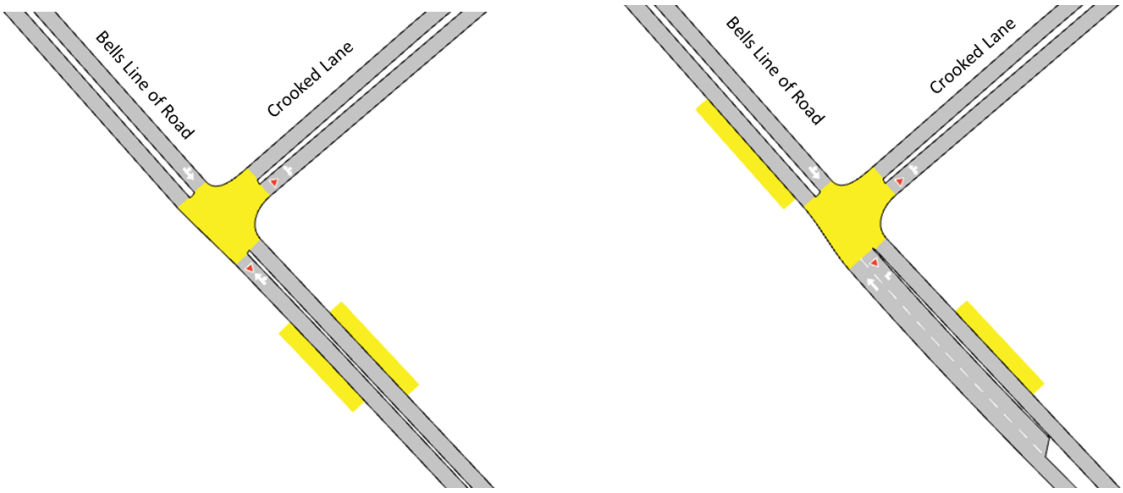


Figure 2-11 Bells Line of Road and Crooked Lane intersection (Location 6) – existing layout (left) and proposed upgrade (right)

The capacity improvements include the upgrade of the Bells Line of Road, Terrace Road and Grose Vale Road intersection (Location 7), including:

- a new third lane on Bells Line of Road eastbound, starting about 140 metres west of the intersection and extending about 140 metres east of the intersection
- increasing the length of right turn lane on Bells Line of Road by about 80 metres east of the intersection and extending the short side lane west of the intersection to about 40 metres beyond Charles Street
- increasing the length of the right turn lane on the west approach by about 70 metres.

Refer to Figure 2-12 for the existing layout (left) and the proposed upgrade (right).

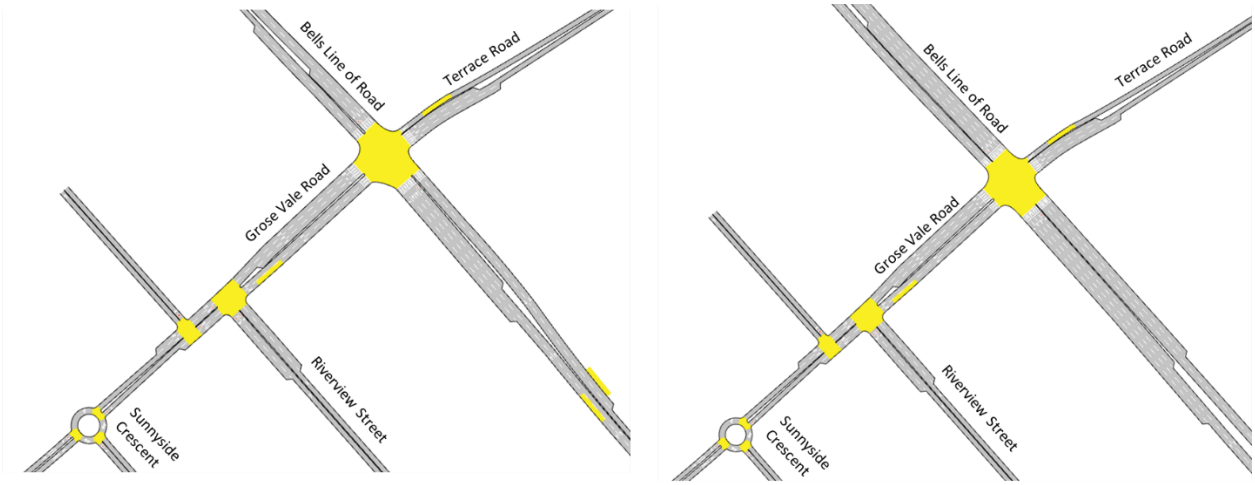


Figure 2-12 Bells Line of Road, Grose Vale Road, Terrace Road (Location 7) – Existing layout (left) and proposed upgrade (right)

The single lane roundabout at the intersection of Richmond bypass and Castlereagh Road (Location 8) would be upgraded to a dual lane roundabout configuration. As shown in Figure 2-13, all approaches to the intersection would have an additional 50 metre short left turn lane and all departure lanes would remain single lanes.

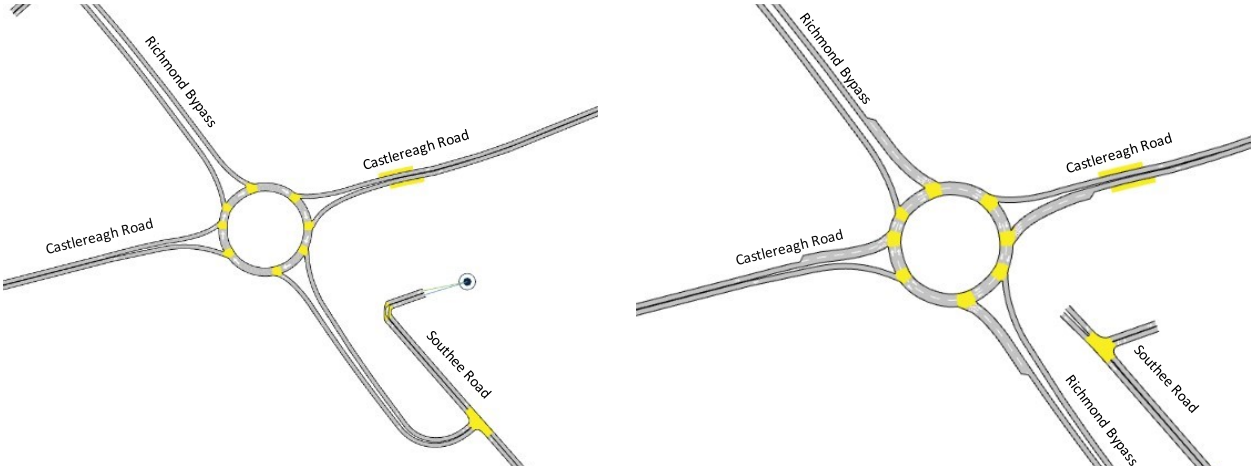


Figure 2-13 Richmond bypass and Castlereagh Road intersection upgrade (Location 8): Stage 2A layout (left) and proposed upgrade (right)

The Richmond bypass road upgrade would include a new parallel road to Southee Road (Location 9), as shown in Figure 2-14. Access to Southee Road would be via an intersection opposite Valder Avenue.

Figure 2-14 Richmond bypass along Southee Road (Location 9): Stage 2A Southee Road alignment (left) and proposed Richmond bypass (right)

As part of the Richmond bypass upgrade, Londonderry Road and Vines Road intersection (Location 10) would be upgraded from the current staggered intersection arrangement to a signalised intersection as shown in Figure 2-15.

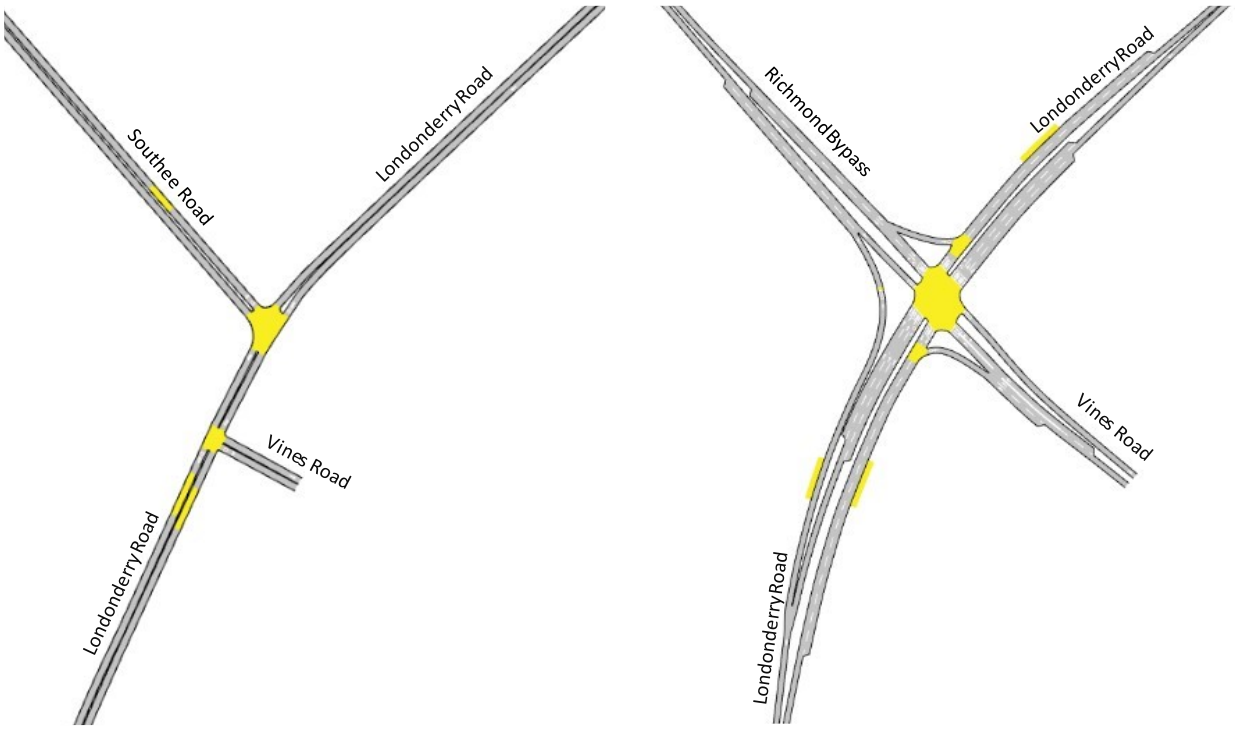


Figure 2-15 Southee Road, Londonderry Road, Vines Road intersection (Location 10): existing layout (left) and proposed upgrade (right)

In addition, two intersection upgrades are proposed along The Driftway to include right turn bays on the intersections' western approaches. Figure 2-16 presents the existing layout (left) and the proposed upgrade (right) for The Driftway and Luxford Road intersection (Location 11), and Figure 2-17 presents the existing layout (left) and the proposed upgrade (right) for The Driftway and Reynolds Road intersection (Location 12).

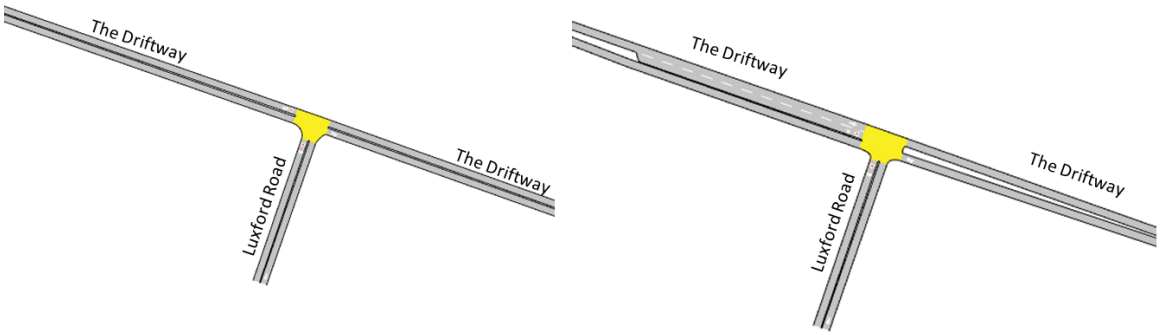


Figure 2-16 The Driftway and Luxford Road intersection (Location 11) – Existing layout (left) and proposed upgrade (right)

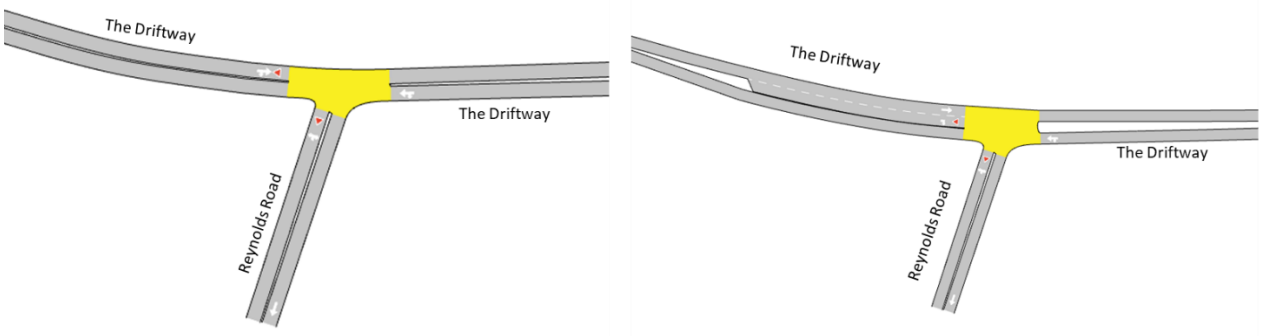


Figure 2-17 The Driftway and Reynolds Road intersection (Location 12) – Existing layout (left) and proposed upgrade (right)

2.4 Traffic performance criteria

2.4.1 Level of service criteria for intersections

Intersection performance has been assessed by evaluating intersection turning volumes, vehicle delays and level of service (LOS).

Table 2-2 outlines the Transport standard LOS criteria for intersection operation. LOS is a measure used to determine the effectiveness of intersection operation and is commonly used to analyse intersections by categorising traffic flow conditions. For a signalised intersection, the overall intersection LOS is determined by the average overall intersection delay, measured in seconds per vehicle. For roundabouts and priority control intersections, the LOS is determined by the movement with the worst delay at the intersection.

Table 2-2 Level of Service criteria for intersections

Level of Service	Average Delay per Vehicle (s/veh)	Traffic Signals, Roundabout	Give way and stop signs
A	<14	Good operation	Good operation
B	15 to 28	Good with acceptable delays & spare capacity	Acceptable delays & spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity & accident study required
E	57 to 70	At capacity, at signals, incidents will cause excessive delays	At capacity, requires other control mode
F	>70	Unsatisfactory and requires additional capacity	Unsatisfactory and requires additional capacity

3 Existing conditions

3.1 Travel behaviour within and near the proposal area

Residents within the City of Hawkesbury LGA own more private vehicles on average than residents in Greater Sydney. Figure 3-1 compares the vehicle ownership in the City of Hawkesbury LGA against Greater Sydney in 2021.

There is higher vehicle ownership in the City of Hawkesbury LGA compared to Greater Sydney. Within the City of Hawkesbury LGA, most households own two or more vehicles, with 35.5 per cent owning two motor vehicles and 30.8 per cent owning three or more motor vehicles. In comparison, most households in Greater Sydney have access to one motor vehicle with 38 per cent of total households surveyed as opposed to 31 per cent of households owning two motor vehicles.

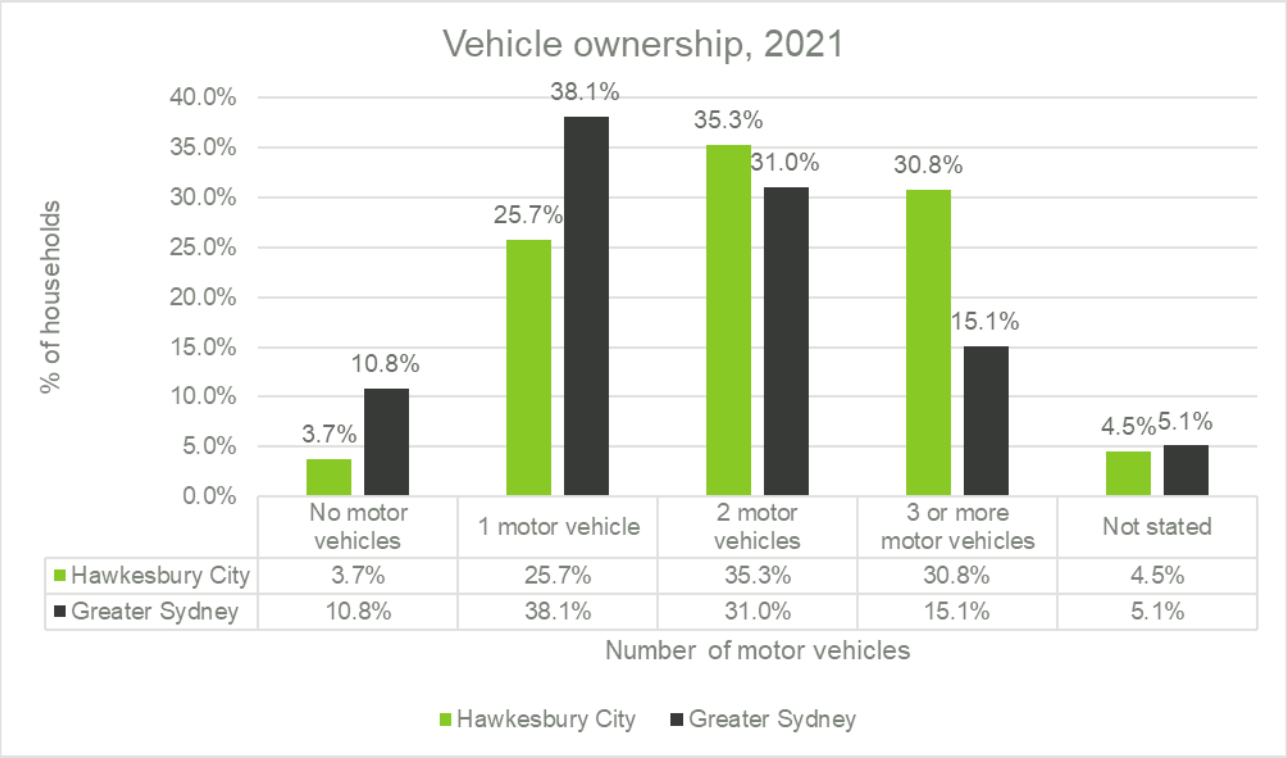


Figure 3-1 Comparison of motor vehicle ownership in 2021 between City of Hawkesbury LGA and Greater Sydney (Source: https://profile.id.com.au/hawkesbury/car-ownership)

The main areas where workers employed within the City of Hawkesbury LGA live and where residents of the City of Hawkesbury LGA work are summarised in Table 3-1 and shown in Figure 3-2. This data shows that 58 per cent of workers in the City of Hawkesbury LGA also live in the area and that 46 per cent of LGA residents work within the same region. This suggests that there is a high number of internal trips within the City of Hawkesbury LGA each day.

Table 3-1 Residential location distribution of local workers and residents within the City of Hawkesbury LGA

Localities	Place of residence of local workers in the City of Hawkesbury LGA	Employment location of City of Hawkesbury LGA residents
Hawkesbury	58 per cent	46 per cent
Blacktown	12 per cent	12 per cent
Penrith	11 per cent	9 per cent
The Hills Shire	6 per cent	7 per cent

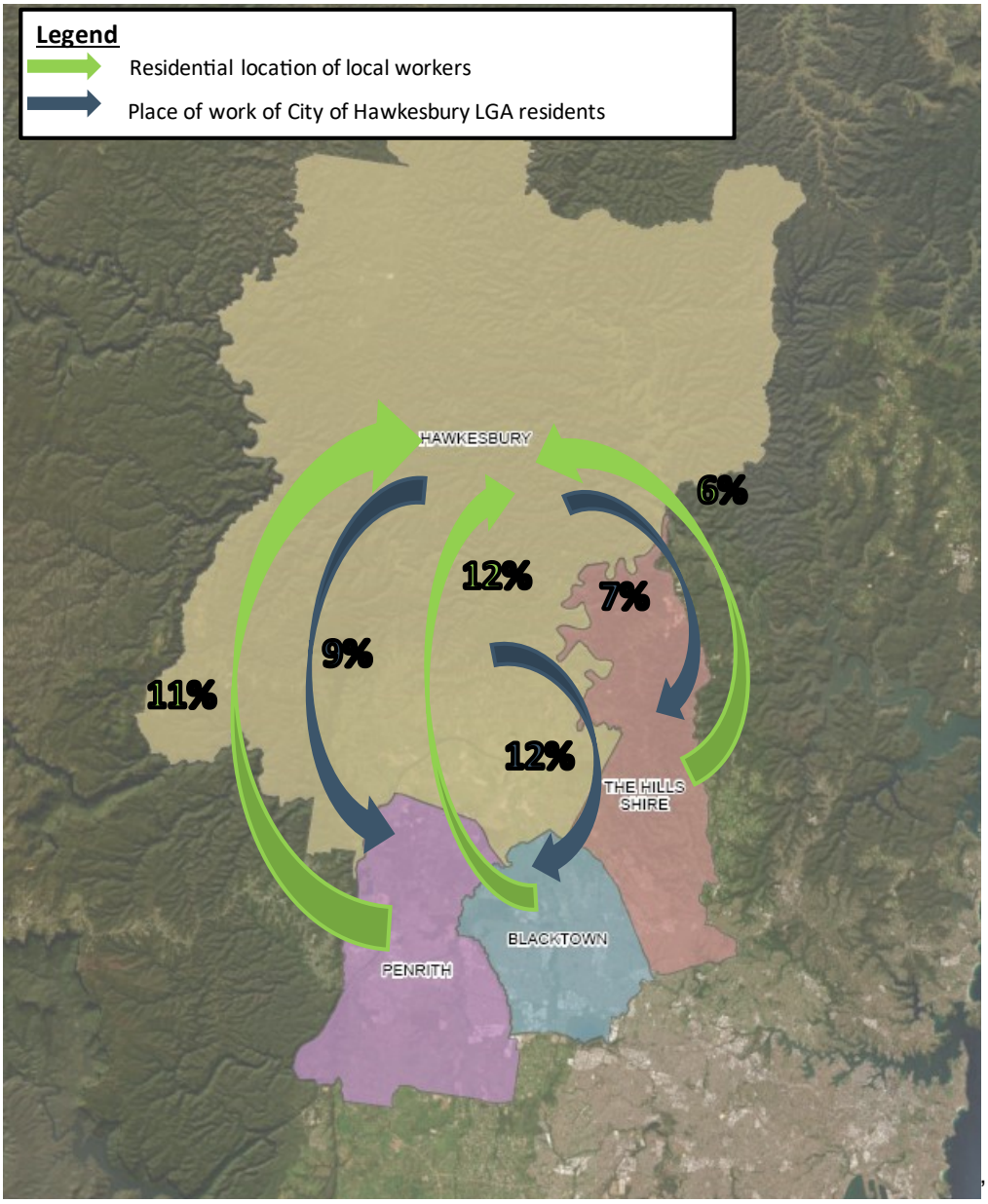


Figure 3-2 Distribution of residential location of local workers within the City of Hawkesbury LGA and the employment location of the residents within the City of Hawkesbury LGA

The following travel characteristics about the modes of transport used by commuters in the City of Hawkesbury LGA were identified:

- The preferred method of travel to work by residents of the City of Hawkesbury LGA and workers travelling to the City of Hawkesbury LGA for work was by car, either as a driver or passenger (53.6 per cent and 56.1 per cent respectively). These percentages are substantially higher than the 36.8 per cent recorded for Greater Sydney.
- A lower proportion of residents in the City of Hawkesbury LGA commute to work by public transport (train, bus, ferry and tram) (1.3 per cent) when compared to Greater Sydney (5.6 per cent).
- Public transport is utilised by only a small portion of the workers travelling to the City of Hawkesbury LGA for work (1.2 per cent), with these journeys mainly being taken by train.
- Bicycle use and walking to work by residents in the City of Hawkesbury LGA were lower than that recorded in the Greater Sydney (0.2 per cent versus 0.4 per cent, and 1.7 per cent versus 2.3 per cent respectively).
- Fewer workers worked from home in the City of Hawkesbury LGA compared to Greater Sydney (25.3 per cent versus 38.9 per cent), which resulted in more trips being generated from the City of Hawkesbury LGA.

Factors contributing to the reliance on private motor vehicles for commuting may include a lower level of public transport access, convenience and limited active transport infrastructure.

Figure 3-3 outlines the transportation modes used by both residents and workers within the City of Hawkesbury LGA to travel to work, compared against Greater Sydney. The 'other' category includes people who worked at home or did not go to work.

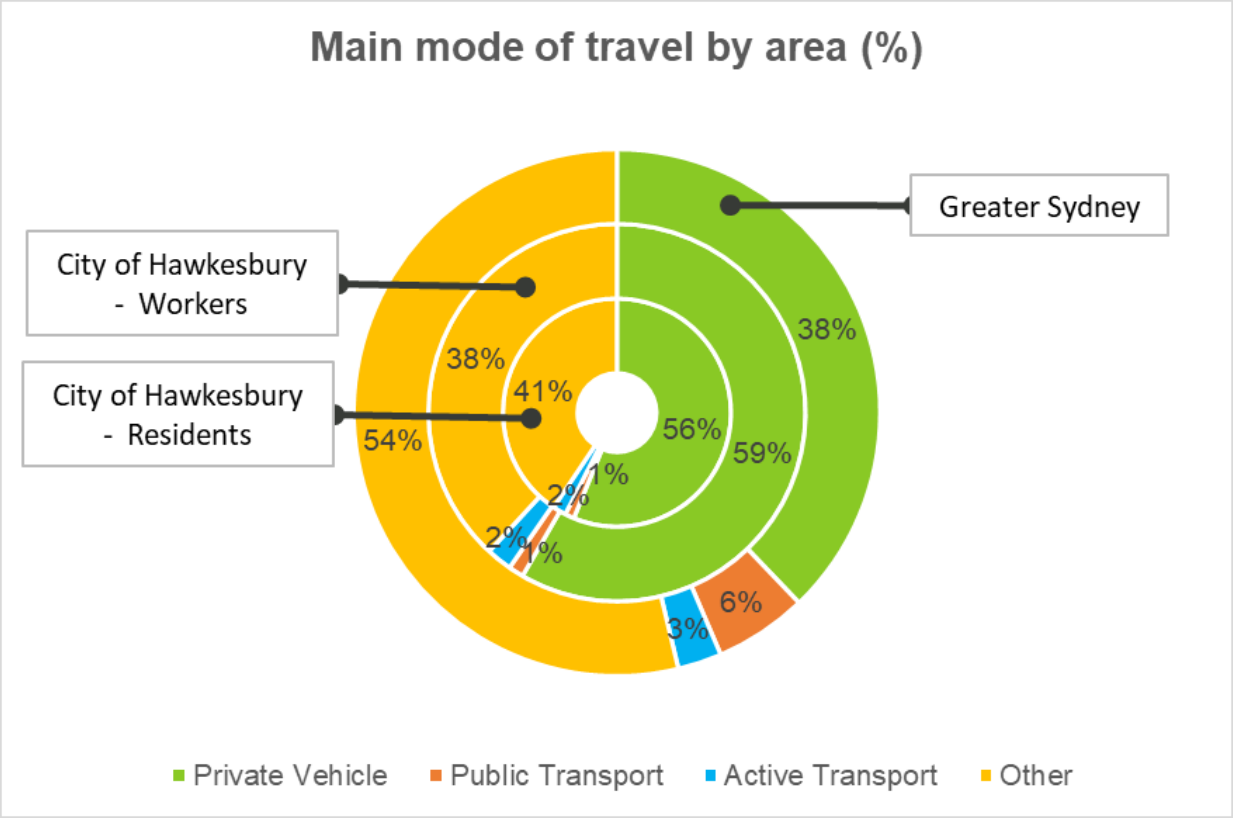


Figure 3-3 Journey to work data (2021) – Mode of transport used by residents and workers of City of Hawkesbury LGA, and Greater Sydney (Source: https://profile.id.com.au/hawkesbury/travel-to-work)

3.2 Road network

3.2.1 Road hierarchy

The traffic and transport assessment study area includes:

- State roads, which form the primary routes for the movement of people and goods within and between major urban centres, comprising:
  - Bells Line of Road, Kurrajong Road, Londonderry Road, Blacktown Road, Castlereagh Road and Hawkesbury Valley Way
  - Windsor Road, between Bourke Street and East Market Street
  - East Market Street, between Windsor Street and Lennox Street
  - Lennox Street, between East Market Street and Bourke Street
  - March Street, between Chapel Street and Kurrajong Road
  - Bosworth Street, between Lennox Street and March Street
- Regional roads, which accommodate travel between smaller towns and districts, and perform a sub-arterial function within major urban centres, comprising:
  - Grose Vale Road and Terrace Road
  - Bourke Street, between Lennox Street and Windsor Street

- March Street, between Bourke Street and East Market Street
- Lennox Street, between East Market Street and Bosworth Street

- Local roads, which provide for local circulation and access to properties, comprising Beaumont Avenue, Southee Road, Inalls Lane, Yarramundi Lane, Old Kurrajong Road, Pitt Lane, Drift Road and The Driftway.

Figure 3-4 outlines the state and regional roads within the study area.

Figure 3-4 Road hierarchy in the vicinity of the proposal (Source: Transport road network classifications map (2023))

3.2.2 Key roads within the proposal area

Key roads that have been identified within the proposal area are outlined in Table 3-2

Table 3-2 Other key roads within the traffic and transport study area

Road	Description
Bells Line of Road	Bells Line of Road is a State road that runs generally in an east-west direction from the Kurrajong Road / Old Kurrajong Road intersection to Bell. It forms part of the B59 arterial route which connects Mulgrave to Lithgow. At the Bells Line of Road / Old Kurrajong Road / Kurrajong Road intersection, B59 continues east towards Richmond as Kurrajong Road. Within the proposal area, Bells Line of Road intersects with Crooked Lane, Charles Street, Grose Vale Road / Terrace Road, Pitt Lane and Old Kurrajong Road. Bells Line of Road is typically configured with one lane in each direction, with additional through and short turning lanes at key intersections. It has a 60 kilometres per hour speed limit between Kurrajong Road to about 200 metres west of Crooked Lane, where it then transitions to a speed limit of 80 kilometres per hour. About 18,300 light vehicles and 2250 heavy vehicles travel through this road daily.
Crooked Lane	Crooked Lane is a local road that runs predominantly in a north-south direction from the intersection with Bells Line of Road to the intersection with Kurmond Road, in the township of North Richmond. It is typically configured with one lane in each direction. It is signposted 70 kilometres per hour. About 3050 light and 480 heavy vehicles travel through this road daily.

Road	Description
Grose Vale Road and Terrace Road	Grose Vale Road and Terrace Road are regional roads that run generally in a north-south direction from the Bells Line of Road / Grose Vale Road / Terrace Road intersection. Grose Vale Road runs south to the intersection with Timms Hill Road in Kurrajong. Terrace Road runs north to the intersection with Kurmond Road in Freemans Reach. Grose Vale Road is typically configured with one lane in each direction with additional lanes and short turning lanes at key intersections. Terrace Road is configured with one lane in each direction. Both roads have a speed limit of 60 kilometres per hour. A school zone 40 kilometres per hour speed limit applies along Grose Vale Road near North Richmond Public School. There is about 17,440 light vehicles and 1450 heavy vehicles travelling through Grose Vale Road daily, while Terrace Road has a daily traffic volume of about 4660 light and 740 heavy vehicles.
Kurrajong Road	Kurrajong Road is a State road that runs generally in an east-west direction from the March Street / Chapel Street intersection to the Bells Line of Road / Old Kurrajong Road intersection. It forms part of the B59 arterial route within Richmond. Kurrajong Road is configured with one lane in each direction. It has an 80 kilometres per hour speed limit, which transitions to 60 kilometres per hour about 250 metres to 300 metres from the March Street and Chapel Street and Bells Line of Road and Old Kurrajong Road intersections. There is about 22,740 light vehicles and 2500 heavy vehicles travelling through Kurrajong Road daily.
Old Kurrajong Road	Old Kurrajong Road is a local road that runs east-west to the north of Kurrajong Road from Windsor Street and turns to run north-south at its western extent to connect with Kurrajong Road and Yarramundi Lane. Old Kurrajong Road is configured with one lane in each direction. It has a merging slip lane for vehicles turning left to Bells Line of Road. It has a 60 kilometres per hour speed limit. About 1760 light and 260 heavy vehicles travel daily through the northern side of Old Kurrajong Road, while about 7800 light and 740 heavy vehicles travel daily through the southern side of Old Kurrajong Road.
Inalls Lane	Inalls Lane is a local road that runs generally in an east-west direction from the intersection with Castlereagh Road and Southee Road to the intersection with Yarramundi Lane. Within the proposal area, Inalls Lane intersects with the Castlereagh Road, Southee Road, Victoria Place, Drift Road and Yarramundi Lane at an at-grade sign-controlled (stop) intersection, with all vehicular turning movements permitted Inalls Lane is configured with one lane in each direction. It is signposted 60 kilometres per hour. There is about 2700 light vehicles and 340 heavy vehicles travelling through Inalls Lane daily.
Castlereagh Road	Castlereagh Road is a State road that runs generally in a north-south direction from the Bosworth Street / Lennox Street intersection to the intersection with the Great Western Highway in Penrith. Within the proposal area, Castlereagh Road intersects with Southee Road and Inalls Lane. It typically has one lane in each direction with additional lanes and short turning lanes at key intersections. It has an 80 kilometres per hour speed limit and transitions to 60 kilometres per hour about 75 metres south of the intersection with Southee Road and Inalls Lane for northbound vehicles. About 6530 light and 790 heavy vehicles travel daily through the northern side of Castlereagh Road, while about 5790 light and 900 heavy vehicles travel daily through the southern side of Castlereagh Road.

Road	Description
Southee Road	Southee Road is a local road that runs generally in an east-west direction from the intersection with Londonderry Road to the Castlereagh Road / Inalls Lane intersection. Within the proposal area, Southee Road intersects Londonderry Road and Castlereagh Road / Inalls Lane. Southee Road typically has one lane in each direction with additional lanes and short turning lanes at key intersections. It has a speed limit of 50 kilometres per hour. About 3100 light and 320 heavy vehicles travel through Southee Road daily.
Londonderry Road	Londonderry Road is a State Road that runs generally in a north-south direction from the College Street / Page Street intersection to the Londonderry Road / Cranebrook Road / The Northern Road roundabout. Within the proposal area, Londonderry Road intersects with Southee Road and Vines Drive. Londonderry Road typically has one lane in each direction. It is signposted 60 kilometres per hour. About 5360 light and 370 heavy vehicles travel daily through the northern side of Londonderry Road from Southee Road, while about 7080 light and 1000 heavy vehicles travel daily through the southern side of Londonderry Road.
Vines Drive	Vines Drive is a private road that runs predominantly in an east-west direction through the Western Sydney University Campus, from the intersection with Londonderry Road to the Resources Road / Clydesdale Lane / Maintenance Lane intersection. It is typically configured with one lane in each direction. It is signposted 40 kilometres per hour. About 3560 light and 190 heavy vehicles travel through Vines Drive daily.

3.2.3 Key intersections within the study area

Table 3-3 summarises the existing key intersections within the traffic and transport study area and their features. The intersections outlined in this table are the existing intersections assessed in the operational traffic assessment (refer to Section 0).

Table 3-3 Key intersections within the traffic and transport study area (Images source: Nearmap)

Name	Image	Layout
Bells Line of Road / Crooked Lane		▪ Sign-controlled (give way) intersection on Crooked Lane. ▪ No safe pedestrian crossing opportunity provided.
Bells Line of Road / Grose Vale Road / Terrace Road		▪ Signalised intersection. ▪ Signalised pedestrian crossings at all approaches. ▪ Dedicated right turning bay at all approaches. ▪ Eastbound merges from two lanes to one lane on the eastern side of this intersection.

Name	Image	Layout
Bells Line of Road / Kurrajong Road / Old Kurrajong Road		■ Sign-controlled (give way) intersection on Old Kurrajong Road. ■ No safe pedestrian crossing opportunity provided. ■ A right turn bay is provided for eastbound traffic on Bells Line of Road turning right onto Old Kurrajong Road ■ A left turn slip lane merges traffic turning left from the southern leg of Old Kurrajong Road with the westbound traffic on Bells Line of Road. ■ Northbound right turn movement from Old Kurrajong Road onto Kurrajong Road is not permitted between 8am to 5pm on weekends. ■ Southbound right turn movement from Old Kurrajong Road onto Bells Line of Road is not permitted between 3pm and 7pm.
March Street / Bosworth Street		■ Signalised intersection. ■ Signalised pedestrian crossings at the north, south and eastern approaches. ■ A short lane is provided at the eastern and western leg of March Street for eastbound and westbound exiting traffic. ■ A short lane is provided at the northern leg of Bosworth Street for northbound exiting and southbound approaching traffic.
Castlereagh Road / Southee Road / Inalls Lane		■ Sign-controlled (stop) intersection. ■ No safe pedestrian crossing opportunity provided, however pram ramps are provided at all corners of the intersection. ■ A left turning bay and slip lane is provided for southbound traffic on Castlereagh Road turning onto Southee Road.

Name	Image	Layout
Londonderry Road / Southee Road / Vines Drive		■ Sign-controlled (give way) intersection. ■ No safe pedestrian crossing opportunity provided. ■ While the western leg of Southee Road and the eastern leg of Vines Drive are not directly aligned, they are in very close proximity to one another with 25 metres separation.
Castlereagh Road / The Driftway		■ Sign-controlled (give way) intersection on The Driftway. ■ No safe pedestrian crossing opportunity provided. ■ Crowleys Lane is located about 80 metres south-west of this intersection along Castlereagh Road.

3.2.4 Freight

The study area is well serviced by roads suitable for heavy vehicles. Figure 3-5 shows the approved freight routes within Richmond and North Richmond for 23 metres and 25 / 26 metres B-Double vehicles. Nineteen metres B-double vehicles (over 50 tonnes) are permitted along the approved routes shown in Figure 3-5 and entirety of Bells Line of Road.

The B59 road network (including Bells Line of Road and Kurrajong Road) is a key route for freight and industrial type business operations that connects urban centres within NSW. Collected traffic count data indicates that freight vehicles in the study area comprises less than six per cent of the total traffic volumes, including four per cent of heavy vehicles and one per cent of B-doubles.

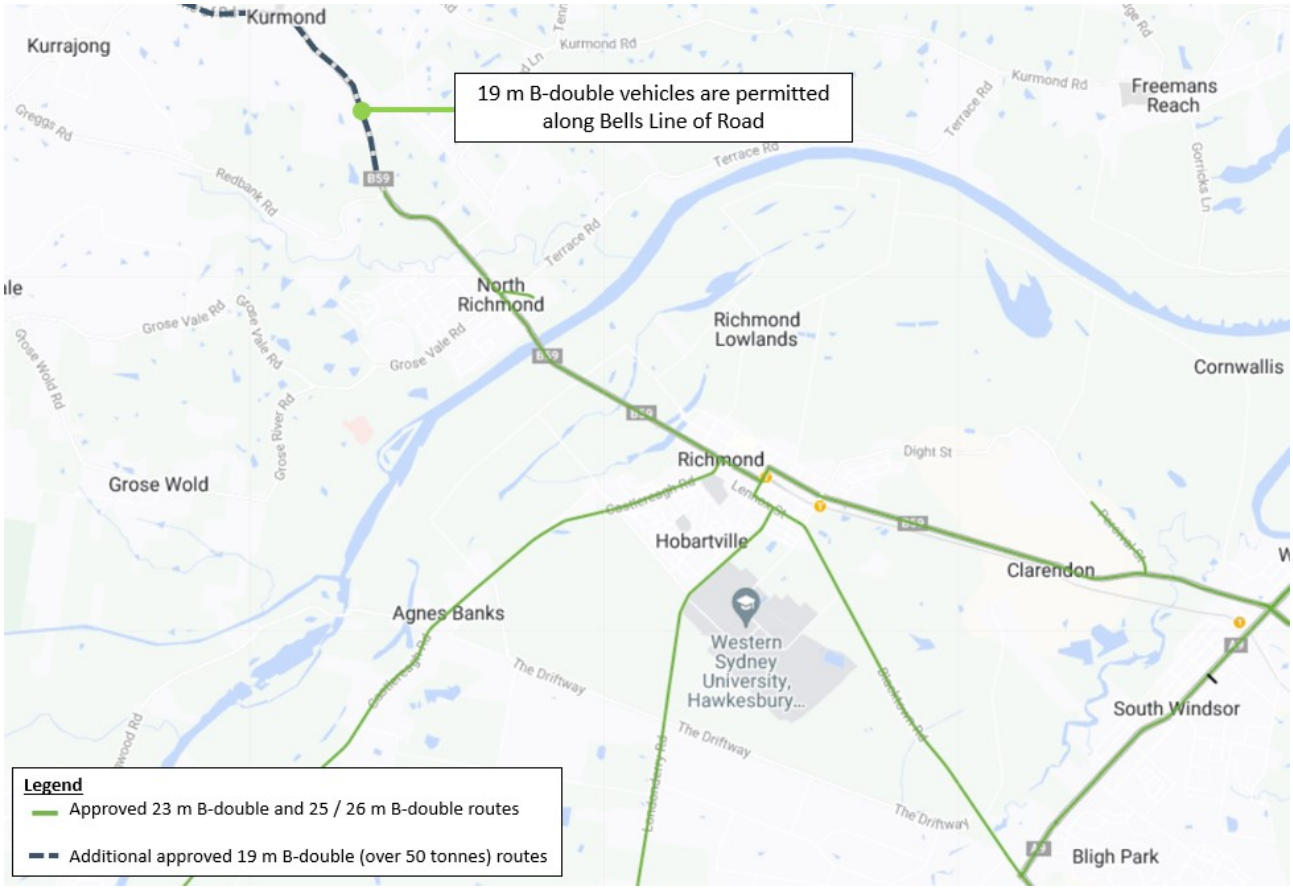


Figure 3-5 Approved heavy vehicle routes (Source: Transport restricted access vehicle (RAV) map)

Table 3-4 presents the combined direction volumes for heavy vehicles at the midblock of key roads. The volumes represent a typical weekday for the AM and PM peak periods. Observed data suggests that the highest number of freight vehicles travel east-west along Bells Line of Road to/from Blacktown Road and Windsor Street. On average, the AM peak period experiences a higher volume of heavy vehicles than the PM peak period.

Table 3-4 Average weekday midblock heavy vehicle volumes - combined directions (Source: Matrix Traffic and Transport Data, February 2023)

Location	Total observed heavy vehicle count	
	7.30–9.30am	3.30am–5.30pm
Bells Line of Road	309	245
Old Kurrajong Road	6	6
Inalls Lane	31	35
Southee Road	29	17

3.2.5 Intersection performance

The following seven intersections were evaluated on their existing operational performance (refer to Figure 3-6 for locations):

- Bells Line of Road / Grose Vale Road / Terrace Road (Location 1)
- Kurrajong Road / Old Kurrajong Road / Bells Line of Road (Location 2)
- March Street / Bosworth Street (Location 3)
- Castlereagh Road / Inalls Lane / Southee Road (Location 4)
- Southee Road / Valder Avenue (local road connection) (Location 5)
- Southee Road / Londonderry Road (Location 6)
- Castlereagh Road / The Driftway (Location 7)

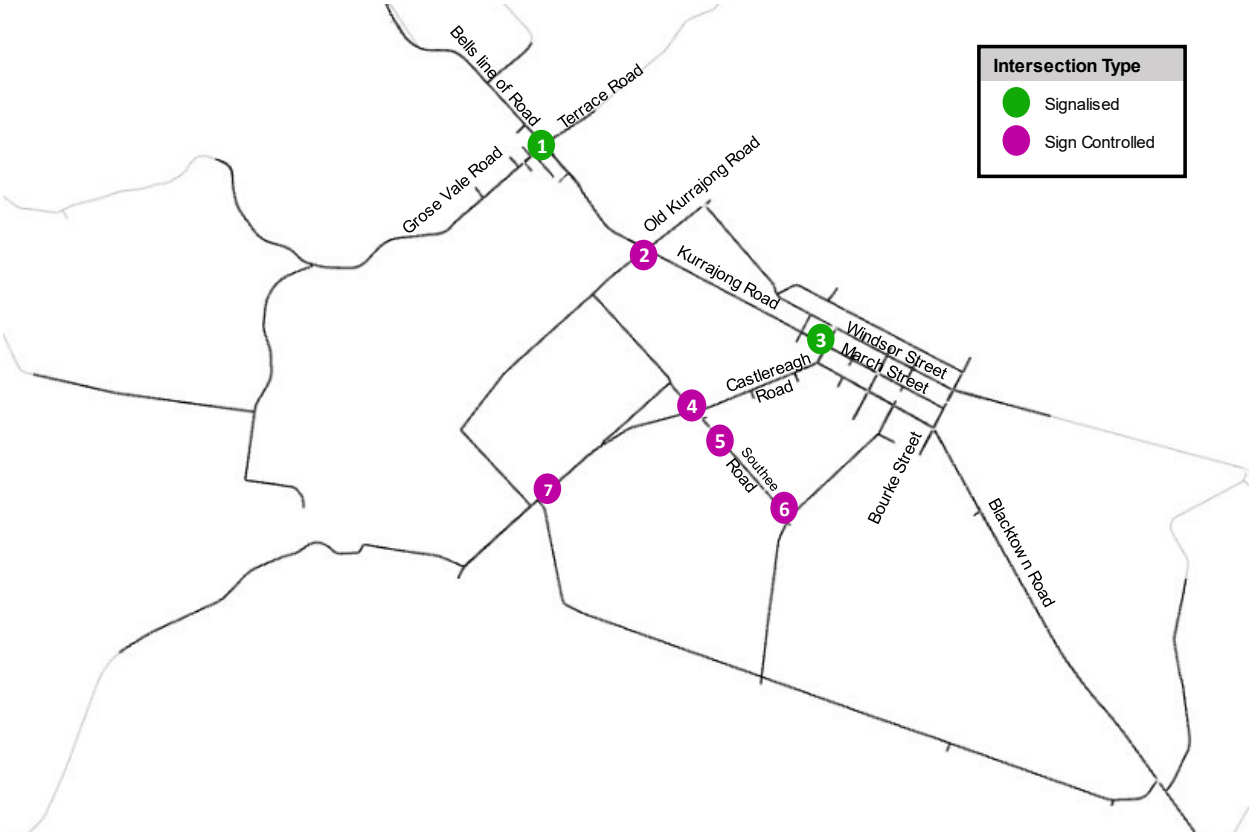


Figure 3-6 Key study area intersections for operational performance assessment

The operational traffic performance of key intersections within the study area as per the existing model results for the 2023 peak periods are presented in the following sections.

AM Peak

The LOS has been analysed during 7.30–8.30am and 8.30–9.30am at the eight key intersections. Table 3-5 presents the delay and LOS summary at intersection level during the weekday AM Peak period. The detailed results per individual movement are presented in Appendix C.

Table 3-5 Intersection performance 2023 AM Peak – Level of Service

ID	Intersection	Control type	7.30–8.30am			8.30–9.30am		
			Volume	Delay (s)	LOS	Volume	Delay (s)	LOS
1	Bells Line of Road / Grose Vale Road / Terrace Road	Signal	2,335	102	F	2,295	94	F
2	Kurrajong Road / Old Kurrajong Road / Bells Line of Road	Priority	2,337	88	F	2,337	124	F
3	March Street / Bosworth Street	Signal	2,044	40	C	2,183	57	E
4	Castlereagh Road / Inalls Lane / Southee Road	Priority	752	14	A	727	16	B
5	Southee Road / Valder Avenue (Local road connection)	Priority	281	7	A	262	6	A
6	Southee Road / Londonderry Road	Priority	650	7	A	623	6	A
7	Castlereagh Road/ The Driftway	Priority	876	27	B	822	11	A

The performance results of the intersection align with the observations made on site, as follows:

- Bells Line of Road / Grose Vale Road / Terrace Road (Location 1) – The intersection performs at a LOS F in both AM peak hours. During the morning peak period, the main traffic movement was in the eastbound direction, heading into the Richmond CBD. Heavy queues and delays were experienced by eastbound and northbound motorists at this intersection. The traffic from these approaches struggled to pass through the intersection resulting in excessive queuing. These delays were due to intersection capacity constraints and the merge located about 200 metres east of the intersection on Bells Line of Road.

- Kurrajong Road / Old Kurrajong Road / Bells Line of Road (Location 2) – The intersection performs at a LOS F based on the delay experienced by northbound vehicles on Old Kurrajong Road waiting to cross Kurrajong Road. Traffic along Bells Line of Road / Kurrajong Road operates at LOS A during the first AM peak hour and LOS B during the second AM peak hour. Congestion is worse along Bells Line of Road after the Grose Vale Road / Terrace Road intersection than east of the intersection along Kurrajong Road.
- March Street / Bosworth Street (Location 3) – This intersection is a bottleneck for eastbound traffic during the morning peak. This is reflected in the LOS E during second hour, indicating that the intersection operates at capacity.
- Castlereagh Road / Inalls Lane / Southee Road (Location 4) – The eastbound right turn from Inalls Lane onto Castlereagh Road would perform at a LOS A during the first hour and LOS B during the second hour, indicating a good level of performance during the AM peak period.
- Southee Road / Valder Avenue (Local road connection) (Location 5) – The westbound right turn from Southee Road onto Valder Avenue operating at LOS A during both the first and second AM peak hours, indicating a good level of intersection performance.
- Southee Road / Londonderry Road (Location 6) – The eastbound right turn movement from Southee Road onto Londonderry Road operates at LOS A during both the first and the second AM peak hour, indicating a good level intersection performance.
- Castlereagh Road / The Driftway (Location 7) – The westbound right turn from The Driftway onto Castlereagh Road operates at LOS B during the first peak hour. During the second AM peak hour, westbound left turn movement from The Driftway onto Castlereagh Road operates at LOS A, indicating a good level intersection performance.

PM Peak

The LOS has been analysed during 3.30–4.30pm and 4.30–5.30pm at the eight key intersections. Table 3-6 presents the delay and LOS summary at intersection level during the weekday PM Peak period. Detailed results for individual movements are presented in Appendix C.

Table 3-6 Intersection performance 2023 PM Peak – Level of Service

ID	Intersection	Control type	3.30–4.30pm			4.30–5.30pm		
			Volume	Delay (s)	LOS	Volume	Delay (s)	LOS
1	Bells Line of Road / Grose Vale Road / Terrace Road	Signal	2,586	43	D	2,657	44	D
2	Kurrajong Road / Old Kurrajong Road / Bells Line of Road	Priority	2,447	173	F	2,513	177	F
3	March Street / Bosworth Street	Signal	2,110	54	D	2,071	52	D
4	Castlereagh Road / Inalls Lane / Southee Road	Priority	967	18	B	1,090	19	B
5	Southee Road / Valder Avenue (Local road connection)	Priority	275	6	A	322	4	A
6	Southee Road / Londonderry Road	Priority	720	9	A	775	10	A
7	Castlereagh Road/ The Driftway	Priority	1,110	28	B	1,100	25	B

The performance results of the intersection align with the observations made on site, as follows:

- Bells Line of Road / Grose Vale Road / Terrace Road (Location 1) – This intersection is a bottleneck for westbound traffic during the PM peak period. This is reflected in the LOS D during both PM peak hours, with delays of 43 seconds experienced during the first hour and 44 seconds experienced during the second hour. This indicates that the intersection operates near capacity.
- Kurrajong Road / Old Kurrajong Road / Bells Line of Road (Location 2) – The intersection performs at LOS F in both PM peak hours. The main traffic flow is in the westbound direction, approaching from the east and south towards North Richmond. At this intersection, heavy delays are experienced by westbound motorists approaching the intersection, especially during the second hour, due to vehicles turning left from Old Kurrajong Road onto Bells Line of Road and merging with westbound traffic on Bells

Line of Road about 70 metres west of this intersection. The westbound traffic turning right from Old Kurrajong Road into Bells Line of Road experience heavy traffic during the first and second hour, despite carrying a low volume of traffic.

- March Street / Bosworth Street (Location 3) – The intersection performs at LOS D in both PM peak hours, with delays of 54 seconds experienced in the first peak hour and 52 seconds experienced in the second peak hour. This indicates that the intersection operates at near capacity.
- Castlereagh Road / Inalls Lane / Southee Road (Location 4) – The intersection performs at LOS B during both peak hours, indicating there are acceptable delays and spare capacity during the PM peak.
- Southee Road / Valder Avenue (Local road connection) (Location 5) – The intersection performs at LOS A during both peak hours, indicating a good level of intersection performance.
- Southee Road / Londonderry Road (Location 6) – The intersection performs at LOS A during both peak hours, indicating a good level of intersection performance.
- Castlereagh Road / The Driftway (Location 7) – The intersection performs at LOS B during both peak hours, indicating there are acceptable delays and spare capacity during the PM peak.

3.3 Crash data analysis

Historical crash data between 2017 and 2021 has been reviewed for the City of Hawkesbury LGA to identify current crash trends and issues within the traffic and transport study area. Over the five-year period, 111 crashes occurred in the study area, of which around 50 per cent (56 crashes) resulted in injuries. Table 3-7 outlines the number and type of crashes throughout the study area. Figure 3-7 shows the crash location and severity.

Table 3-7 Study area detailed crash history (2017 to 2021) (Source: Transport Centre for Road Safety)

Location	Incident with injury	Incident without injury (towaway)	Total
Bells Line of Road	13	6	19
Bells Line of Road / Cooked Lane intersection	3	1	4
Bells Line of Road / Pitt Lane intersection	0	1	1
Bells Line of Road / Grose Vale Road / Terrace Road intersection	1	2	3
Bells Line of Road / Kurrajong Road / Old Kurrajong Road	4	3	7
Grose Vale Road	2	5	7
Terrace Road	0	1	1
Kurrajong Road	7	4	11
Kurrajong Road / March Street / Chapel Street intersection	3	1	4
March Street (between Kurrajong Road / Chapel Street intersection and West Market Street intersection)	1	2	3
March Street / Bosworth Street intersection	12	11	23
March Street / West Market Street intersection	1	4	5
Inalls Lane	1	2	3
Inalls Lane / Drift Road intersection	0	4	4
Inalls Lane / Castlereagh Road / Southee Road intersection	5	3	8
Castlereagh Road	0	1	1
Southee Road	1	3	4
Londonderry Road	2	1	3
Total	**56**	**55**	**111**

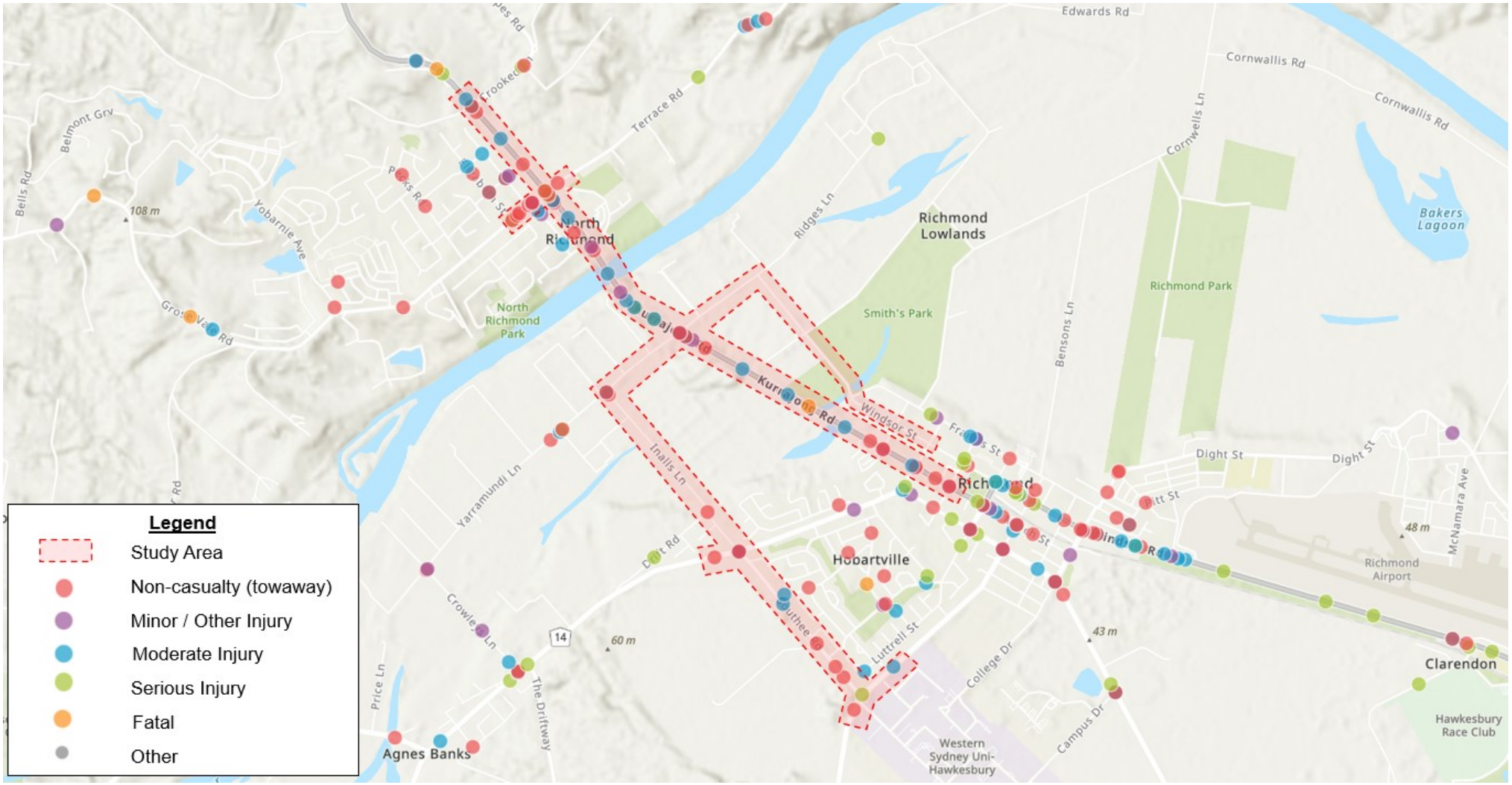


Figure 3-7 Crash history (2017 to 2021) locations and severities within traffic and transport study area (Source: Transport Centre for Road Safety)

Figure 3-8 outlines the type of crashes within the study area during the same period. ‘Right through’ crashes (where a motorist is turning right and crashes into a vehicle travelling in the opposite direction) make up 23 per cent of the total crashes within the study area. ‘Cross traffic’ crashes (where vehicles crash at about 90 degrees) make up 18 per cent of total crashes and ‘rear end’ crashes make up 14 per cent of total crashes. Crashes classified as ‘other’ include crash types with a less than 5 per cent incidence.

The key trends observed in the recorded crash data within the study area are:

- The March Street / Bosworth Street intersection had the highest number of crashes of all locations within the study area, with a record of 23 crashes during the five-year period. The most common crashes were ‘right through collisions’, occurring 11 times, which resulted in five serious injuries during the five-year period.
- Eight crashes were recorded at the Inalls Lane / Castlereagh Road / Southee Road intersection. ‘Cross traffic collisions’ dominated the crashes at this intersection, occurring seven times throughout the five-year period. These crashes resulted in moderate or non-injury accidents, and all occurred during daylight conditions.
- The Bells Line of Road / Kurrajong Road / Old Kurrajong Road intersection experienced the third highest number of crashes, with seven recorded crashes. ‘Cross traffic collisions’ dominated the crashes at this intersection, occurring six times during the five-year period, with two of the crashes resulting in serious injuries. All six crashes occurred during dark light conditions.
- The Bells Line of Road / Kurrajong Road corridor experienced 30 crashes during the five-year period. 13 rear end collisions occurred along this corridor during the five-year period. A single crash involving a pedestrian walking occurred to the west of the Bells Line of Road / Kurrajong Road / Old Kurrajong Road intersection and resulted in serious injury. One fatal crash was also recorded within the study area on Kurrajong Road between the Bells Line of Road / Old Kurrajong Road intersection and the March Street / Chapel Street intersection in 2019. This involved a vehicle coming off the carriageway and crashing into an object / parked vehicle. The crash occurred during dark lighting conditions and resulted in two fatalities.

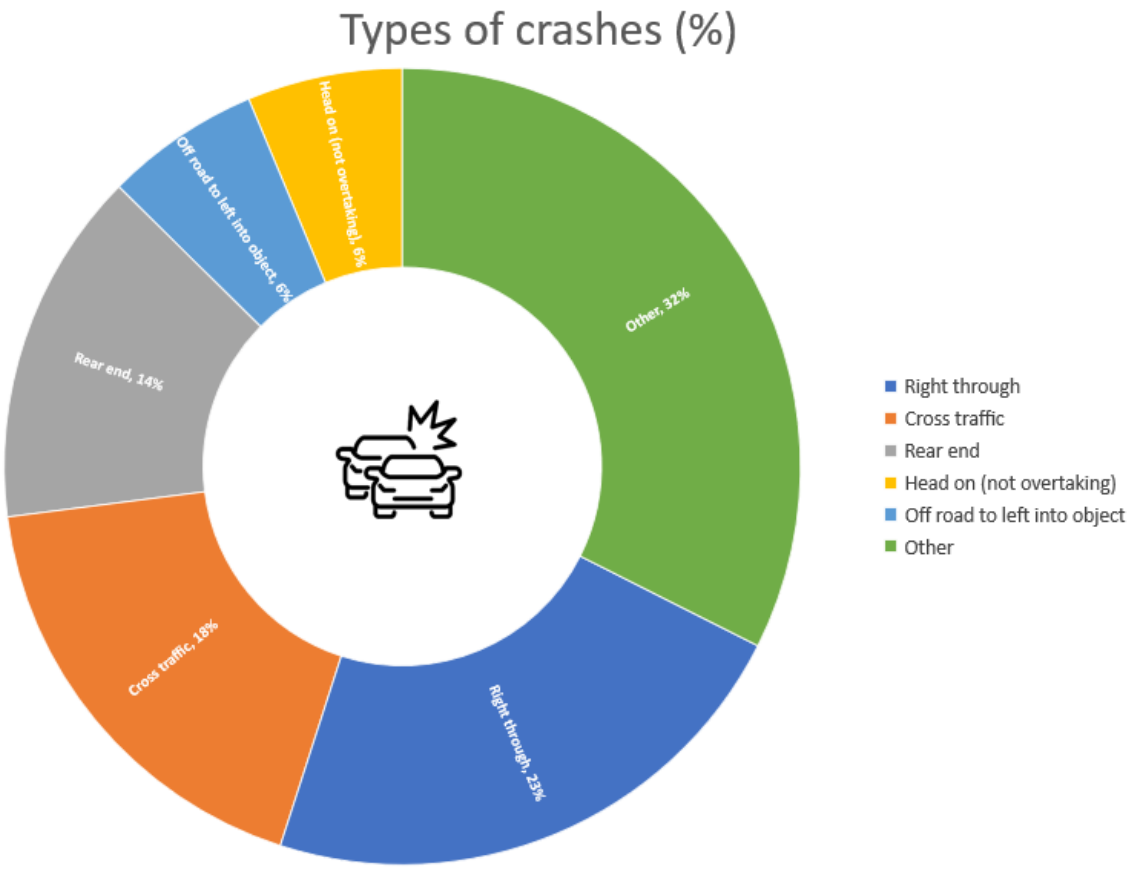
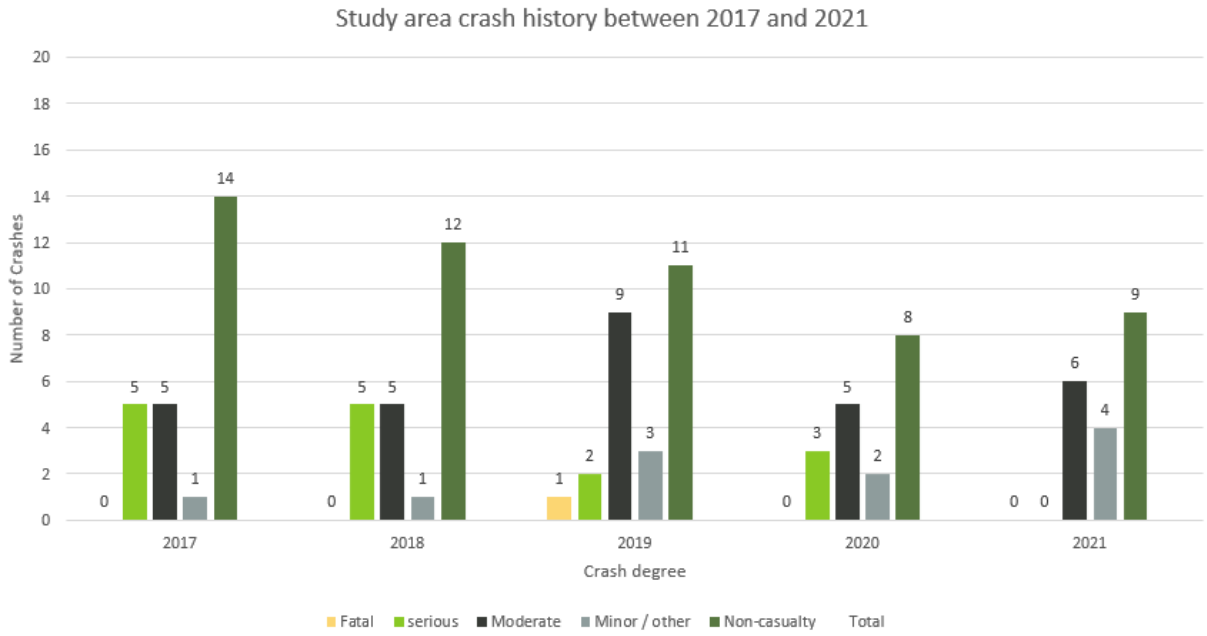


Figure 3-8 Crash history (2017 to 2021) by type in study area (Source: Transport Centre for Road Safety)

Figure 3-9 shows annual crash history between 2017 and 2021 in the study area. Between 2017 and 2019, non-injury crashes experienced a downward trend. However, in 2019 there was a slight increase in the number of crashes resulting in moderate injuries. 2020 and 2021 experienced a lower number of crashes, however this may be attributed to the Stay-at-Home orders in place due to the COVID-19 pandemic.



	2017	2018	2019	2020	2021
Total	25	23	26	18	19

Figure 3-9 Annual crash history (2017 to 2021) in study area (Source: Transport Centre for Road Safety)

In addition, the Hawkesbury LGA represents two to three per cent of the total crashes in the Greater Sydney area and one per cent of the total crashes across NSW. The Hawkesbury LGA has a similar distribution of degree of crashes when compared to the distributions across both Greater Sydney and NSW. A proportionally higher amount of 'non-injury' crashes were recorded in the Hawkesbury LGA compared to Greater Sydney and NSW.

3.4 Parking considerations

3.4.1 North Richmond

There are 80 on-street car parking spaces available within the proposal area in North Richmond, comprised of:

- 50 unrestricted parking spaces on Terrace Road, Beaumont Avenue and Pitt Lane
- eight 1P restricted parking spaces on Pitt Lane
- seven 1/2P restricted parking spaces on Grose Vale Road
- 15 1/4P restricted parking spaces on Bells Line of Road.

The actual usable parking spaces are dependent on vehicle lengths and space left between vehicles.

A site visit was carried out on 4 May 2023 to identify on-street parking availability. The on-street parking spaces were observed to not be fully utilised near the Bells Line of Road / Grose Vale Road / Terrace Road intersection. The unrestricted on-street parking along the western side of Terrace Road, 1/4P on-street parking along the northern side of Bells Line of Road and on-street parking on Pitt Lane were highly utilised. These parking spaces are closer to commercial, retail and motor vehicle servicing businesses, including the North Richmond Heritage Plaza.

3.4.2 Richmond

There are 66 unrestricted on-street parking spaces within the proposal area in Richmond on Drift Road, Victoria Place, Castlereagh Road and Southee Road, assuming vehicles do not park within 10 metres of intersections. The actual usable parking spaces are dependent on vehicle lengths and space left between vehicles.

There was generally low utilisation of parking spaces observed during the site visit. This aligns with the residential nature of the proposal area within Richmond.

3.5 Public transport

3.5.1 Rail network

The traffic and transport study area encompasses two rail stations, both in Richmond (as shown in Figure 3-10). They are:

- Richmond Station – located east of East Market Street, between the March Street and Windsor Street intersections
- East Richmond Station – located east of Bourke Street, between the March Street and Windsor Street intersections.

Figure 3-10 Rail stations in traffic and transport study area (Background image source: Nearmap)

Both train stations are serviced by the following passenger train lines:

- **T1 – North Shore & Western Line** which operates between Richmond Station and Central Station.
- **T5 – Cumberland Line** which operates between Richmond Station and Leppington Station.

Train service frequency from Richmond Station is typically at 30 minute intervals during both peak and off peak periods. All train services travelling to and from Richmond Station also stop at East Richmond Station. The trains that operate on the T5 – Cumberland Line only service Richmond Station and East Richmond Station during the evenings.

Commuter car parking is available near both the Richmond Station and East Richmond Stations, including a car park north of Richmond Station which can accommodate 195 vehicles and a car park north-west of East Richmond Station which can accommodate 52 vehicles.

A level crossing is provided directly to the east of the East Richmond Station, to facilitate train and vehicular movements across Bourke Street.

3.5.2 Bus network

Busways and CDC NSW operate commuter bus services in the Richmond and North Richmond area. These existing bus services are listed in Table 3-8, and presented in Figure 3-11 along with the existing bus stops along the routes.

Table 3-8 Existing bus services within the traffic and transport study area

Bus Service	Route
668	Operates between Windsor and Richmond via Wilberforce & Glossodia
675A	(Loop service) Operates between Windsor and Richmond via RAAF Base Richmond & Bligh Park
675C	
677	Operates between Richmond and Penrith via Londonderry
678	Operates between Richmond and Penrith via Cranebrook
680	(Loop service) Operates between Richmond and Bowen Mountain via Grose Vale & Grose Wold
682	(Loop service) Operates between Richmond and Kurrajong via Berambing
N71	(Night service) Operates between Richmond and City Town Hall via Parramatta

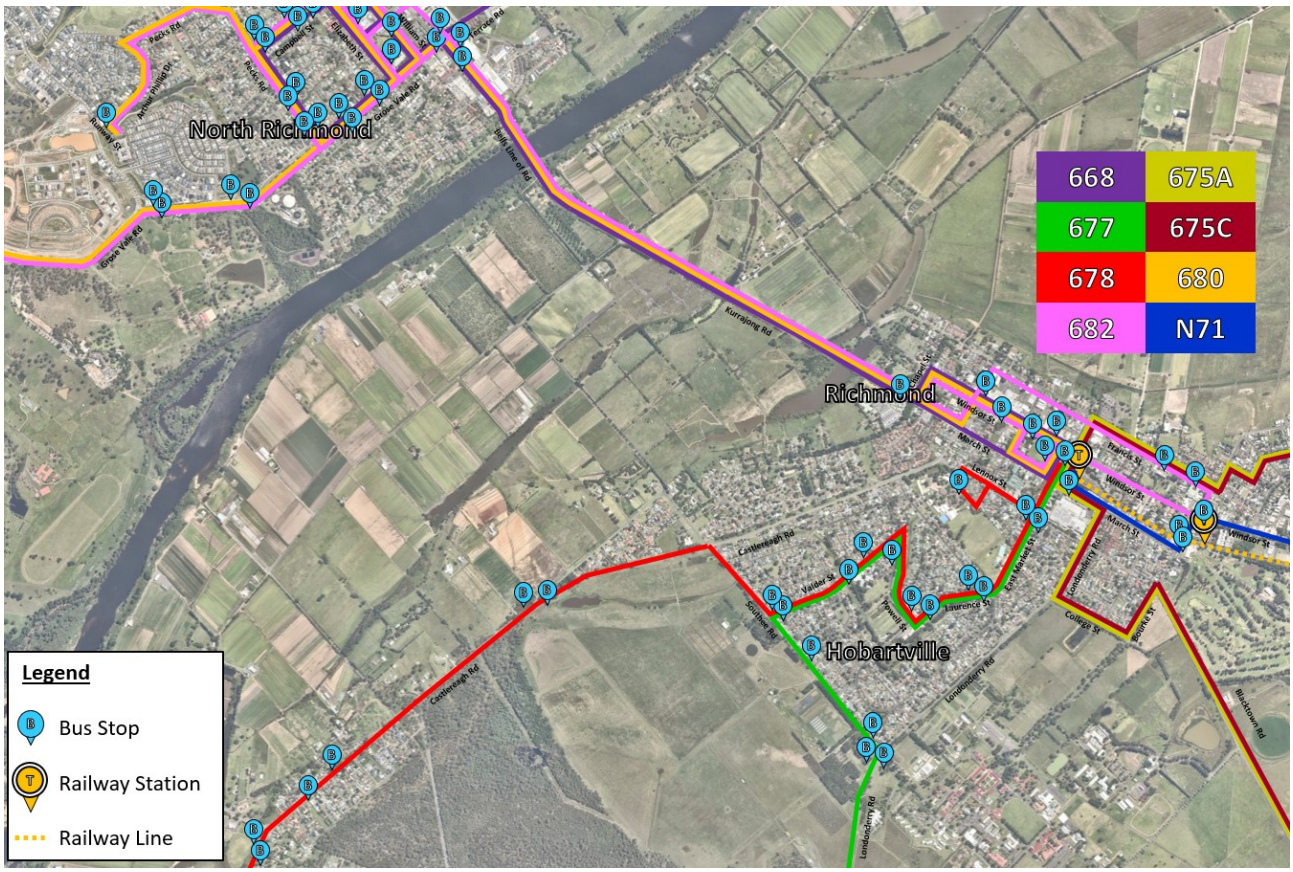


Figure 3-11 Existing bus services and bus stops within the traffic and transport study area (Background image source: Nearmap)

These services operate at low frequencies during the AM and PM peak periods. The time between each service varies for each bus route and ranges from about one service every 40 minutes to 120 minutes. Service frequency along Richmond Bridge is of four buses during the AM and PM peak periods in each direction of traffic.

Twenty-seven school bus routes also operate within the traffic and transport study area in the morning period and 30 school bus routes operate in the afternoon period. These routes offer service to schools in Richmond, North Richmond and the surrounds.

Opal data for bus stops located within the study area, including within Hobartville and Richmond was reviewed for the period of 1 May 2023 to 31 May 2023. The average total bus stop passenger activity for weekdays is shown in Figure 3-12 and for weekends is shown in Figure 3-13. These figures indicate the number of passengers that tapped on and tapped off at each location during this period. During this period, there was low bus utilisation recorded at the bus stops throughout the proposal area. The highest bus stop utilisation, during both weekdays and weekends, was recorded in North Richmond along Bells Line of Road.

Figure 3-12 Average total weekday bus stop passenger activity in Richmond and North Richmond (Background image source: TomTom)

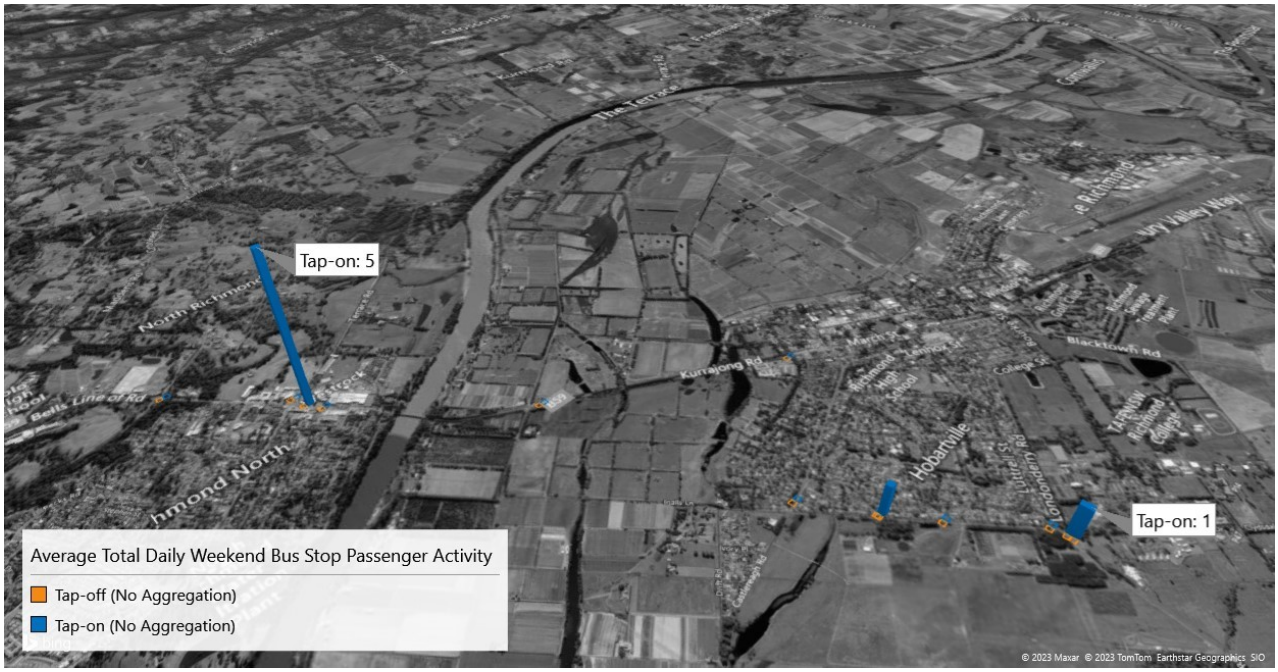


Figure 3-13 Average total weekend bus stop passenger activity in Richmond and North Richmond (Background image source: TomTom)

3.6 Active transport

3.6.1 Pedestrian infrastructure

There are integrated networks of active transport connections in both Richmond and North Richmond along the main routes in the town centres. Pedestrian infrastructure currently includes an array of amenities, including footpaths, pedestrian crossings and traffic signal-controlled crossings. Traffic signal-controlled pedestrian crossings are located at critical intersections characterised by a high traffic flow such as at the March Street / Bosworth Street intersection in Richmond and the Bells Line of Road / Grose Vale Road / Terrace Road intersection in North Richmond.

However, there are limited existing footpath networks between North Richmond and Richmond. There are existing footpaths along the eastern and western sides of Bells Line of Road including an informal pedestrian refuge crossing from the Westrock industrial premises (on the eastbound side of the road) to the North Richmond Heritage Plaza (on the westbound side). Additionally, there is a section of existing footpath in Hanna Park that extends to the existing Richmond Bridge footpath and continues along Bells Line of Road (on the westbound side) for about 50 metres until it reaches Old Kurrajong Road. There is no continuous footpath between this point and Richmond. In Richmond, the existing footpath starts at the Kurrajong Road / Chapel Street intersection, then extends east into March Street and continues through the Richmond town centre. There are no formal pedestrian pathways along Southee Road, Castlereagh Road, Inalls Lane, Kurrajong Road, Old Kurrajong Road and sections of Bells Line of Road. The existing pedestrian infrastructure is shown in Figure 3-14.

Figure 3-14 Existing pedestrian infrastructure (Background image source: Nearmap)

3.6.2 Cyclist infrastructure

In addition to the network of pedestrian footpaths, there are on-street and off-street cycling routes within the traffic and transport study area. Figure 3-15 shows the cycling infrastructure, which comprises the following:

- shared paths, which are for shared use by pedestrians and cyclists, including sections of Bourke Street, College Drive and Bells Line of Road in North Richmond
- general roads, where bicycles share space with motor vehicles (mixed traffic), buses (bus lane) or parked cars (parking lane), including Castlereagh Road, March Street, Southee Road, Londonderry Road, Inalls Lane, Kurrajong Road, Old Kurrajong Road, Grose Vale Road and sections of Bells Line of Road
- road shoulders, including Blacktown Road and The Driftway.

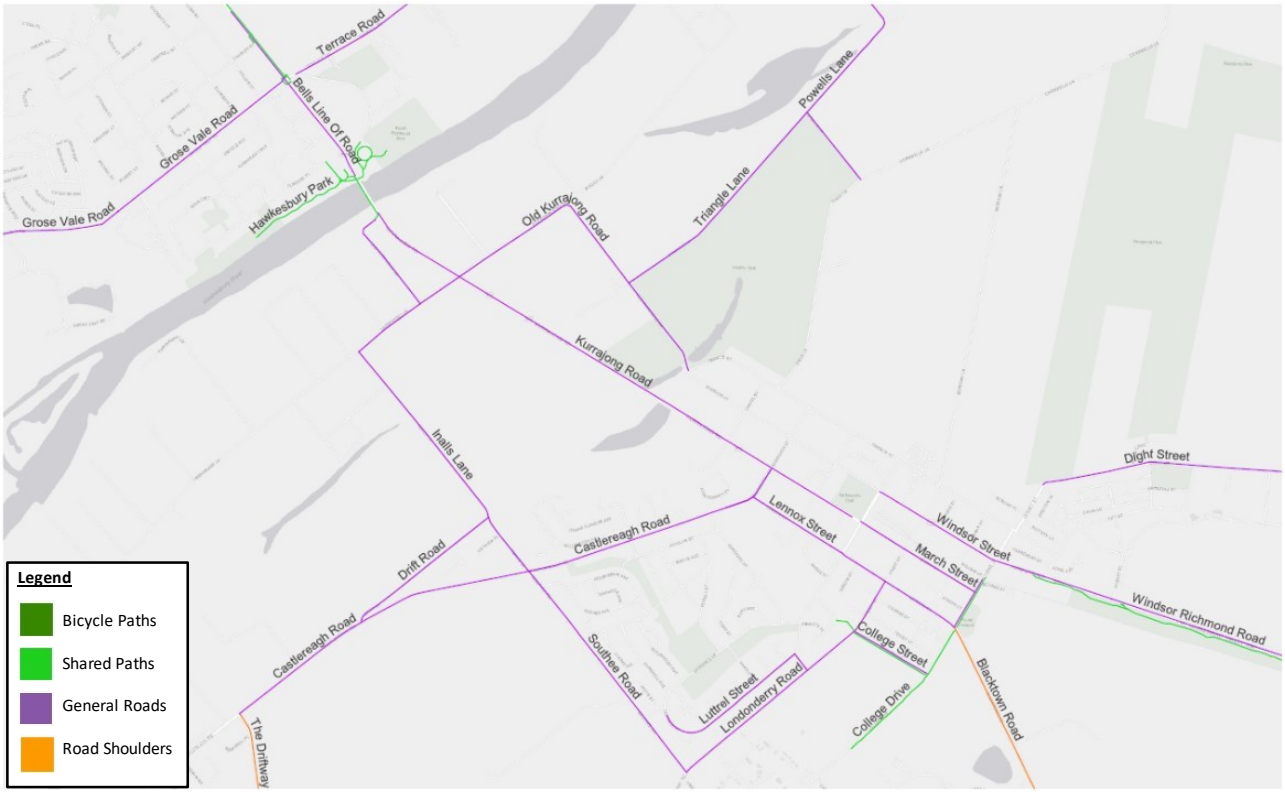


Figure 3-15 Cyclist infrastructure available within the study area (Source: Transport Cycleway Finder map)

In Richmond and North Richmond, cyclists are mainly required to use on-street, mixed traffic routes. These environments generally consist of high traffic volume roads and dark lighting conditions which are likely to discourage inexperienced riders. In Richmond, there are cycling routes within line marked parking areas that are only marginally wider than the parked vehicles, which creates the potential for interactions between parked vehicles and cyclists. An example of this is shown Figure 3-16 along Windsor Street.

Figure 3-16 Parking lane cycling facility along Windsor Street, Richmond

The existing Richmond Bridge currently provides a 1.6 metre wide footpath along the western side of the bridge (as shown in Figure 3-17). This is not wide enough to allow for active transport users to pass one other.

Figure 3-17 Pathway along the existing Richmond Bridge

There is also no road lighting provided along Kurrajong Road and Bells Line of Road between Richmond and North Richmond. This may also discourage commuters from choosing active transportation.

3.7 Emergency vehicles

There are currently no emergency services located in North Richmond. Any emergency services that require access to North Richmond currently cross either the existing Richmond Bridge (for the most direct route from Richmond) or Windsor Bridge.

4 Impact assessment

4.1 Construction impacts

4.1.1 Impacts on the road network

The proposal would generate light and heavy vehicle movements on the surrounding road network, associated with the delivery or removal of construction materials and equipment and construction worker movements to and from the proposal area. This would result in construction traffic impacts throughout the duration of construction (about three years for Stage 2A and about two years for Stage 2B).

The construction traffic for delivery or removal of construction materials and equipment would be staged throughout the day. Construction workers would generally arrive at the start of each shift and leave at end of each shift. Table 4-1 provides the expected construction vehicles numbers during construction of Stage 2A and Stage 2B.

Table 4-1 Expected construction traffic on the study area – Stage 2A and Stage 2B

Vehicle type	Typical peak – Vehicle movements				Peak construction period – Vehicle movements			
	Average per day	AM peak	PM peak	Off peak	Average per day	AM peak	PM peak	Off peak
Stage 2A								
Light vehicles	200	10[1]	90[2]	20	400	20[1]	180[2]	20
Light construction vehicles[3]	100	18	18	64	120	22	22	76
Heavy vehicles[3]	65	12	12	41	75	14	14	47
Stage 2B								
Light vehicles	160	8[1]	72[2]	20	240	12[1]	108[2]	20
Light construction vehicles[3]	80	15	15	50	100	18	18	64
Heavy vehicles[3]	60	11	11	38	70	13	13	45

Note 1: 90 per cent of construction personnel are assumed to arrive before start of construction hours and the start of the AM peak.

Note 2: 90 per cent of construction personnel are assumed to leave the site during the PM peak.

Note 3: Light and heavy construction vehicles are assumed to be distributed uniformly across construction hours (7:00 AM to 6:00 PM)

The proposal area is well serviced by a road network suitable for heavy vehicles and is expected to be able to accommodate the vehicles required during construction. Construction vehicles accessing the proposal area are not expected to result in substantial impacts to the existing traffic movements near the proposal due to the relatively low number of vehicle movements compared to the existing traffic volumes. As a result, access to and use of public transport, active transport connections, local roads, local properties and intersections are not expected to be substantially impacted by construction vehicles accessing the proposal area.

The Bells Line of Road corridor through North Richmond is quite narrow, with limited shoulders, meaning that construction vehicles have limited space to stop. Roads such as Terrace Road would be used to access ancillary facility A and turn around during construction of both stages of the proposal. East of the Hawkesbury River, within the extent of work for Stage 2A, the road reserves have a greater shoulder width available for construction.

Construction traffic may also circulate around the proposal area via the following roads:

- Londonderry Road
- The Driftway
- Castlereagh Road
- Crowleys Lane
- Yarramundi Lane.

Construction activities related to utility relocation, offline construction and finishing work (including landscaping and final asphalting, which would occur during off-peak periods) will be staged to minimise traffic disruptions and to allow for the safe construction of the proposal. While traffic would largely be accommodated on the existing road network, temporary traffic management and short-term network changes may be required to maintain traffic performance. As construction progress, traffic switches to shift traffic onto completed sections of road would occur and would further improve the road network performance. As such, there would not be substantial construction traffic impacts during the AM and PM peak periods during construction.

Stage 2A

During construction of Stage 2A, construction activities would mostly be carried out offline, except for early works along the existing Richmond Bridge, near tie-in areas and work along Bells Line of Road. Early works would involve the installation of compliant handrails to facilitate the bridge becoming a safe active transport route. As work would need to be undertaken from the bridge deck and would involve the closure of one lane of traffic, work would need to be undertaken at night to avoid disrupting traffic along the road corridor. During this work, traffic control would be installed to establish a contra-flow to maintain traffic flow. Other early work activities including geotechnical, contamination and utility investigations during Stage 2A and Stage 2B of the proposal would have negligible impacts on traffic due to the small and temporary nature of works

During the main construction work, the delivery of large construction materials such as bridge girders would be carried out at night under traffic control to minimise impacts to the road network near the proposal. Temporary traffic management measures would be implemented as required during construction, including reduced speed limits, temporary lane closures and diversions. These measures would maintain traffic movement along the main arterial roads near the proposal, including Bells Line of Road and Kurrajong Road.

Construction staging during Stage 2A would result in broader changes to traffic movement during peak periods throughout the traffic and transport study area in the following construction scenarios:

- Scenario 1, comprising:
  - closure of eastbound right turn from Bells Line of Road into Pitt Lane
  - shifting traffic south on Bells Line of Road in North Richmond
  - closure of the northern leg of Old Kurrajong Road
  - opening the bypass to traffic between Kurrajong Road and Drift Road
  - a temporary four-way intersection at the Castlereagh Road / Southee Road intersection
  - a temporary roundabout at the Kurrajong Road / Chapel Street intersection
- Scenario 2, comprising Scenario 1 construction traffic arrangements, except that there would be a new single lane roundabout open to traffic at the Castlereagh Road / Southee Road intersection rather than a four-way intersection (as per the Scenario 1 arrangement).

As a result, construction traffic modelling was carried out for Stage 2A only for these two scenarios. These results have been compared against the 2029 without proposal scenario. This provides a conservative assessment as the construction work associated with these two scenarios would occur in 2028 and the 2029 without proposal scenario reflects worsened traffic network performance compared to 2028.

Table 4-2 presents the overall network performance during the AM and PM peak periods (two hours), including a summary of travel time results. Overall, during both construction scenarios, the road network

would operate at a marginally reduced performance compared to without the proposal. This would be due to there being slightly higher average vehicle delays and slightly lower average vehicle speeds.

Construction scenario travel time statistics have been analysed for the following route corridors:

- **Route 1**, which extends from Hobart Street to Crooked Lane
- **Route 2A**, which extends from the Blacktown Road /The Driftway / Racecourse Road intersection to Crooked Lane via Richmond town centre

During the AM peak period, eastbound travel times along both Route 1 and Route 2A would increase by about two minutes during both construction scenarios. This would be caused by high volumes of traffic expected to travel along March Street and the operation of the temporary roundabout at the Kurrajong Road / Chapel Street intersection, which would require through traffic on Kurrajong Road to give way to vehicles turning right from Chapel Street onto March Street. Westbound traffic on both routes would experience similar travel times with and without the proposal.

During the PM peak period, westbound travel time would decrease by about one minute with the proposal along Route 1 during both construction scenarios and along Route 2A during Scenario 1. This would be because the westbound merge west of the Bells Line of Road / Kurrajong Road / Old Kurrajong Road intersection would be removed. Westbound travel time along Route 2A during Scenario 2 would increase marginally (by about 20 seconds) compared to without the proposal due to delays in Richmond town centre. Eastbound travel time would increase by about one minute along Route 1 and about 30 seconds along Route 2A due to the traffic along March Street and the temporary roundabout at the Kurrajong Road / Chapel Street intersection (similar to the AM peak period).

Table 4-2 Overall network performance – AM and PM peak periods (2 hours)

Metrics	Unit	AM peak period			PM peak period		
		2029 Without proposal	Construction Scenario 1	Construction Scenario 2	2029 Without proposal	Construction Scenario 1	Construction Scenario 2
Average travel time (Route 1) – Westbound	Min	10:22	10:23	10:26	13:12	12:29	12:01
Average travel time (Route 1) – Eastbound	Min	10:16	12:26	12:03	09:08	09:45	09:56
Average travel time (Route 2A) – Westbound	Min	14:02	14:29	14:04	14:44	13:52	15:02
Average travel time (Route 2A) – Eastbound	Min	12:53	15:00	14:34	11:44	12:17	12:21
Traffic demand	Veh	14,102	14,160	14,142	16,495	16,711	16,615
Vehicle kilometres travelled (VKT)	km	77,206	77,628	77,739	82,568	84,547	84,107
Vehicle hours travelled (VHT)	h	1,817	1,903	1,912	1,974	2,085	2,061
Average Speed	km/h	43	42	42	42	41	41
Latent Demand	Veh	0	1	1	14	2	13
Number of Stops	Veh	42,272	39,993	41,290	45,918	48,573	48,040

Metrics	Unit	AM peak period			PM peak period		
		2029 Without proposal	Construction Scenario 1	Construction Scenario 2	2029 Without proposal	Construction Scenario 1	Construction Scenario 2
Completed Trips	Veh	13,805	13,742	13,708	15,800	16,181	16,094
Average Delay	sec/ km	34	35	35	38	40	39

In addition, the closure of the northern leg of Old Kurrajong Road at the Bells Line of Road / Kurrajong Road / Old Kurrajong Road intersection would result in an improvement in intersection performance during construction. This intersection would be closed once establishing work and offline construction has been completed and remain closed for the remainder of Stage 2A construction (including Scenarios 1 and 2, as previously outlined) and during operation of Stage 2A. With the closure of the northern leg, the intersection performance would improve from LOS F during both AM peak hours without the proposal to LOS D and LOS B (1st and 2nd peak hours) for Scenario 1 and LOS E and LOS B (1st and 2nd peak hours) for Scenario 2. This would be due to motorists on Old Kurrajong Road travelling to the Kurrajong Road / Chapel Street intersection to access Kurrajong Road. Without the proposal, the delays on the northern leg would worsen overall intersection performance. During the PM peak hours, while this intersection would perform at a LOS F under all scenarios, delays would reduce by between 30 and 60 seconds during both construction scenarios.

The changes at the Castlereagh Road / Southee Road intersection to a temporary four-way intersection during Scenario 1 construction, would result in a reduction in intersection performance in all AM and PM peak hours from LOS B without the proposal to LOS F with the proposal. This would be due to higher volumes of traffic using this intersection with the bypass, with stop signs on all approaches to the intersection. The conversion of this intersection to a single-lane roundabout would return the intersection performance to LOS B during all AM and PM peak hours of Scenario 2.

Stage 2B

During Stage 2B, construction work would be limited to the section of Bells Line of Road between Crooked Lane and Terrace Road / Grose Vale Road intersection, as well as the offline construction of the Bypass parallel to Southee Road between the Bypass / Castlereagh Road intersection and Londonderry Road / Southee Road intersection. While the bypass construction would mostly be offline, there would be tie-in works at the Bypass / Castlereagh Road and Bypass / Londonderry Road intersections, as well as at the connection of the Bypass with Southee Road opposite Valder Avenue. However, it is anticipated that there would be minimal traffic impacts expected as the closure of Southee Road to Castlereagh Road and Londonderry Road would be undertaken once the bypass is completed, enabling continuation of traffic movements.

A detailed construction staging strategy for Stage 2B would be developed during detailed design along with construction stage traffic modelling. The work along Bells Line of Road would require traffic management to maintain traffic flow while minimising traffic delays, and to provide safe passage for all users. Work in this area would require temporary traffic management during tie-in activities and finishing work and would result in localised construction impacts near where work is occurring.

Most construction work required as part of the extension of the bypass between Castlereagh Road and Londonderry Road, including tie-in activities, would occur offline and not result in changes to the traffic network or intersection arrangements along Southee Road.

The upgrade of the staggered intersection of Londonderry Road with Southee Road and Vines Drive to a four- way intersection would involve staged offline works on available area, as well as needing to shift the travel lanes to ensure a safe work environment and maintain traffic flow. Traffic switches onto the completed section of upgrade would occur, and the new signals will be commissioned, along with finishing works. Temporary traffic management, which may include temporary lane closures, would be required to maintain traffic performance, and safe access for pedestrians and cyclist during the upgrade to the Bypass / Londonderry Road / Vines Drive intersection, tie-in activities and finishing work. Minimal traffic impacts would be experienced, including localised delays due to traffic changes or reduced speed limits.

In addition, as outlined in Table 4-1, construction of Stage 2B would involve fewer construction vehicle movements than Stage 2A. This would be due to work being mainly at a similar level to the existing surface, with smaller volumes of earthworks and minimal large pre-cast structural items to be delivered compared to those required for Stage 2A. There would also be a reduced construction workforce, resulting in fewer construction worker vehicles travelling to and from the site every day. During Stage 2B, construction vehicle movements would be focused on the two areas where work would occur (along Bells Line of Road in North Richmond and near Southee Road in Richmond) and be less dispersed across the whole proposal area, compared to Stage 2A.

As a result, construction staging arrangements during Stage 2B are not expected to result in substantial construction traffic impacts to traffic movement throughout the broader traffic and transport study area during the AM and PM peak periods during these activities.

4.1.2 Impacts on local road access and emergency vehicles

Where possible, roads within the proposal area would remain open, there may be a need for temporary lane closures at times during construction of both Stage 2A and Stage 2B. As construction progresses and sections of road are completed, traffic switches to shift traffic onto new sections of road would occur to enable work on the existing pavement to be completed. Construction work areas would be appropriately fenced, and traffic deflection barriers installed, to avoid public vehicles accidentally accessing the construction site. Works affecting the road network would be undertaken in accordance with a Road Occupancy Licence (ROL) to be obtained from the relevant roads authority prior to works starting on public roads. Access for emergency vehicles would also be maintained along roads within the proposal area during construction.

There may be short periods of time where local roads may need to be closed or opened only for residents. These periods would, where possible, be undertaken outside of peak traffic periods. This would include avoiding road closures on Inalls Lane on weekends where the playing fields are in use for community sport activities.

Old Kurrajong Road closure – Stage 2A

During Stage 2A, the northern leg of Old Kurrajong Road would be closed to traffic during construction and permanently converted to an emergency access gate. While this road is used to access properties located on Old Kurrajong Road, Ridges and Triangle lanes, it has increasingly become a ‘rat-run’ whereby drivers bypass the traffic along Kurrajong Road to access Richmond. This closure would redirect traffic along Kurrajong Road. During the AM peak, which is the most heavily trafficked period through the day, the closure would redirect up to 130 vehicles during the AM peak hour, comprising about 97 per cent light vehicles and three per cent medium sized vehicles, as observed during the 2023 traffic surveys. The redirected traffic would therefore be primarily light vehicles, which is also evident from full seven day traffic survey undertaken in 2023 where only two heavy vehicles (one 6-axle Articulated vehicle, and one B-Double vehicle) were observed using Old Kurrajong Road.

Traffic accessing Old Kurrajong Road or Windsor Street would need to turn at the most convenient cross street (eg. Chapel Street, Bosworth Street, West Market Street and East Market Street). To assess the worst case impact of this redirection of traffic, traffic modelling was undertaken assuming all traffic passing through the March Street / Bosworth Street intersection. With the additional traffic through the AM peak period, the modelling showed that there was no change to the LOS at this intersection. The redirection of traffic is not expected to have a noticeable impact to the overall operation of the March Street / Bosworth Street intersection during construction.

In addition, during construction a roundabout would be implemented at the Kurrajong Road / Chapel Street intersection to allow construction vehicles to safely perform U-turns when traveling to/from surrounding work areas within the proposal area. This is expected to also improve accessibility to and from Chapel Street during construction and provide an alternative to Bosworth Street for the redirected traffic.

The redirected traffic, as a result of the closure of the northern leg of Old Kurrajong Road, is therefore not expected to have a significant impact to the overall operation of the March Street / Bosworth Street intersection during construction.

Bells Line of Road / Terrace Road / Grose Vale Road intersection – Stage 2B

During construction of Stage 2B, substantial traffic signal modifications would be required at the Bells Line of Road / Terrace Road / Grose Vale Road intersection in conjunction with contraflow/ shifting of active travel lanes. This staged construction would be required to provide sufficient width for construction, maintaining of traffic connectivity and safe detours/ passage for active transport users. These changed conditions could result in localised vehicular delays at the intersection during times in construction as traffic movements are altered and potential reduction in speed limits. Changed conditions and crossing delays may also be experienced by active transport users.

The final construction traffic signal staging at this location would be confirmed by the contractor during detailed design. Access through this intersection would be maintained and the staging would be designed to minimise the potential traffic impacts at this location.

4.1.3 Impacts on property access

Across the proposal area, there are accesses to residential, commercial, recreation and agricultural properties. Access to properties would be maintained during construction where possible. Landowners and occupiers would be consulted by the construction contractor about any potential impacts to access and methods to minimise these impacts. Consultation would be undertaken well in advance of property accesses being impacted.

Within the proposal area in North Richmond, commercial properties predominantly front Grose Vale Road, Terrace Road and Bells Line of Road. During Construction, where reasonable and feasible, access to these properties would be maintained. However, where not possible alternate access arrangements would be required for vehicles accessing these properties, which may require travelling slightly longer distances. As an example, the entry to the Westrock facility in North Richmond would temporarily take place from the rear of the facility, via Beaumont Avenue, instead of from Bells Line of Road, whilst construction works are underway along Bells Line of Road during Stage 2A construction. The exit from the facility will however remain on Bells Line of Road via a temporarily relocated driveway 20 metres east of the existing exit driveway. Agreement would be sought from the business prior to implementation of the alternate access arrangement.

In addition, from the start of the construction of Stage 2A, the right turn movement into the BP service station for eastbound vehicles travelling on Bells Line of Road in North Richmond would be closed. This change in access may change or alter the behaviour of eastbound travelling drivers who need to access these services The final Stage 2A design would also permanently remove this right turn access. Left-in, left-out only access would be maintained during construction and operation at this property and access would be maintained at all times.

4.1.4 Impacts on parking

During Stage 2A, the proposal would permanently remove 23 on-street parking spaces, comprised of:

- 15 spaces on Bells Line of Road, between Grose Vale Road and Pitt Lane
- five spaces on Drift Road, south of Inalls Lane
- one space on Inalls Lane, west of Castlereagh Road
- two spaces on Southee Road.

These parking spaces would be removed to facilitate additional travel lanes or intersections and would not be reinstated during operation, resulting in a reduction in parking spaces in these locations. However, to mitigate the removal of parking spaces along Bells Line of Road, nine new parking spaces will be provided on the northern side of Beaumont Avenue, near its intersection with Terrace Road, which will be coordinated with the mentioned parking removal. Additionally, existing parking is expected to be maintained in the surrounding road network, which may require visitors to walk slightly longer to reach their destinations. As such, the Stage 2A construction is not expected to result in substantial impacts to parking availability. As such the Stage 2A construction is not expected to result in substantial impacts to parking availability.

While the proposal would remove some parking on Drift Road, Inalls Lane and Southee Road, due to the amount of sufficient unrestricted on-street parking along those streets, the proposal would not result in a shortfall of parking spaces.

In addition to the permanent removal of these parking spaces during construction, on-street parking would also be temporarily affected at the following locations:

- indented on-street parking spaces along the northern side of Beaumont Avenue
- unrestricted on-street parking spaces at the northern extent of Drift Road
- unrestricted on-street parking spaces at the northern extent of Victoria Place
- indented on-street parking spaces along the northern side of Inalls Lane in the vicinity of the Castlereagh Road intersection with Inalls Lane and Southee Road
- unrestricted on-street parking spaces on the northern side of Southee Road, at its western extent near Castlereagh Road.

During Stage 2B, there would be no additional permanent impacts on parking. Construction of Stage 2B would temporarily impact the availability of on-street parking spaces on the northern side of Southee Road, at its eastern and western extremities near the Londonderry Road and Castlereagh Road intersections respectively. While removal of parking on Southee Road would not result in a deficiency of parking due to sufficient unrestricted on-street parking elsewhere in this area, residents may need to park further away from their destination.

In addition, ample parking for construction workers would be accommodated at the two main ancillary facilities accessible off Terrace Road and Castlereagh Road during construction of both stages of the proposal. As such, it is expected that construction worker vehicles would not affect the availability of existing on-street parking spaces near the proposal.

4.1.5 Impacts on public transport

As detailed in Section 3.5.2, there are eight bus services that currently operate near the proposal area. There are 11 bus stops within and surrounding the proposal area. While pedestrian access to these bus stops would be maintained during construction, impacts to commuters using these bus services would include:

- longer travel times when travelling through the proposal area near construction work due to traffic management including speed reduction and additional construction vehicles and deliveries
- temporary relocation of bus stops away from construction areas when work is occurring near the bus stops, which may require passengers to walk between 10 and 300 metres further to relocated bus stops, at the following bus stops:
  - Stage 2A:
    - Bells Line of Road after Terrace Road (ID 275455)
    - North Richmond Village, Bells Line of Road (ID 275418)
    - Kurrajong Road after Yarramundi Lane (ID 275317)
    - Kurrajong Road before Yarramundi Lane (ID 275373)
    - Hawkesbury Retirement Village, Kurrajong Road (ID 275372)
    - Castlereagh Rd after Inalls Lane (ID 275331)
  - Stage 2B:
    - Bells Line of Road opposite Crooked Lane (ID 275414)
    - Bells Line of Road at Crooked Lane (ID 275422)
    - Londonderry Road opposite Vines Drive (ID 275354)
    - Londonderry Road at Vines Drive (ID 275341).

The construction contractor would liaise with service operators prior to and during construction to maintain access to and operation of bus stops and services and minimise potential delays or disruptions to commuters and these services.

4.1.6 Impacts on active transport

The proposal area currently lacks continuous dedicated pedestrian and cyclist paths between North Richmond and Richmond. As such, for most of the construction works (eg along Kurrajong Road and along the bypass), no construction impacts are expected on the existing active transport facilities.

However, construction work along Bells Line of Road in North Richmond which may disrupt pedestrian and cyclist access along the existing footpaths and at crossing points at the Bells Line of Road / Terrace Road / Grose Vale Road intersections. This would result in a change in conditions and slower travel times for users. Safe detours for pedestrian and cyclist access, or notification of changed conditions would be implemented within the proposal area.

During Stage 2A, large sections of Hanna Park would be converted into an ancillary facility (as shown in Figure 1-1a) to facilitate the delivery of girders and construction of the new bridge. While work is occurring at this location, the ancillary facility would be converted into a construction area and public access along existing active transport paths within the ancillary facility would be disrupted.

In addition, upgrades to Bells Line of Road between the new bridge and the Grose Vale Road / Terrace Road intersection in Stage 2A would impact the footpath connections between the existing bridge and North Richmond town centre. This would include along both sides of Bells Line of Road through North Richmond town centre.

Detours would be implemented to maintain pedestrian and cyclist access and alternative arrangements would be managed through signage and wayfinding in this area to maintain access to the existing bridge. Indicative proposed cyclist and pedestrian detour are shown in Figure 4-1.

Construction of Stage 2B may result in disruption to pedestrian use of the footpaths along Bells Line of Road in North Richmond west of the Grose Vale Road / Terrace Road intersection. Localised detour arrangements would be provided as required so that pedestrian access along this section of Bells Line of Road is maintained.

Final detour arrangements would be confirmed by the construction contractor during detailed design.

Figure 4-1 Proposed active transport connection during construction

In addition, during construction of Stage 2A, road shoulders along Bells Line of Road and Kurrajong Road used by cyclists would be disrupted by the establishment of construction areas. Where feasible, a minimum 1.2 metre shoulder would be provided to accommodate cyclists during construction.

Pedestrian access across the existing Richmond bridge would be maintained through construction where possible, however, would be closed during early work where compliant hand rails need to be installed along the existing pedestrian path. As this work would need to be undertaken at night, it is anticipated that there would be minimal impacts to connectivity. On the eastern side of the existing Richmond bridge, the pedestrian path diverts away from Kurrajong Road along the property access road (Old Kurrajong Road) to Yarramundi Lane, where there is no active transport facilities from this point, along the proposal area including Inalls Lane or Southee Road. As such, no additional impacts on active transport is expected in the proposal area through Richmond and Hobartville.

4.2 Operational impacts

This section provides an assessment of the operational impacts on road network performance with and without the proposal in 2029 (opening of the proposal) and 2039 (10 years after opening of the proposal). As outlined in Section 2.3.3, the operational traffic impacts assessed for 2029 reflect the Stage 2A design and the impacts assessed for 2039 reflect the combined operational traffic arrangements of the Stage 2A and 2B design.

4.2.1 Intersection performance

Intersection performance has been assessed for the following seven key intersections, based on the LOS criteria noted in Table 2-2. The seven key intersections are shown in Figure 4-2 and they are:

- intersection 1 – Bells Line of Road / Grose Vale Road / Terrace Road
- intersection 2 – Kurrajong Road / Old Kurrajong Road / Bells Line of Road
- intersection 3 – March Street / Bosworth Street
- intersection 4 – Richmond bypass / Castlereagh Road

- intersection 5 – Richmond bypass / Valder Avenue (local road connection)
- intersection 6 – Richmond bypass / Londonderry Road
- intersection 7 – Castlereagh Road / The Driftway

The proposal intersection performance is compared against the 'Base Case' (existing scenario) and 'Without proposal' scenarios.

Detailed intersection performance results are included in Appendix C.

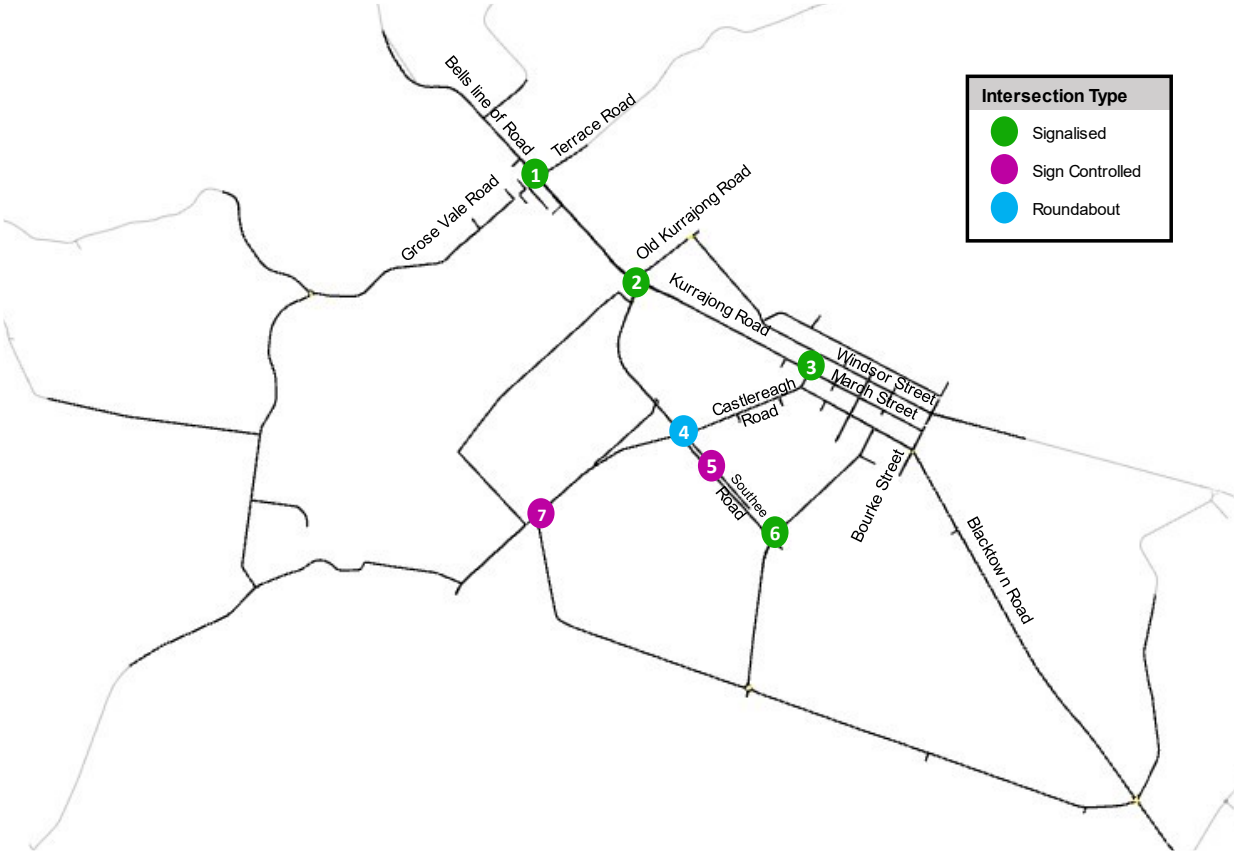


Figure 4-2 Key study area intersections – With proposal

AM Peak

Table 4-3 and Table 4-4 present a summary of the performance of the seven key intersections during the two AM peak hours. Intersection performance results for the AM peak periods are as follows:

- **Intersection 1 – Bells Line of Road / Grose Vale Road / Terrace Road:** Without the proposal, this intersection would perform at LOS E in 2029 and at LOS F in 2039.

  Stage 2A of the proposal would upgrade Bells Line of Road to include four lanes (two in each direction) on the eastern side of the intersection in 2029. Stage 2B of the proposal would include widening to four lanes (two in each direction) west of the intersection in 2039, which would reduce the congestion at this intersection. This would result in a LOS D in both 2029 (Stage 2A) and 2039 (Stage 2B). Even with the proposal, there would still be queuing for vehicles wishing to turn right onto Bells Line of Road from Grose Vale Road due to high right turn demand.

  Intersection 2 – Kurrajong Road / Old Kurrajong Road / Bells Line of Road: Without the proposal, this intersection would operate at LOS F in both 2029 and 2039, Stage 2A of the proposal would include a signalised intersection with a two-way gated emergency driveway access to Old Kurrajong Road (north of Kurrajong Road). These key features would enhance the overall performance of this intersection which would operate at LOS B in both 2029 (Stage 2A) and 2039 (Stage 2B), despite the projected increase in traffic volume travelling through the intersection with the proposal.

- **Intersection 3 – March Street / Bosworth Street:** Without the proposal, this intersection would operate at LOS C in 2029 and LOS D and 2039.

  While this intersection is outside the proposal area and there would be no changes to the intersection arrangement with the proposal, the intersection would operate satisfactorily at LOS C in both 2029 (Stage 2A) and 2039 (Stage 2B) with the proposal. This would be due to lower volumes of traffic travelling through the intersection, due to vehicles using the bypass.

  There would also be higher delays for westbound and northbound motorists travelling through this intersection both with and without the proposal in 2029) and 2039. This would be caused by traffic light signal phasing giving more time to the eastbound traffic at this intersection, the main direction of traffic during the AM peak period.

- **Intersection 4 – Richmond bypass / Castlereagh Road:** Without the proposal, this intersection would perform at LOS B during 2029 and 2039, except during first hour in 2029, where it would operate at LOS A. The worst-performing direction of travel would be the eastbound traffic through movement and right turn from Inalls Lane to Castlereagh Road.

  In 2029, Stage 2A of the proposal would convert this intersection into a single lane roundabout, which would be further upgraded to a dual lane roundabout as part of Stage 2B in 2039 (Stage 2B). With the proposal in both 2029 (Stage 2A) and 2039 (Stage 2B), the intersection would have satisfactory performance with a LOS B.

  Intersection 5 – Richmond bypass / Valder Avenue (local road connection): With Stage 2A, in 2029, this intersection would remain unchanged compared to the existing scenario and be a local road unsignalised intersection between Southee Road and Valder Avenue. With Stage 2B, in 2039, the intersection would remain an unsignalised intersection, but be converted to a local road connection between the bypass and Valder Avenue, providing access to Southee Road and Hobartville.

  In all scenarios (with and without the proposal in both 2029 and 2039), this intersection would have a good level of performance during the AM peak period and operate at a LOS A.

- **Intersection 6 – Richmond bypass / Londonderry Road:** Without the proposal, this intersection would perform at LOS A in 2029 and 2039.

  With Stage 2A, in 2029, this intersection would remain unchanged. It would perform at LOS A.

  Stage 2B of the proposal would close the existing Southee Road / Londonderry Road intersection and include a new signalised intersection at the junction of Londonderry Road, the new bypass and Vines Drive. Under this arrangement, the intersection would operate at LOS B in 2039.

- **Intersection 7 – Castlereagh Road / The Driftway:** The New Richmond Bridge and traffic improvements Stage 1 upgrades along The Driftway and the opening of the Grose River Bridge, would lead to higher westbound traffic volumes through this intersection. As a result, without the proposal, the westbound right turn and left turn movements from The Driftway onto Castlereagh Road would operate at LOS D in both 2029 and 2039 except during second hour in 2029 and first hour in 2039, where it would operate at LOS B and LOS C respectively.

  While there would be no changes to the intersection arrangement with the proposal, the bypass would be an efficient route for motorists to use and result in redistribution of traffic moving through this intersection. This would result in a similar intersection performance during first AM peak hour, where it would operate at LOS D in 2029 and at LOS B in 2039. During second AM peak hour, this would result in a better performance, operating at LOS B in both 2029 (Stage 2A) and 2039 (Stage 2B).

Table 4-3 Key intersection performance summary – 7.30–8.30am

#	Intersection	Intersection type	2023 AM			2029 AM						2039 AM					
			Base			Without proposal			With proposal (Stage 2A)			Without proposal			With proposal (Stage 2B)		
			Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS
1	Bells Line of Road / Grose Vale Road / Terrace Road	Signal	2,335	102	F	2,514	61	E	2,618	51	D	2,577	88	F	2,874	47	D
2	Kurrajong Road / Old Kurrajong Road / Bells Line of Road	Priority (Base / Without proposal), Signal (Proposal case)	2,337	88	F	2,406	115	F	2,383	17	B	2,475	163	F	2,633	19	B
3	March Street / Bosworth Street	Signal	2,044	40	C	2,144	41	C	2,207	37	C	2,237	51	D	2,218	33	C
4	Richmond bypass / Castlereagh Road	Priority (Base / Without proposal), Roundabout (Proposal case)	752	14	A	777	14	A	1,366	23	B	859	17	B	1,705	20	B
5	Richmond bypass / Valder Avenue (local road connection)	Priority	281	7	A	190	2	A	477	3	A	237	3	A	935	11	A
6	Richmond bypass / Londonderry Road	Priority (Base/Without proposal/Stage 2A 2029 proposal case), Signal (2039 Stage 2B proposal case)	650	7	A	521	6	A	817	10	A	553	8	A	1,195	21	B
7	Castlereagh Road / The Driftway	Priority	876	27	B	1,259	51	D	1,239	50	D	1,272	42	C	1,136	33	C

Table 4-4 Key intersection performance summary – 8.30–9:30am

#	Intersection	Control Type	2023 AM			2029 AM						2039 AM					
			Base			Without proposal			With proposal (Stage 2A)			Without proposal			With proposal (Stage 2B)		
			Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS
1	Bells Line of Road / Grose Vale Road / Terrace Road	Signal	2,295	94	F	2,500	66	E	2,544	49	D	2,684	126	F	2,842	50	D
2	Kurrajong Road / Old Kurrajong Road / Bells Line of Road	Priority (Base / Without proposal), Signal (Proposal case)	2,337	124	F	2,432	128	F	2,319	17	B	2,605	236	F	2,601	18	B
3	March Street / Bosworth Street	Signal	2,183	57	E	2,185	41	C	2,192	34	C	2,387	53	D	2,210	32	C
4	Richmond bypass / Castlereagh Road	Priority (Base / Without proposal), Roundabout (Proposal case)	727	16	B	820	16	B	1,378	23	B	880	21	B	1,700	21	B
5	Richmond bypass / Valder Avenue (local road connection)	Priority	262	6	A	230	2	A	509	4	A	274	2	A	913	10	A
6	Richmond bypass / Londonderry Road	Priority (Base/Without proposal/Stage 2A 2029 proposal case), Signal (2039 Stage 2B proposal case)	623	6	A	534	6	A	828	12	A	556	8	A	1,165	22	B
7	Castlereagh Road/ The Driftway	Priority	822	11	A	1,221	19	B	1,213	15	B	1,278	47	D	1,111	16	B

PM peak

Table 4-5 and Table 4-6 present the intersection performance summary for the two PM peak hours with and without the proposal in 2029 and 2039. Intersection performance results for the PM peak periods are as follows:

- **Intersection 1 – Bells Line of Road / Grose Vale Road / Terrace Road:** The intersection would perform at LOS D with and without the proposal in both 2029 and 2039 in both PM peak hours. The proposal would increase traffic demand at this intersection as performance at the Kurrajong Road / Old Kurrajong Road / Bells Line of Road intersection would allow more westbound vehicles to travel through the intersection. Despite this, there would still be similar delays experienced at this intersection.
- **Intersection 2 – Kurrajong Road / Old Kurrajong Road / Bells Line of Road:** Without the proposal, this intersection would operate at LOS F in both 2029 and 2039, caused by delays turning from Old Kurrajong Road and high traffic volumes travelling along Bells Line of Road and Kurrajong Road.

  With the proposal, the new signalised intersection configuration would result in a better intersection performance at LOS B in 2029 (Stage 2A) and LOS C in 2039 (Stage 2B). The upgraded intersection arrangement with two way gated emergency access on northern leg of Old Kurrajong Road and additional through and turning lanes would be able to accommodate higher volumes of traffic that would travel through the intersection during operation of the proposal.
- **Intersection 3 – March Street / Bosworth Street:** During the PM peak, this intersection would perform at LOS E without the proposal in 2029 and LOS D without the proposal in 2039. While this intersection is outside the proposal area and there would be no changes to the intersection arrangement with the proposal, the intersection performance would improve slightly and operate at LOS C during first PM peak hour and LOS D during second PM peak hour in both 2029 (Stage 2A) and 2039 (Stage 2B). The intersection would perform slightly better with the proposal than without the proposal due to the proposed network upgrades which would allow the redistribution of traffic onto alternate routes in the area, including along the bypass.
- **Intersection 4 – Richmond bypass / Castlereagh Road:** Without the proposal, the intersection would operate at LOS B in both 2029 and 2039.

  In 2029, Stage 2A of the proposal would include a single lane roundabout at the bypass / Castlereagh Road / Southee Road intersection. The northbound right turn from Southee Road onto Castlereagh Road would operate at LOS D based on the increased traffic volumes travelling through the roundabout from other directions due to the bypass and roundabout configuration.

  From 2039 onwards, Stage 2B of the proposal would include an upgrade to a dual lane roundabout configuration which would substantially improve the performance of vehicle movements through the roundabout to LOS B in 2039. This indicates that the Stage 2B dual lane configuration could accommodate the increase in traffic volumes.
- **Intersection 5 – Richmond bypass / Valder Avenue (local road connection):** Similar to the AM peak period, in all scenarios (with and without the proposal in both 2029 and 2039), this intersection would have a good level of performance during the PM peak period and operate at a LOS A.
- **Intersection 6 – Richmond bypass / Londonderry Road:** The intersection would operate at a LOS A without the proposal in both 2029 and 2039.

  In 2029, with Stage 2A, the intersection will remain unchanged and would operate at LOS B.

  Stage 2B of the proposal would include a new signalised intersection at the junction of Londonderry Road, the bypass and Vines Drive in 2039. This would result in the intersection operating at a LOS B while accommodating about twice as many vehicles in each peak hour compared to without the proposal.

- **Intersection 7 – Castlereagh Road / The Driftway:** The New Richmond Bridge and traffic improvements Stage 1 upgrades along The Driftway, including the opening of the Grose River Bridge, would lead to higher westbound traffic volumes through this intersection. As a result, without the proposal, the westbound right and left turn from the Driftway onto Castlereagh Road would operate at LOS D or betterand LOS E, in 2029 and 2039 respectively. This indicates that westbound motorists would experience higher delays at this intersection.

  While this intersection is outside the proposal area and there would be no changes to the intersection arrangement with the proposal, with the proposal, this intersection would operate at a LOS C in both 2029 (Stage 2A) and 2039 (Stage 2B), except during first PM peak hour in 2029, where it would operate at LOS B. This would be because the bypass would be an efficient alternate route and lead to the redistribution of traffic.

Table 4-5 Key intersection performance summary – 3.30–4.30pm

#	Intersection	Control Type	2023 PM			2029 PM						2039 PM					
			Base			Without proposal			With proposal (Stage 2A)			Without proposal			With proposal (Stage 2B)		
			Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS
1	Bells Line of Road / Grose Vale Road / Terrace Road	Signal	2,586	43	D	2,695	45	D	2,805	46	D	2,742	46	D	2,947	47	D
2	Kurrajong Road / Old Kurrajong Road / Bells Line of Road	Priority (Base / Without proposal), Signal (Proposal case)	2,447	173	F	2,401	152	F	2,429	24	B	2,445	262	F	2,575	28	B
3	March Street / Bosworth Street	Signal	2,110	54	D	2,097	43	D	2,060	42	C	2,178	45	D	2,026	37	C
4	Richmond bypass / Castlereagh Road	Priority (Base / Without proposal), Roundabout (Proposal case)	967	18	B	990	19	B	1,544	47	D	1,006	17	B	1,947	24	B
5	Richmond bypass / Valder Avenue (local road connection)	Priority	275	6	A	278	3	A	628	6	A	292	3	A	1,049	11	A
6	Richmond bypass / Londonderry Road	Priority (Base/Without proposal/Stage 2A 2029 proposal case), Signal (2039 Stage 2B proposal case)	720	9	A	654	9	A	1,000	15	B	679	9	A	1,406	15	B
7	Castlereagh Road / The Driftway	Priority	1,110	28	B	1,408	45	D	1,272	27	B	1,422	68	E	1,283	31	C

Table 4-6 Key intersection performance summary – 4.30–5:30pm

#	Intersection	Control Type	2023 PM			2029 PM						2039 PM					
			Base			Without proposal			With proposal (Stage 2A)			Without proposal			With proposal (Stage 2B)		
			Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS	Volume (veh)	Ave delay (s)	LOS
1	Bells Line of Road / Grose Vale Road / Terrace Road	Signal	2,657	44	D	2,810	45	D	2,974	48	D	2,878	48	D	3,067	48	D
2	Kurrajong Road / Old Kurrajong Road / Bells Line of Road	Priority (Base / Without proposal), Signal (Proposal case)	2,513	177	F	2,528	290	F	2,597	25	B	2,601	272	F	2,666	30	C
3	March Street / Bosworth Street	Signal	2,071	52	D	2,129	59	E	2,073	47	D	2,113	53	D	2,034	43	D
4	Richmond bypass / Castlereagh Road	Priority (Base / Without proposal), Roundabout (Proposal case)	1,090	19	B	1,085	20	B	1,640	56	D	1,152	26	B	2,019	25	B
5	Richmond bypass / Valder Avenue (Local road connection)	Priority	322	4	A	337	4	A	647	7	A	355	5	A	1,045	10	A
6	Richmond bypass / Londonderry Road	Priority (Base/Without proposal/Stage 2A 2029 proposal case), Signal (2039 Stage 2B proposal case)	775	10	A	732	10	A	1,042	16	B	771	11	A	1,418	16	B
7	Castlereagh Road/ The Driftway	Priority	1,100	25	B	1,411	40	C	1,302	36	C	1,432	64	E	1,346	30	C

4.2.2 Congestion

Levels of congestion throughout the traffic and transport study area have been reviewed. Without the proposal, in both 2029 and 2039 there would be high levels of congestion along Kurrajong Road, Bells Line of Road and in the Richmond and North Richmond town centres. However, the proposal would alleviate the congestion hotspots and lead to improved network performance. During the PM peak period, westbound congestion on Kurrajong Road would reduce with the proposal, with vehicles using the new bypass as well as Kurrajong Road.

Figure 4-3 and Figure 4-4 show levels of congestion throughout the traffic and transport proposal area in the second hour of the AM and PM peak periods respectively. The figures show the second hour of each peak period only as there is higher congestion in the second hour than first hour in both the AM and PM peak.

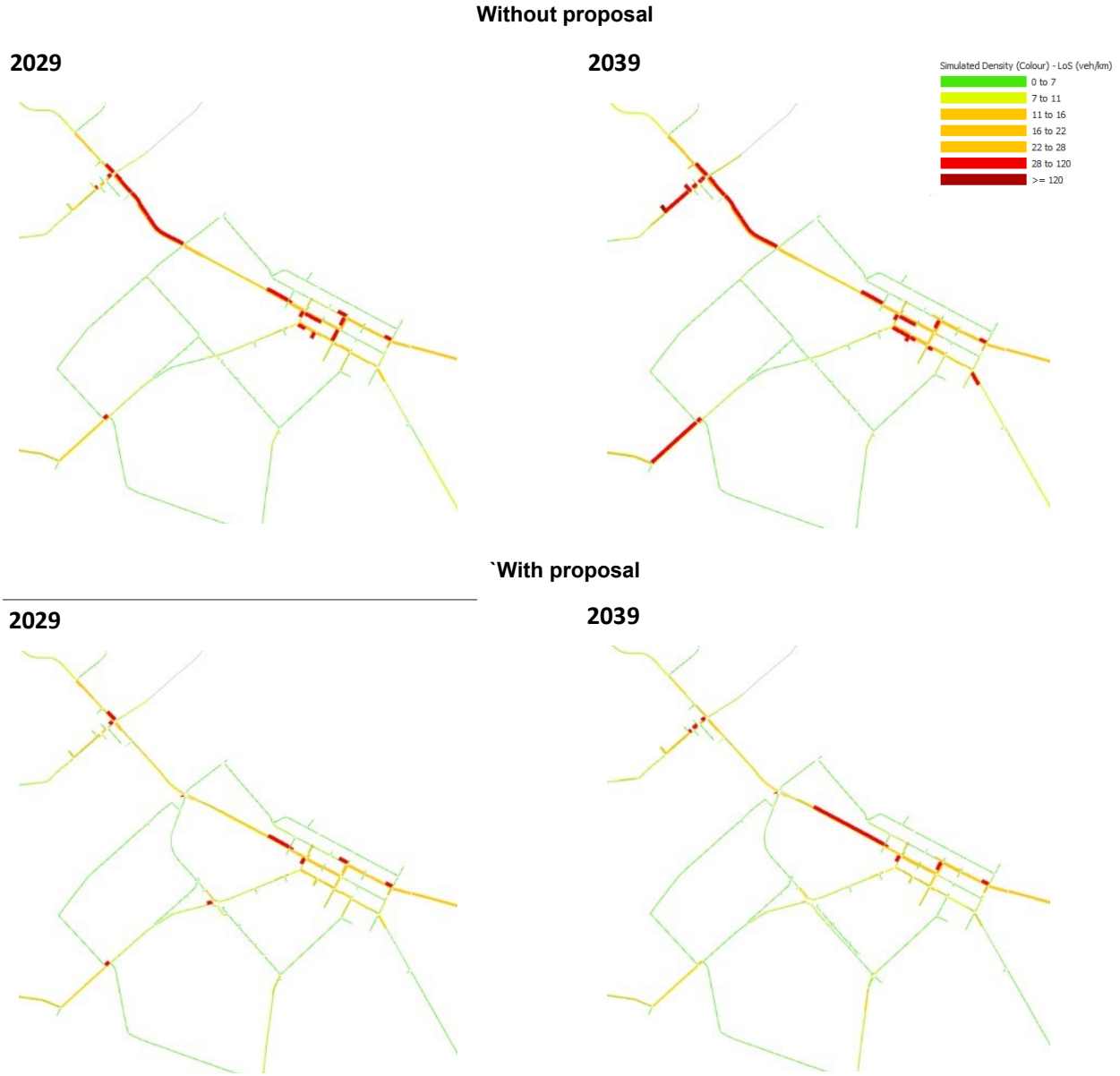


Figure 4-3 Levels of congestion – 8.30–9:30am

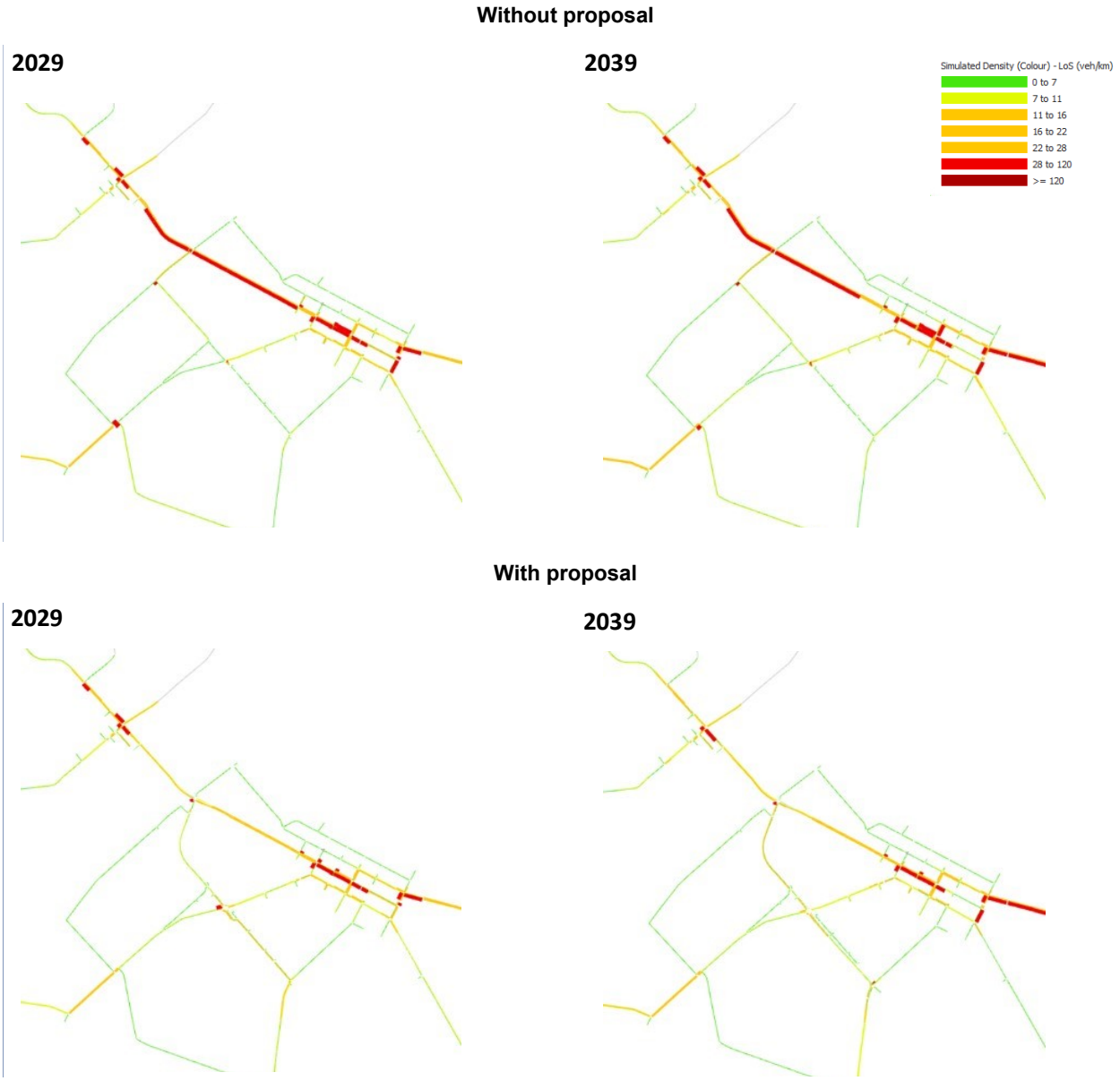


Figure 4-4 Levels of congestion – 4.30–5:30pm

4.2.3 Travel time

The travel time statistics for the future year models have been analysed for the following three route corridors:

- **Route 1**, which extends along Kurrajong Road and Bells Line of Road from Hobart Street to Crooked Lane
- **Route 2A**, which extends from the Blacktown Road /The Driftway / Racecourse Road intersection and along Kurrajong Road and Bells Line of Road to Crooked Lane via Richmond town centre
- **Route 2B**, which extends from Blacktown Road /The Driftway / Racecourse Road intersection and along Bells Line of Road to Crooked Lane via the proposed Richmond bypass.

Travel time results for Route 1 with the proposal (both future scenarios) have been assessed against the 2023 existing and future without proposal travel times for the AM and PM peak periods.

Given that the bypass and the road network upgrades included as part of the proposal would provide an alternative route to bypass Richmond town centre, travel time statistics for Route 2A and Route 2B across both future scenarios) have been compared between the Route 2A without proposal and Route 2A / 2B with proposal scenario to identify the overall travel time benefits of the proposal.

These route corridors are shown in Figure 4-5.

Figure 4-5 Travel time routes

AM peak modelled travel times

Route 1

Table 4-7 outlines the AM peak travel times in the eastbound and westbound directions along Route 1.

Table 4-7 AM peak – Route 1

Direction	2023	2029		2039	
	Base Case	Without proposal	With proposal (Stage 2A)	Without proposal	With proposal (Stage 2B)
7.30–8.30am					
Westbound	09:31	10:07	10:17	10:40	10:31
Eastbound	11:16	10:00	09:36	10:42	09:46
8.30–9.30am					
Westbound	10:34	10:14	10:24	11:08	10:27
Eastbound	10:53	10:08	09:34	11:25	09:45
Average travel time (min)					
Westbound	10:02	10:10	10:21	10:54	10:29
Eastbound	11:04	10:04	09:35	11:04	09:46

Considering expected increased future traffic demand, travel time along Route 1 is expected to reduce with the proposal, suggesting that the proposal would alleviate overall network congestion.

In 2029 (Stage 2A), the average eastbound travel time is expected to be reduced by 29 seconds with the proposal compared to without the proposal. This would be due to the increased capacity along the Kurrajong Road and Bells Line of Road corridor provided by the proposal. The westbound (off-peak travel direction)

travel time is expected to have a minor increase of about 10 seconds on average with the proposal compared to without the proposal. This is due to the following factors:

- Reduction in posted speed on Kurrajong Road between Chapel Street and Old Kurrajong Road, from 80 km/hr without the proposal, to 60 km/hr with the proposal.
- Upgrade of Kurrajong Road and Old Kurrajong Road intersection, from priority control without the proposal, to signalised configuration with the proposal, to improve safety for pedestrians and cyclists and overall performance of intersection.

The without proposal scenario would also experience better travel times than the 2023 existing scenario in the eastbound direction. This is because some traffic would use the Grose River Bridge instead of the existing Richmond Bridge, resulting in less traffic travelling along the existing Richmond Bridge.

In 2039 (Stage 2B), the average eastbound travel time is expected to decrease by one minute and 18 seconds and average westbound travel time would decrease by 25 seconds with the proposal compared to without the proposal.

Route 2A and Route 2B

Table 4-8 outlines the AM peak travel times and average speed in the eastbound and westbound directions along Route 2A for the with and without proposal scenarios and along Route 2B for the with proposal scenario only.

Table 4-8 AM peak – Route 2

Direction	2029			2039		
	Route 2A		Route 2B	Route 2A		Route 2B
	Without proposal	Proposal Stage 2A	Proposal Stage 2A	Without proposal	Proposal Stage 2B	Proposal Stage 2B
7:30 AM-8:30 AM						
Westbound	13:39	13:31	11:51	15:20	13:27	11:07
Eastbound	12:43	12:18	12:18	13:22	12:21	11:28
8:30 AM-9:30 AM						
Westbound	13:38	13:37	11:54	14:35	13:18	11:08
Eastbound	12:43	12:10	12:04	14:27	12:10	11:21
Average travel time (min)						
Westbound	13:38	13:34	11:52	14:58	13:22	11:08
Eastbound	12:43	12:14	12:11	13:55	12:16	11:25
Average speed (km/h)						
Westbound	40.48	40.68	52.57	36.90	41.28	56.06
Eastbound	43.40	45.13	51.24	39.67	45.02	54.67

These results indicate that the proposal would reduce travel time for vehicles travelling both directions between Richmond and North Richmond as well as reduce congestion within the Richmond town centre. This would largely be due to the construction of the bypass as a new route between Richmond and North Richmond. Route 2B (via Richmond Bypass) is also expected to achieve higher average speed than Route 2A (via Richmond CBD) with the proposal.

In 2029 (Stage 2A), the average eastbound travel time with the proposal is expected to reduce by 32 seconds via Route 2B and by about 30 seconds via Route 2A when compared to without the proposal. The westbound average travel time would decrease by one minute and 46 seconds via Route 2B with the proposal compared to without the proposal, while travel time via Route 2A with the proposal would be marginally better than without the proposal.

In 2039 (Stage 2B), the average eastbound travel time with the proposal is expected to reduce by two minutes and 30 seconds via Route 2B and by one minute and 39 seconds via Route 2A, when compared to

without the proposal. The westbound average travel time would decrease by three minutes and 50 seconds via Route 2B and by one minute and 35 seconds via route 2A with the proposal compared to without the proposal.

The extension of the bypass from Castlereagh Road to Londonderry Road in 2039 as part of Stage 2B would further improve travel time along the bypass (in Route 2B) and through Richmond town centre (in Stage 2A) compared to travel times with the proposal in Stage 2A only. The bypass would be more efficient and is expected to be attractive to motorists travelling between Richmond and North Richmond that does not need to pass through the Richmond town centre. There would also be consistent travel times and average speed with the proposal along the bypass for eastbound traffic in 2039, indicating that the bypass would be able to maintain stable performance during the AM peak period and accommodate traffic increases in future years.

PM peak modelled travel time

Route 1

Table 4-9 outlines the PM peak travel times in the eastbound and westbound directions along Route 1.

Table 4-9 PM peak – Route 1

Direction	2023	2029		2039	
	Base Case	Without proposal	Proposal Stage 2A	Without proposal	Proposal Stage 2B
3.30–4.30pm					
Westbound	12:01	11:12	10:55	11:54	10:58
Eastbound	08:45	08:50	08:59	08:59	08:48
4.30–5.30pm					
Westbound	14:24	14:30	11:46	16:19	11:57
Eastbound	08:47	08:59	09:00	09:12	08:49
Average travel time (min)					
Westbound	13:13	12:51	11:21	14:07	11:27
Eastbound	08:46	08:55	09:00	09:05	08:49

Considering increased future traffic demand, travel time in the westbound direction along Route 1 is expected to reduce by about two minutes and 40 seconds with the proposal. Travel times without the proposal would increase progressively in the future, indicates that the existing road network would not be able to cope with expected future increased demand.

In 2029 (Stage 2A), westbound travel time is expected to reduce by one minute and 30 seconds with the proposal, compared to without the proposal. Eastbound travel time would be similar (about nine minutes) with and without the proposal. Similar travel times for the 2023 existing scenario and without proposal scenario are expected due to traffic re-routing via the Grose River Bridge instead of using the existing Richmond Bridge. This would result in less traffic using the existing Richmond Bridge and reduce reducing travel times as traffic increases.

In 2039 (Stage 2B), the average westbound travel time is expected to decrease by two minutes and 40 seconds and marginally (by 14 seconds) for eastbound traffic with the proposal compared to without the proposal.

Route 2A and Route 2B

Table 4-10 outlines the AM peak travel times and average speed in the eastbound and westbound directions along Route 2A for the with and without proposal scenarios and along Route 2B for the with proposal scenario only.

Table 4-10 PM peak – Route 2

Direction	2029			2039		
	Route 2A		Route 2B	Route 2A		Route 2B
	Without proposal	Proposal Stage 2A	Proposal Stage 2A	Without proposal	Proposal Stage 2B	Proposal Stage 2B
3.30–4.30pm						
Westbound	13:31	12:52	12:29	13:56	12:24	11:59
Eastbound	11:33	11:38	11:28	11:48	11:28	11:20
4.30–5.30pm						
Westbound	15:04	12:51	12:45	16:23	12:17	12:06
Eastbound	11:46	11:44	11:29	11:52	11:34	11:19
Average travel time (min)						
Westbound	14:18	12:52	12:37	15:09	12:20	12:02
Eastbound	11:40	11:41	11:29	11:50	11:31	11:20
Average Speed (km/h)						
Westbound	38.62	42.93	49.46	36.43	44.73	51.84
Eastbound	47.34	47.24	54.37	46.66	47.93	55.10

These results indicate that the proposal would result in travel time savings for vehicles travelling in both westbound and eastbound directions between Richmond and North Richmond and would reduce the congestion within Richmond town centre upon opening of Stage 2A in 2029. This would largely be due to the bypass providing an alternate route for vehicles travelling to and from North Richmond other than Kurrajong Road. The extension of the bypass and upgrades to Bells Line of Road west of the Terrace Road / Grose Vale Road intersection as part of Stage 2B in 2039 would further improve the travel time and reduce congestion in Richmond town centre. Route 2B (via Richmond Bypass) is also expected to achieve higher average speed than Route 2A (via Richmond CBD) with the proposal.

In 2029 (Stage 2A), the average westbound travel time is expected to decrease by one minute and 41 seconds via Route 2B and one minute and 26 seconds via Route 2A with the proposal compared to without the proposal. Eastbound travel time is expected to decrease by 11 seconds via Route 2B with the proposal compared to without the proposal and provide a marginally faster journey than via Route 2A. Eastbound travel time via Route 2A with the proposal would be similar to without the proposal (about 11 minutes and 40 seconds).

In 2039 (Stage 2B), the average westbound travel time with the proposal is expected to reduce by three minutes and seven seconds via Route 2B and by two minutes and 49 seconds via Route 2A compared to without the proposal. Eastbound travel time with the proposal is expected to decrease by 30 seconds via Route 2B and by 19 seconds via route 2A in the proposal scenario compared to without the proposal.

In addition, there would be consistent travel times and average speed along the bypass with the proposal in both directions in both 2029 (Stage 2A) and 2039 (Stage 2B). This indicates that the bypass would maintain stable performance during the PM peak period despite the expected increase in traffic demand in later years, resulting in similar travel times from opening.

4.2.4 Overall network performance

Table 4-11 and Table 4-12 present the overall network performance during the AM and PM peak periods, respectively, in 2023, 2029 (Stage 2A) and 2039 (Stage 2B). Detailed network performance statistics per vehicle type, completed and incomplete trips are presented in Appendix D.

The results indicate that overall road network would perform better with the proposal than without the proposal as there would be:

- less vehicle hours travelled (VHT) by all vehicles in the model
- higher network speeds

- less latent demand (number of vehicles that can't enter the model area due to queuing)
- a higher number of completed trips during the peak periods.

During the AM peak across all years, the Vehicle Kilometres Travelled (VKT) (total kilometres travelled by all vehicles in the model) are higher with the proposal than without the proposal, as the proposed Richmond bypass is a slightly longer but faster alternative route. Despite this the increased number of completed trips, together with the reduced number of VHT, latent demand, average delay and number of stops, suggests a better performance with the proposal.

In the PM peak, higher traffic along March Street would result in latent demand along West Market Street and Paget Street. Overall, during this scenario, the proposal would provide a higher network capacity, with increased number of completed trips and reduced latent demand.

Table 4-11 Overall network performance – AM peak period (2 hours)

Metrics	Unit	2023	2029		2039	
		Base Case	Without proposal	With proposal Stage 2A	Without proposal	With proposal Stage 2B
Traffic demand	Veh	12,749	14,102		14,814	
VKT	km	66,871	77,209	77,475	80,298	81,217
VHT	h	1,696	1,801	1,738	2,065	1,820
Average Speed	km/h	41	43	44	41	44
Latent Demand	Veh	4	0	0	54	1
Number of Stops	Veh	40,121	41,621	37,281	50,544	39,778
Completed Trips	Veh	12,437	13,816	13,811	14,223	14,405
Average Delay	sec/km	41	33	29	43	30

Table 4-12 Overall network performance – PM peak period (2 hours)

Metrics	Unit	2023	2029		2039	
		Base Case	Without proposal	With proposal Stage 2A	Without proposal	With proposal Stage 2B
Traffic demand	Veh	14,990	16,495		17,126	
VKT	km	72,541	82,788	82,270	86,590	86,606
VHT	h	1,757	1,954	1,879	2,116	1,963
Average Speed	km/h	42	43	43	42	43
Latent Demand	Veh	0	2	0	5	3
Number of Stops	Veh	40,907	45,398	42,348	50,718	45,526
Completed Trips	Veh	14,605	15,836	15,952	16,510	16,636
Average Delay	sec/km	37	36	33	40	33

4.2.5 Impacts on local road access and emergency vehicles

During operation, both stages of the proposal would maintain access to all local roads. However, there would be adjustments to access routes to a number of local roads, as outlined in the following sections.

All traffic accessing Old Kurrajong Road, Yarramundi Lane, Inalls Lane and Southee Road, including emergency vehicles, would be required to use the new or adjusted local road connections provided as part of the proposal. As such, the proposal would not have substantial impacts on emergency vehicle access arrangements. As noted in Section 4.2.3, the proposal would provide improved travel times between Richmond and North Richmond, including along the new bypass.

Stage 2A

Old Kurrajong Road

As noted in Section 4.1.2, during Stage 2A, the northern leg of Old Kurrajong Road would be closed to traffic during construction and permanently converted to an emergency access gate. This would require the existing traffic along Old Kurrajong Road to be redirected through the March Street / Bosworth Street intersection to access Kurrajong Road. As indicated in Section 4.1.2, this would redirect up to 130 vehicles during the AM peak hour, comprising about 97 per cent light vehicles and three per cent medium sized vehicles, as observed during the 2023 traffic surveys

The redirection of vehicles from Old Kurrajong Road was considered as part of the operational traffic modelling for 2029 (Stage 2A) and 2039 (Stage 2B) outlined in Section 4.2.1. This showed acceptable performance (LOS D or better) at the March Street / Bosworth Street intersection during all AM and PM peak hours. The redirected traffic, as a result of the closure of the northern leg of Old Kurrajong Road, is therefore not expected to have a significant impact to the overall operation of the March Street / Bosworth Street intersection during operation.

The emergency access gate would be opened by relevant roads authority during emergencies such as flood events, allowing Old Kurrajong Road to be used as an evacuation route for local landholders and emergency services.

Yarramundi Lane

Yarramundi Lane currently connects with Old Kurrajong Road on the southern leg of the Bells Line of Road / Kurrajong Road / Old Kurrajong Road intersection. Stage 2A of the proposal would close this leg of the intersection as it would create a three-way signalised intersection connecting Bells Line of Road, Kurrajong Road and the bypass. To maintain connection to Yarramundi Lane in this area, there would be a new east-west connection provided between Yarramundi Lane and the bypass, as shown in **Error! Reference source not found.**.

Motorists on Yarramundi Lane would be able to access the bypass towards the Bells Line of Road / Kurrajong Road / Old Kurrajong Road intersection but would not be able turn right from Yarramundi Lane onto the bypass. These motorists would need to use the bypass to access either the Richmond or North Richmond town centres to turn around or use the local road network to travel east. This could lead to longer travel times for motorists.

Figure 4-6 Yarramundi Lane access impacts (Background image source: Nearmap)

Inalls Lane / Drift Road

During Stage 2A, the bypass would truncate Inalls Lane about 400 metres south-east of its intersection with Yarramundi Lane.

A new intersection would be provided to connect the bypass, Drift Road and Inalls Lane. The intersection would include:

- a dedicated right turn lane from the bypass onto both Inalls Lane and Drift Road
- left turn movements from the bypass onto Inalls Lane and Drift Road from a combined through/left turn lane on the bypass
- one lane in each direction on Inalls Lane and Drift Road, with a give way arrangement permitting left turn, through and right turn movements for motorists wishing to turn onto the bypass, or to travel between Inalls Lane and Drift Road.

For sections of Inalls Lane west of the bypass, access would remain via Yarramundi Lane. For sections of Inalls Lane east of the bypass, access would be provided via a northern leg at the new proposed bypass / Drift Road intersection.

A turning head would be provided on the existing Drift Road alignment to maintain access to residential properties (as outlined in Section 4.2.6).

This new intersection arrangement is shown in Figure 4-11 in Section 4.2.6.

Victoria Place

The proposal would connect Victoria Place with the bypass, as shown in **Error! Reference source not found.**. The intersection would include:

- a dedicated right turn lane onto Victoria Place provided for vehicles travelling eastbound on the bypass
- a combined through / left-turn lane for vehicles travelling westbound on the bypass
- one lane in each direction on Victoria Place

- a give way arrangement permitting left turn and right turn movements from Victoria Place onto the bypass.

This arrangement would maintain all existing turning movements and so would not impact access to Victoria Place.

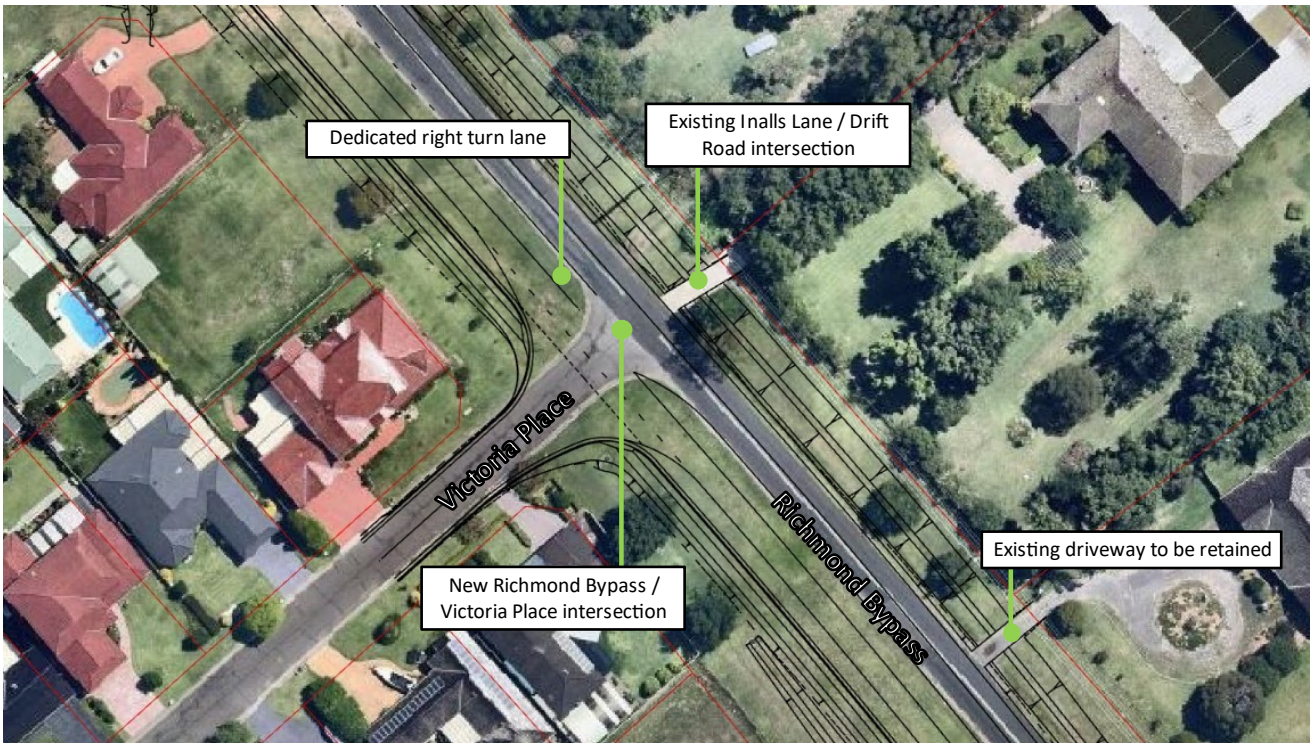


Figure 4-7 Victoria Place access to and from Richmond Bypass (Background image source: Nearmap)

Southee Road

During Stage 2A, Southee Road would be converted to a cul-de-sac near its intersection with Castlereagh Road. Local road access between Southee Road and the Castlereagh Road / bypass roundabout would be provided, with a stop-sign arrangement where the local road connection meets Southee Road, as shown in **Error! Reference source not found.**. There would be no other changes to Southee Road during Stage 2A.

Figure 4-8 Local access between Southee Road and Castlereagh Road / bypass roundabout (Background image source: Nearmap)

Stage 2B

Crooked Lane

Stage 2B of the proposal would upgrade the Bells Line of Road / Crooked Lane intersection. The intersection would:

- include a dedicated right turn lane for vehicles turning from Bells Line of Road onto Crooked Lane
- maintain the two existing through lanes (one eastbound and one westbound) on Bells Line of Road
- maintain the existing single lane in each direction on Crooked Lane, allowing vehicles to turn left or right out of Crooked Lane onto Bells Line of Road.

As such, the new arrangement would improve access for westbound motorists wishing to turn right into Crooked Lane by providing a dedicated turning lane and would otherwise maintain all turning movements.

Southee Road

During Stage 2B, with the extension of the bypass parallel to Southee Road, access to Hobartville would be provided via a local road connection from the bypass at Valder Avenue, as shown in **Error! Reference source not found.**. A cul-de-sac would also be provided on the eastern end of Southee Road near its intersection with Londonderry Road.

Figure 4-9 Southee Road access impacts (Background image source: Nearmap)

Bypass – Stages 2A and 2B

The proposal would involve the installation of a raised concrete median along the bypass, with turning lanes provided at key intersections. There would be changes to local road access during both Stage 2A and Stage 2B, as outlined in the following sections. While access to local roads would be retained, there would be slight realignment of local access roads at some locations or new connecting local access roads.

4.2.6 Impacts on property access

During operation, the proposal would maintain access to all properties within the proposal area that would not be fully acquired by the proposal. Modifications to property access for some properties would be required to align with the proposal design.

The following sections outline locations where property access changes would occur. All vehicular access to other properties not identified in this section would be retained. Landowners and occupiers would be consulted about any potential operational access impacts prior to and during construction.

Beaumont Avenue / Westrock facility

The Westrock facility fronts Bells Line of Road in North Richmond. Currently, it is accessible via a combined entry / exit driveway, as well as a dedicated exit driveway, off the Bells Line Road. Stage 2A of the proposal would relocate the existing dedicated exit driveway about 50 metres west of its current location, and the existing combined entry / exit driveway would be reconfigured to an entry only driveway. In addition, a new vehicular connection to Beaumont Avenue would be provided as a secondary entry / exit to the facility for light vehicles only. These changes would not impact eastbound travelling traffic, which would still be able to enter and exiting the property on Bells Line of Road, although there would only via one exit on this road. The westbound travelling traffic to and from the property would need to travel a slightly longer distance to the Bells Line of Road / Terrace Road / Grose Vale Road intersection to use the secondary entry/ exit along

Beaumont Avenue, which may also result in a minor localised increase in traffic along Beaumont Avenue. Refer to Figure 4-10 for the Westrock facility's current and new proposed access arrangement.

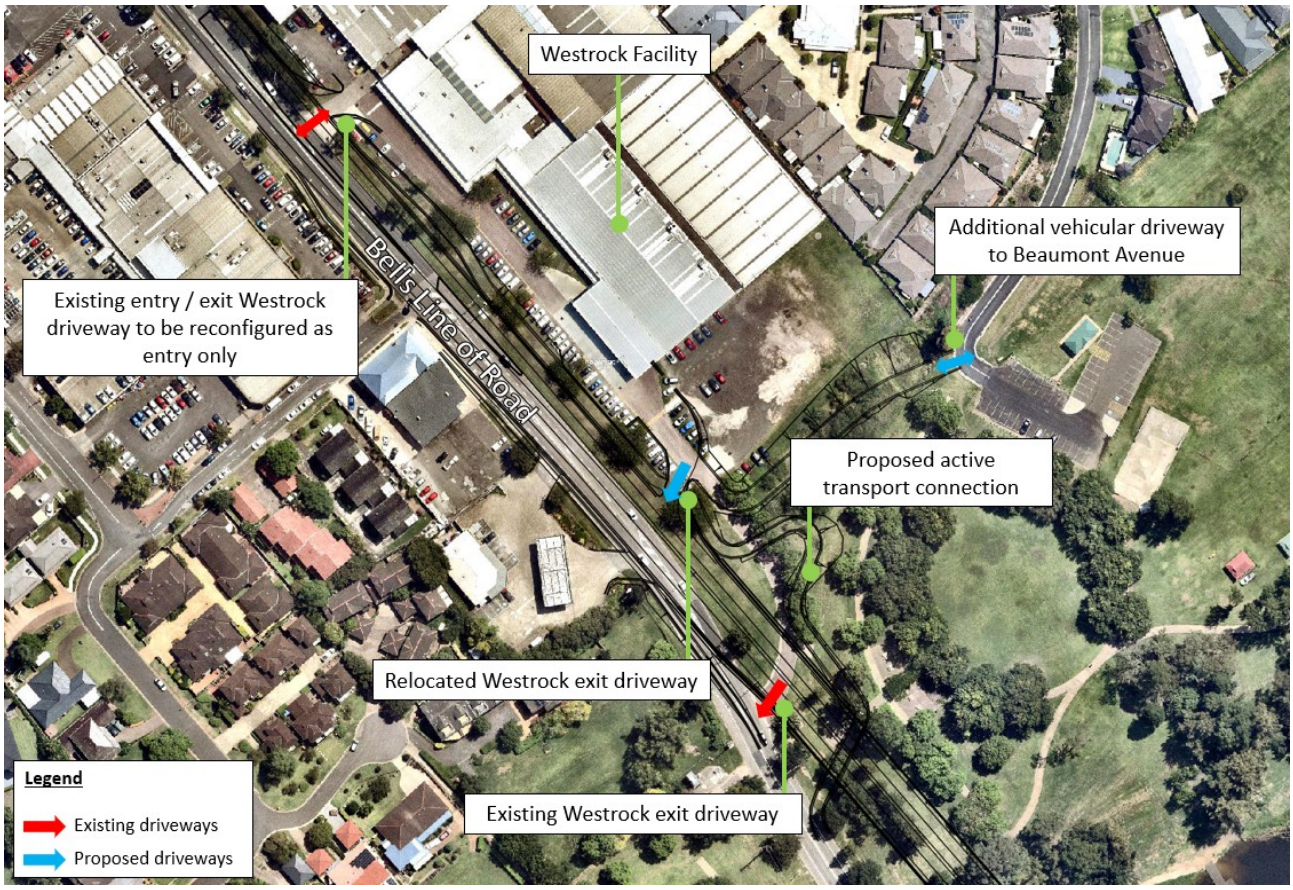


Figure 4-10 Access impacts to the Westrock facility

Bells Line of Road/ BP Service station

The BP service station on Bells Line of Road in North Richmond can be accessed via a right turn in and left turn in movement but exit only left out, with no right turn out traffic movement (towards Richmond) allowed. The right turn movement into the BP service station (eastbound direction) would be closed. The closure of this right turn in movement from Bells Line of Road may impact on how customers access the business, with eastbound travelling vehicles unable to turn right into the BP service station. This may result in customers and delivery vehicles having to alter travel routes to access the business. Left turn into and out of the service station would be retained and as per the existing situation, no right turn out would be allowed.

Drift Road

Several properties located along Drift Road would be impacted by the bypass during operation of Stage 2A.

There are two properties located in the vicinity of the bypass / Drift Road intersection and realigned Drift Road that would be impacted, as follows:

- **3 Drift Road:** vehicular access would be provided via a new cul-de-sac off Drift Road due to the realignment of Drift Road with the bypass. There would be minimal change to accessing this property due to the new intersection with Drift Road and the bypass.
- **2 Drift Road:** would be acquired and demolished as part of the proposal.

Figure 4-11 illustrates the new access arrangement in this location.

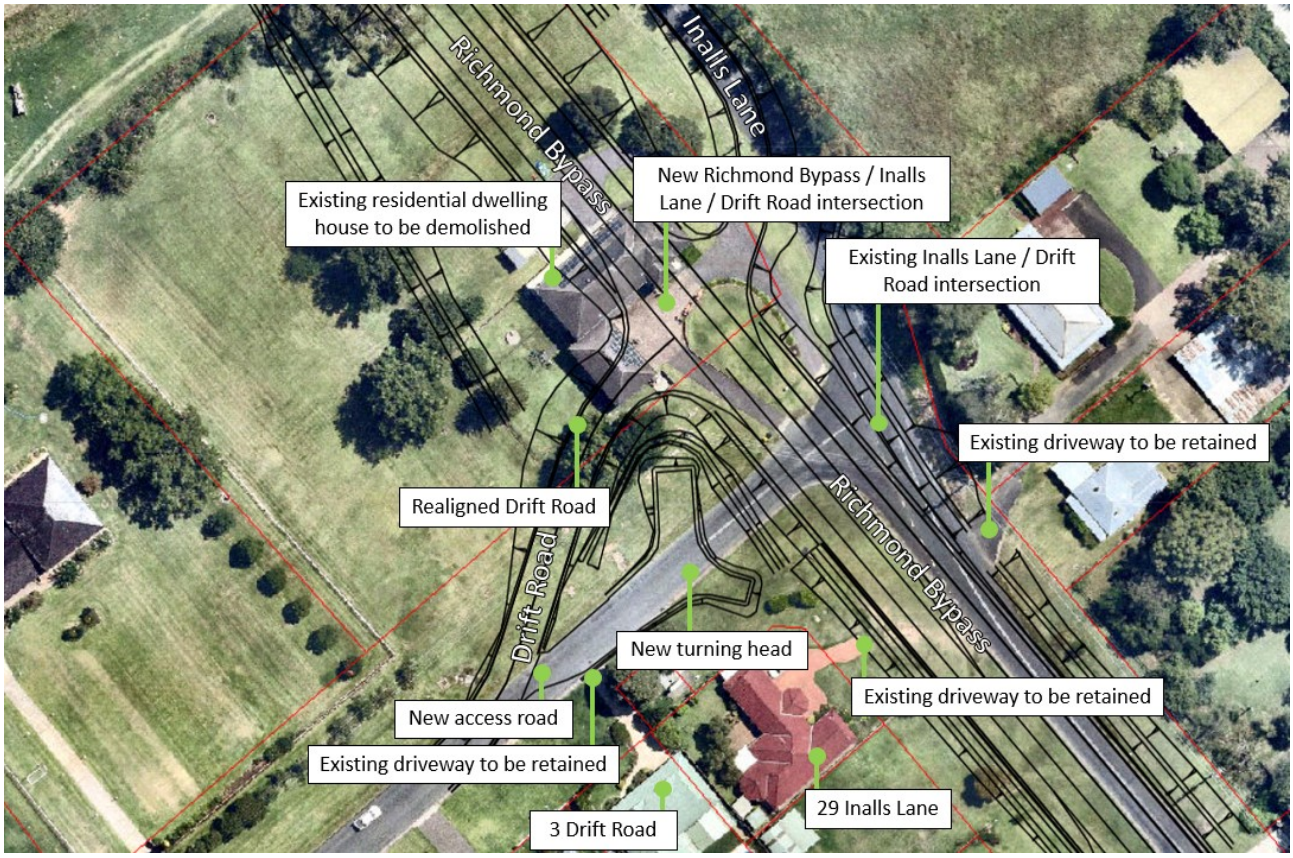


Figure 4-11 Residential property access impacted by the proposal (3 Drift Road and 2 Drift Road)

Inalls Lane

Access to four residential properties located along the northern side of Inalls Lane (2, 4, 6 and 8 Inalls Lane) would be impacted. These properties currently have driveways off Inalls Lane, in close proximity to the existing Castlereagh Road / Inalls Lane intersection. As part of Stage 2A, access to all four residential properties would be provided through a new single access road off the bypass on the existing Inalls Lane alignment. Existing driveways would be retained.

This new access road would operate as left-in left-out only. This would reduce the current accessibility to these properties as residents can currently enter and exit their properties via all turning movements. Residents approaching from Castlereagh Road, or from the east along the new Richmond bypass, would need to detour via Drift Road to access their properties. Figure 4-12 illustrates the new access arrangement.

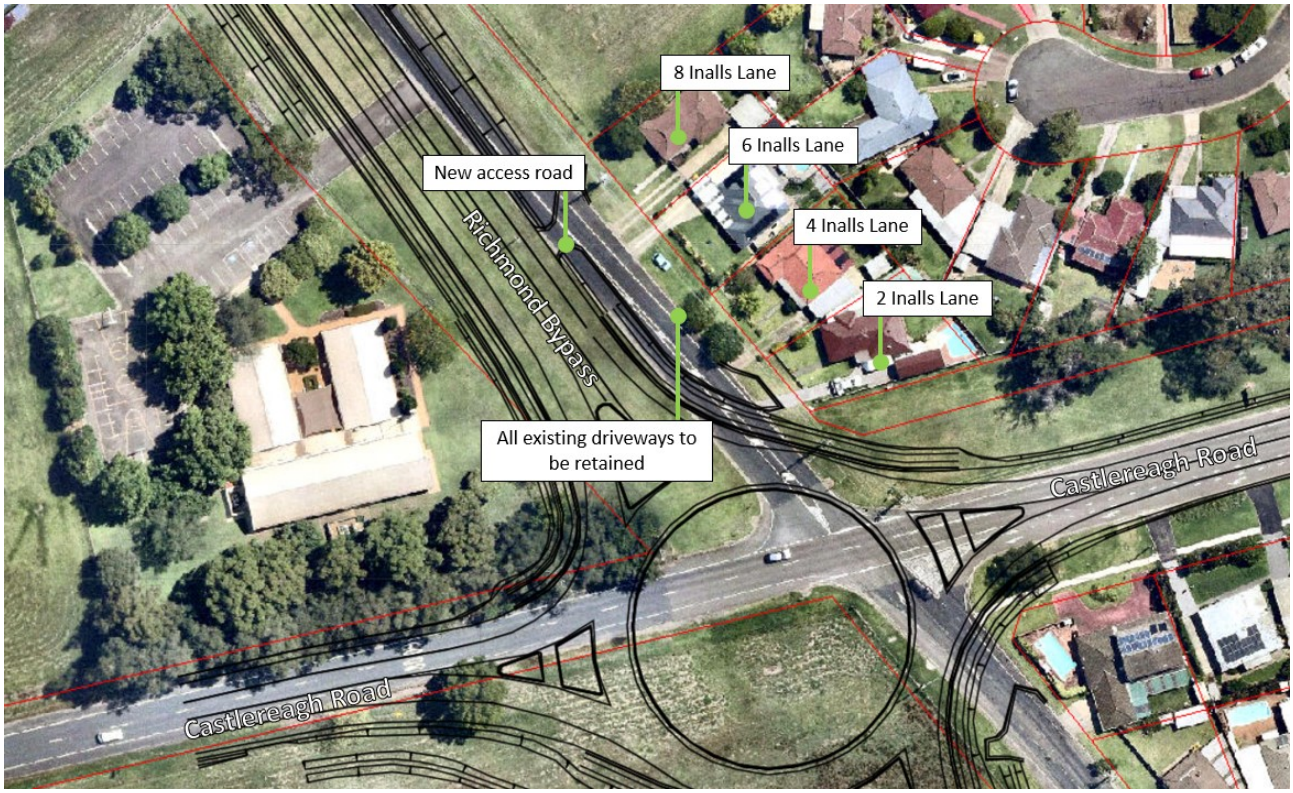


Figure 4-12 Residential property access impacted by the proposal (2, 4, 6 and 8 Inalls Lane)

Southee Road

Southee Road currently serves as a through road between Londonderry Road and Castlereagh Road, and provides access to Hobartville to the north, as well as Western Sydney University (WSU) facilities to the south.

As noted in Section 4.2.5, during Stage 2A, Southee Road would be converted to a cul-de-sac near its intersection with Castlereagh Road. A small new access road from the Castlereagh Road roundabout to Southee Road (opposite Hughes Avenue) would be provided to maintain access.

During Stage 2B, Southee Road would also be converted to a cul-de-sac near its intersections with Londonderry Road, at which time access to/from Southee Road from either Londonderry Road or Castlereagh Road would be provided via a local road connection from the Bypass at Valder Avenue. This may cause minor traffic route changes (including distance and travel time) to residents who currently access Hobartville via Southee Road from either Castlereagh Road or Londonderry Road. All residential properties along Southee Road would maintain their existing access arrangements on Southee Road.

The bypass would also adjust access to the WSU facilities which currently have direct driveway access off Southee Road. A new driveway would be provided on the south-western side of the bypass between Valder Avenue and Hill Avenue, as shown in Figure 4-13.

Figure 4-13 Property vehicular access changes along Southee Road due to the proposal

4.2.7 Impacts on parking

During Stage 2A, the proposal would remove 23 on-street parking spaces, comprised of:

- 15 spaces on Bells Line of Road, between Grose Vale Road and Pitt Lane
- five spaces on Drift Road, south of Inalls Lane
- one space on Inalls Lane, west of Castlereagh Road
- two spaces on Southee Road.

Due to the removal of parking spaces along Bells Line of Road, nine new parking spaces would be provided on the northern side of Beaumont Avenue, near its intersection with Terrace Road as part of Stage 2A. The removal of parking on Drift Road, Inalls Lane and Southee Road would not result in substantial impacts to parking availability during the operation of Stage 2A as there is sufficient unrestricted on-street parking in these areas.

There would be no additional impacts on parking during the operation of Stage 2B as the provision of the cul-de-sac along Southee Road near Londonderry Road is not expected to impact on parking.

Further details on these changes are provided in the following sections.

Bells Line of Road and Beaumont Avenue

The widening of Bells Line of Road through North Richmond town centre would impact up to 15 (¼ P) on-street parking spaces (eight eastbound and seven westbound), as shown in Figure 4-14.

Due to the removal of these on-street parking spaces, the proposal would provide about a 60-metre extension to the existing indented unrestricted parking along the northern side of Beaumont Avenue, as shown in Figure 4-15. This would provide an additional nine unrestricted on-street carparking spaces. Given there is also off-street parking available at the North Richmond Shopping Village, the net removal of six

parking spaces is not expected to result in a substantial impact on parking availability in North Richmond town centre.

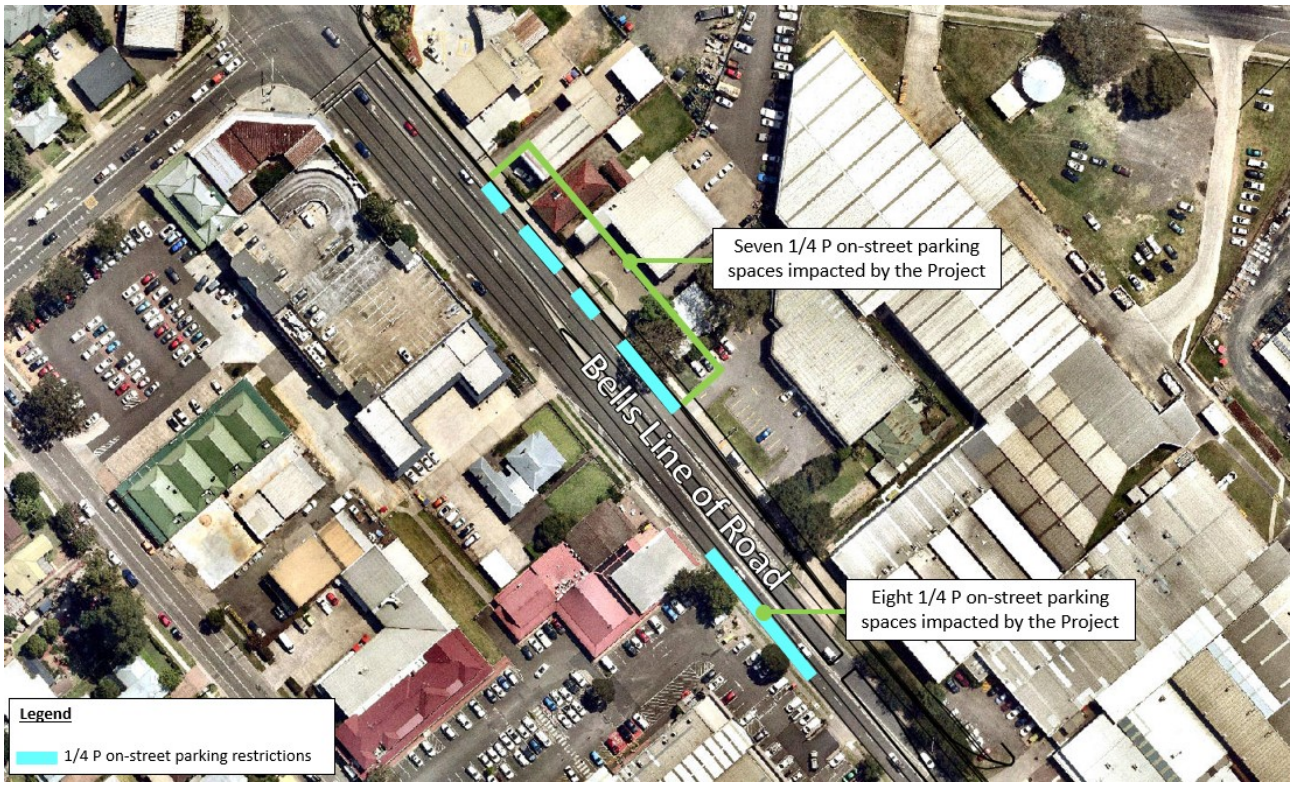


Figure 4-14 On-street parking spaces along Bells Line of Road impacted by the proposal

Figure 4-15 Proposed extension to the existing indented on-street parking

Drift Road

The realignment of Drift Road to connect with the bypass and the provision of a new access road to the adjoining residential properties would require the removal of five existing unrestricted on-street carparking spaces along the eastern side of the existing Drift Road. This is shown in Figure 4-15.

This would not result in substantial impacts to parking availability as there is sufficient unrestricted on-street parking along Drift Road in this area.

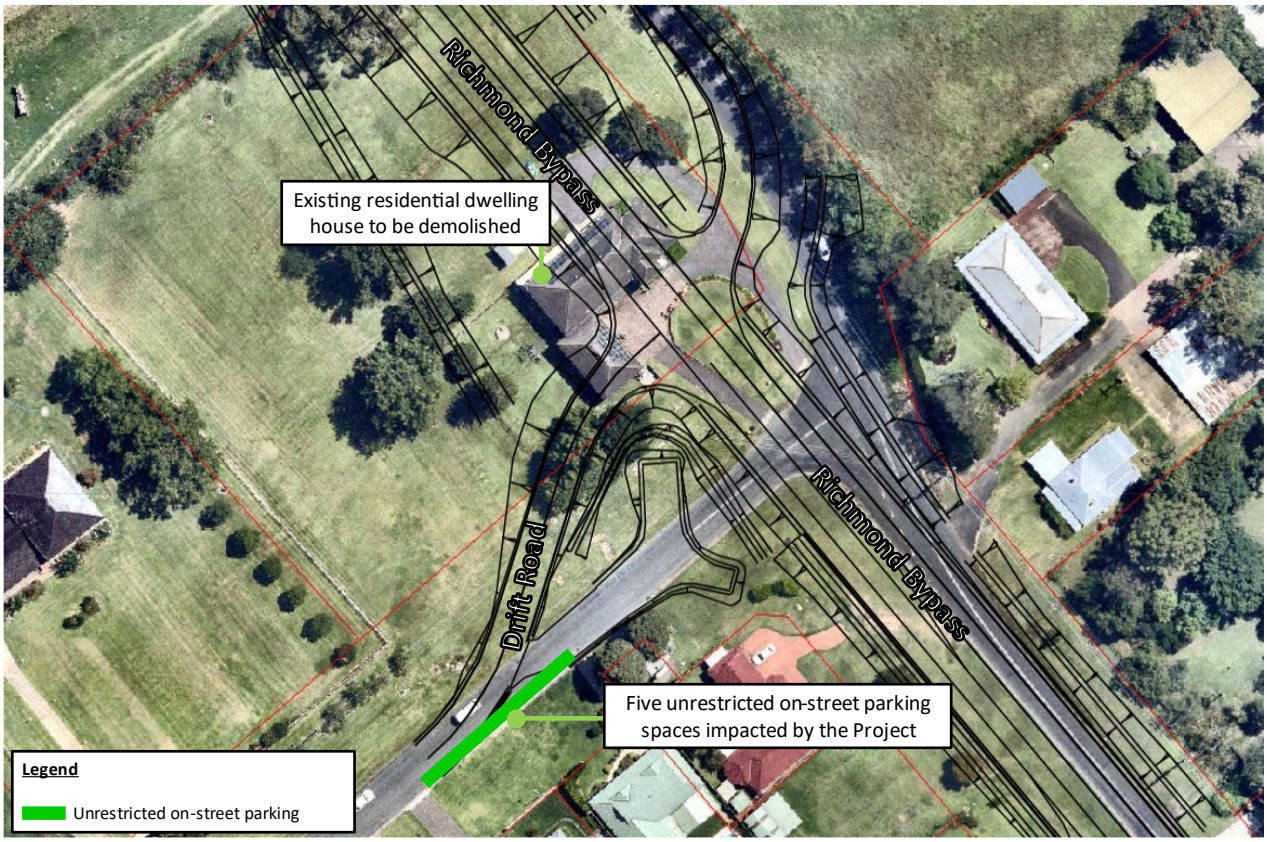


Figure 4-16 Unrestricted on-street parking spaces along Drift Road impacted by the proposal

Inalls Lane

The provision of a new access road off the bypass to 2, 4, 6 and 8 Inalls Lane would impact one existing unrestricted on-street carparking space within an indented parking area on the northern side of Inalls Lane, as shown in Figure 4-17. As this area would only be used by four residential properties, this is not expected to result in substantial impacts to parking availability in this area.

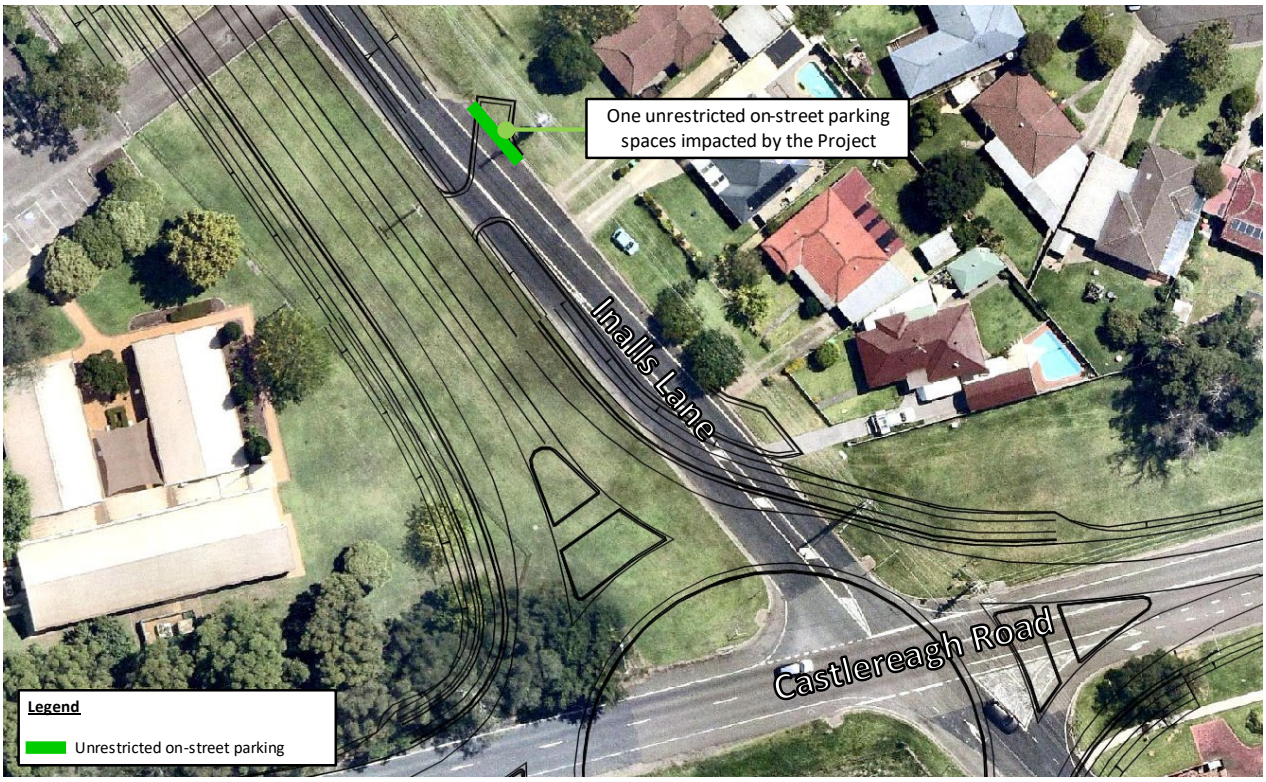


Figure 4-17 Unrestricted on-street parking spaces along Inalls Lane impacted by the proposal

Southee Road

The provision of a new turning head at the northern extent of Southee Road due to the installation of the new bypass / Castlereagh Road / Southee Road roundabout would impact two existing on-street carparking spaces on the northern side of Southee Road, as shown in Figure 4-18. This would not result in substantial impacts to parking availability as there is sufficient unrestricted on-street parking along Southee Road in this area.

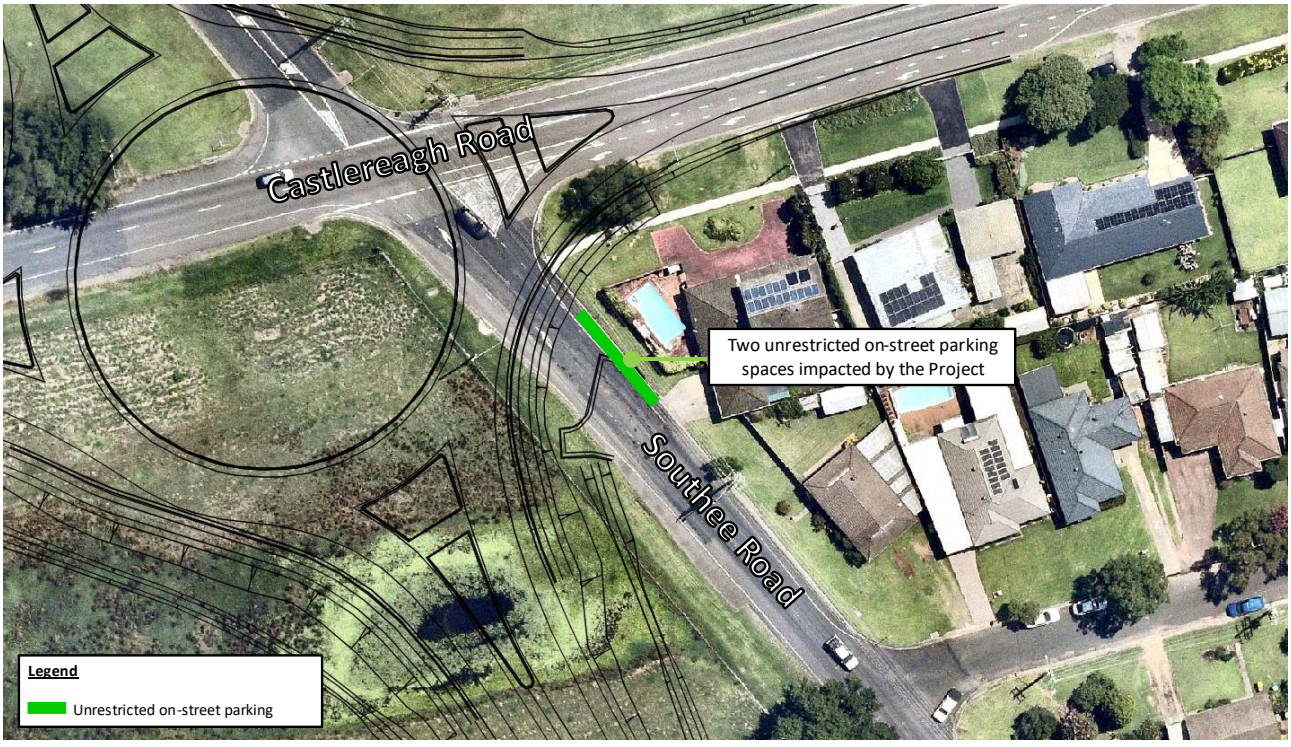


Figure 4-18 Unrestricted on-street parking spaces along Southee Road impacted by the proposal

4.2.8 Impacts on public transport

The operation of the proposal would not result in any changes to the two existing train stations, Richmond Station and East Richmond Station, nor the passenger train lines.

However, the proposal would result in impacts to bus routes and stops within the proposal area, as outlined in the following sections. These bus stops would be relocated to cater for the increase in road width and changes in road alignment.

Stage 2A bus route / stop impacts

During Stage 2A, the Bells Line of Road upgrade and the construction of a new bridge and bypass would result in changes to the existing public bus stops. These impacts would be minor, with bus stops either retained or relocated close to their existing locations.

Along Bells Line of Road, between the intersection with Grose Vale Road and Terrace Road and the intersection with Pitt Lane, the existing northbound bus stop is expected to be retained and a new bus zone about 25 metres in length would be provided. The existing eastbound bus stop, which is currently located within a service road, would be relocated about 250 metres east in front of the Westrock facility, as shown in Figure 4-19. This relocation may require public transport users to walk a slightly longer distance depending on their origins/destinations. The relocation of the bus stop would also remove the traffic bottleneck at the existing location of the bus stop, and improve safety and traffic performance in the eastbound direction on Bells Line of Road.

Figure 4-19 Impacts to existing bus stops along Bells Line of Road in North Richmond (Background image source: Nearmap)

At the Bells Line of Road / Kurrajong Road intersection, the existing eastbound bus stop would be relocated about 10 meters east, and a new bus zone about 25 metres in length would be provided. Similarly, the existing bus stop for westbound buses, currently located on the eastern side of the intersection, would be relocated about 120 meters west as shown in Figure 4-20, with a new bus zone provided. Providing the bus stop on the western side of the intersection would provide better public transport connectivity to the active transport connections proposed on existing Richmond bridge. This relocation may require public transport users to walk a slightly longer distance depending on their origins and destinations.

Figure 4-20 Impacts to existing bus stops in the vicinity of the Bells Line of Road intersection with Kurrajong Road and Old Kurrajong Road (Background image source: Nearmap)

In addition, Stage 2A of the proposal would impact school bus route 5014 operating westbound on Yarramundi Lane and Inalls Lane. The right turn restriction from Yarramundi Lane onto the proposed Richmond bypass would prevent the bus from following its existing route, this may result in longer travel time for school bus users. This bus route would need to be rerouted to adapt to the proposed changes in the road network subject to consultation with the relevant bus operator/s. It is not expected that any other school bus routes would be impacted by the proposal.

Stage 2B bus route / stop impacts

During Stage 2B, at the Bells Line of Road / Crooked Lane intersection, the existing eastbound bus stop would be retained. The westbound bus stop located on Bells Line of Road would be relocated about 80 metres west of the intersection, as shown in Figure 4-21. This may require some public transport users to walk a slightly longer distances to access the relocated bus stop. However, the widening of the intersection to allow for the short right turn lane into Crooked Lane will result in the widening of the intersection (i.e. refuge island) at the new proposed bus stop, which will allow for a safer environment for pedestrians to cross the road than at the current bus stop location.

Figure 4-21 Impacts to existing bus stops in the vicinity of the Bells Line of Road intersection with Crooked Lane (Background image source: Nearmap)

At the Londonderry Road / Southee Road intersection, the existing bus stop on the eastern side of Southee Road would be removed due to the upgrades that would occur at this intersection during Stage 2B. The existing southbound bus stop would be relocated about 60 meters south. The existing northbound bus stop on Londonderry Road would be removed and two new bus stops installed. These would be located on the left turn slip lane and 50 meters north of the intersection and would only be accessible by school bus routes. Figure 4-22 shows the location of existing and new bus stops. Few public transport users may have to walk slightly longer distance to access the bus stops. However, the upgrade of on-road bus stop to bus bay would provide safer environments to get on or off the bus, while improving the traffic performance for all road users and bus services.

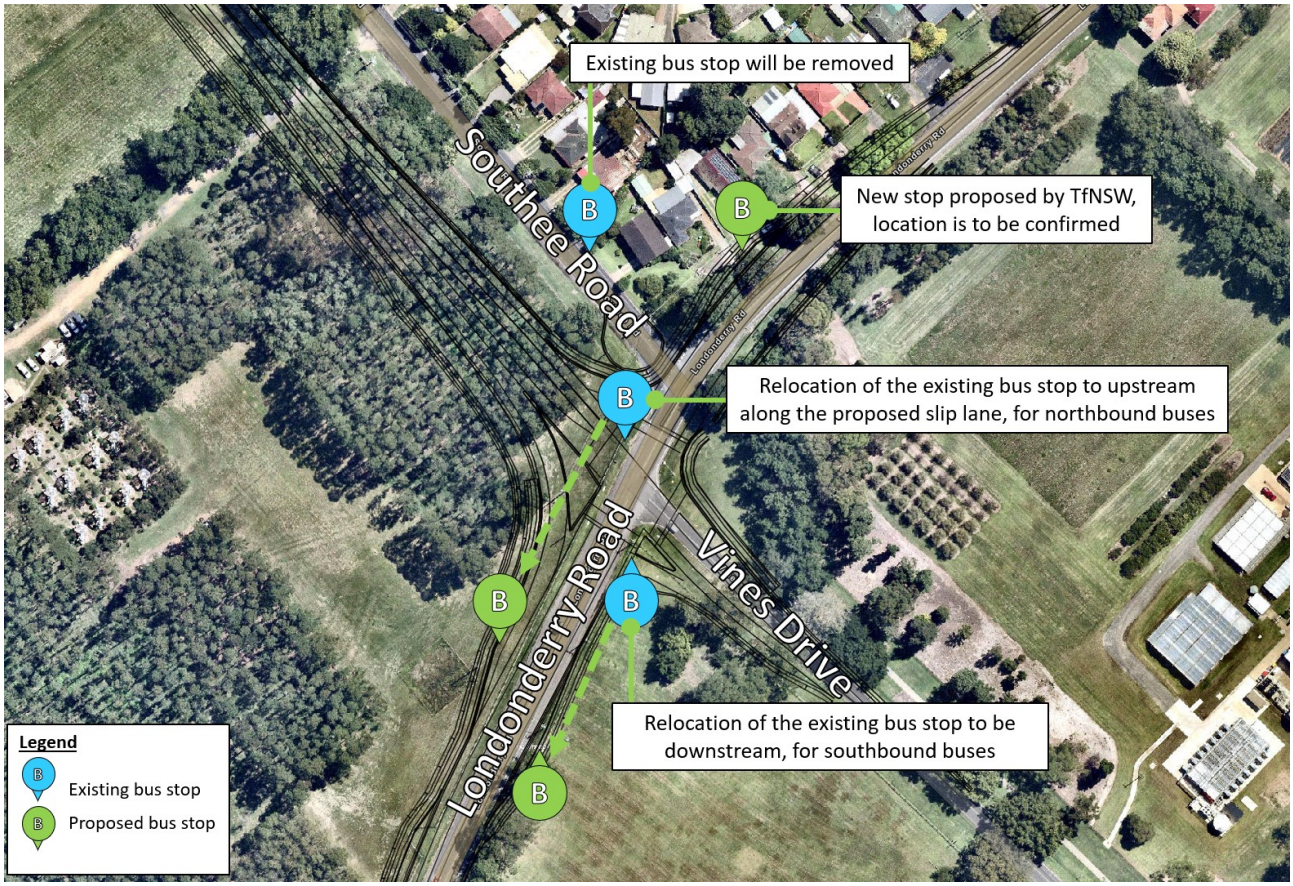


Figure 4-22 Impacts to existing bus stops at the Londonderry Road intersection with Southee Road, and with Vines Drive (Background image source: Nearmap)

Buses currently travelling along Southee Road would likely be rerouted due to the opening of the bypass, subject to consultation with the relevant bus operator/s. The existing eastbound bus stop on Southee Road would be removed and a new eastbound bus stop provided on the bypass. A new westbound bus stop would also be provided on the bypass. These are shown in Figure 4-23. The new bus stops would allow use of bus services routed on bypass along Southee Road.

Figure 4-23 Impacts to existing bus stops in the vicinity of the Southee Road intersection with Hill Avenue (Background image source: Nearmap)

All other existing bus stops would be retained with minor adjustments to accommodate the widening of the road carriageway.

4.2.9 Impacts on active transport

Stage 2A

Stage 2A of the proposal would provide an improved active transport connection between Richmond and North Richmond. These improvements would greatly benefit the community by enhancing pedestrian access and connectivity between North Richmond and Richmond, while actively encouraging the use of active transport This would include:

- A shared path on the northern side of Bells Line of Road in North Richmond between the Terrace Road / Grose Vale Road intersection
- Conversion of the existing Richmond Bridge to an active transport connection
- A new shared path on the southern side of Kurrajong Road between the bypass / Bells Line of Road / Kurrajong Road intersection and the Kurrajong Road / Chapel Street intersection.

The conversion of the existing Richmond Bridge to a dedicated active transport connection would provide a high degree of separation from the new four-lane bridge, creating a safer and more direct route for pedestrians and cyclists. In Hanna Park, there would be an underpass crossing under the new bridge connecting the existing bridge with a new shared path extension along the northern side of Bells Line of Road as shown in Figure 4-24.

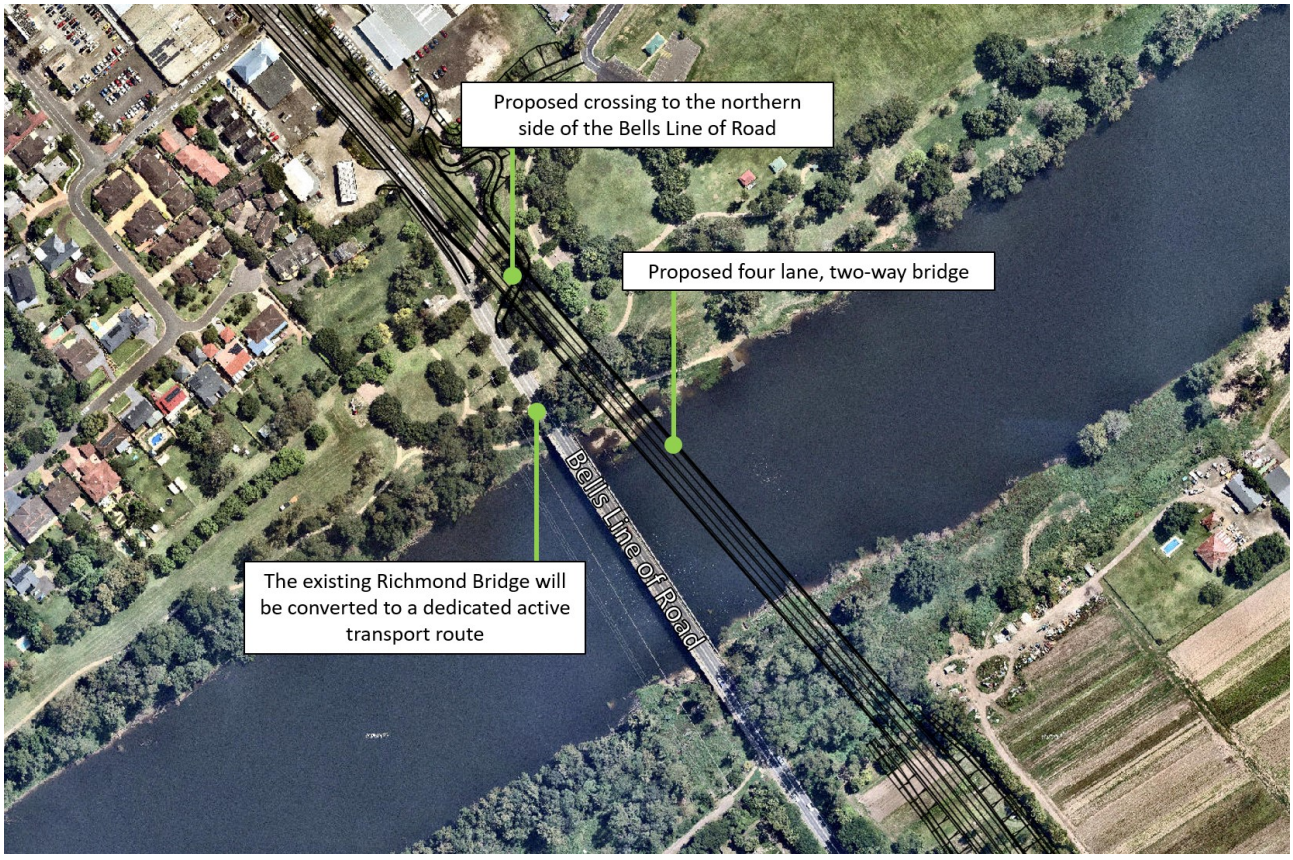


Figure 4-24 Northern extent of the proposed active transport connection along Bells Line of Road (Background image source: Nearmap)

At the Kurrajong Road / Chapel Street intersection, the shared path along the southern side of Kurrajong Road would connect with the existing footpaths in Richmond through the provision of a pedestrian refuge island along Kurrajong Road. The proposed pedestrian refuge island would provide a safe crossing opportunity for active transport users to access the existing footpath along the northern side of Kurrajong Road as shown in Figure 4-25.

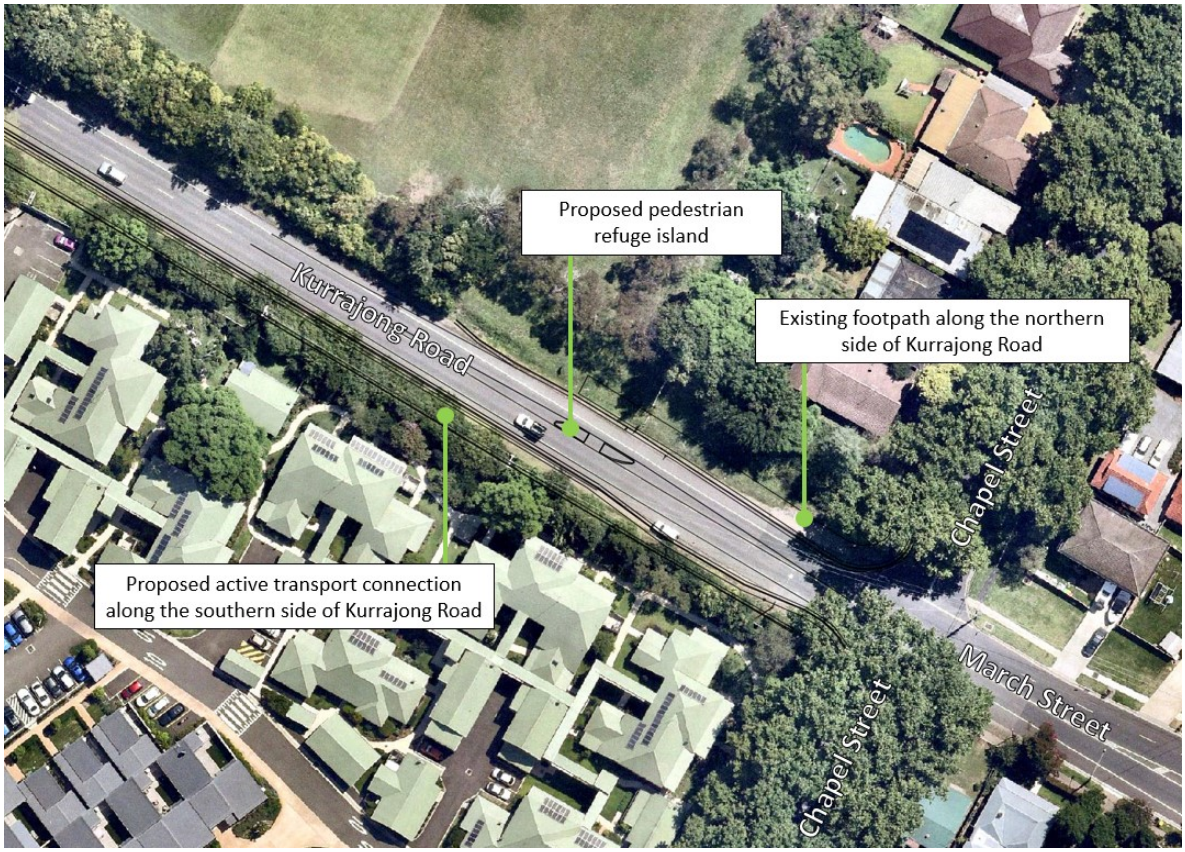


Figure 4-25 Southern extent of the active transport connection along Kurrajong Road (Background image source: Nearmap)

At the proposed bypass / Castlereagh Road intersection, safe movement and crossing for pedestrians would be facilitated through provision of footpaths and pedestrian refuge islands on all sides of the roundabout. A new footpath would extent along the southern side of the bypass from the roundabout to just before Drift Road, as shown in Figure 4-26.

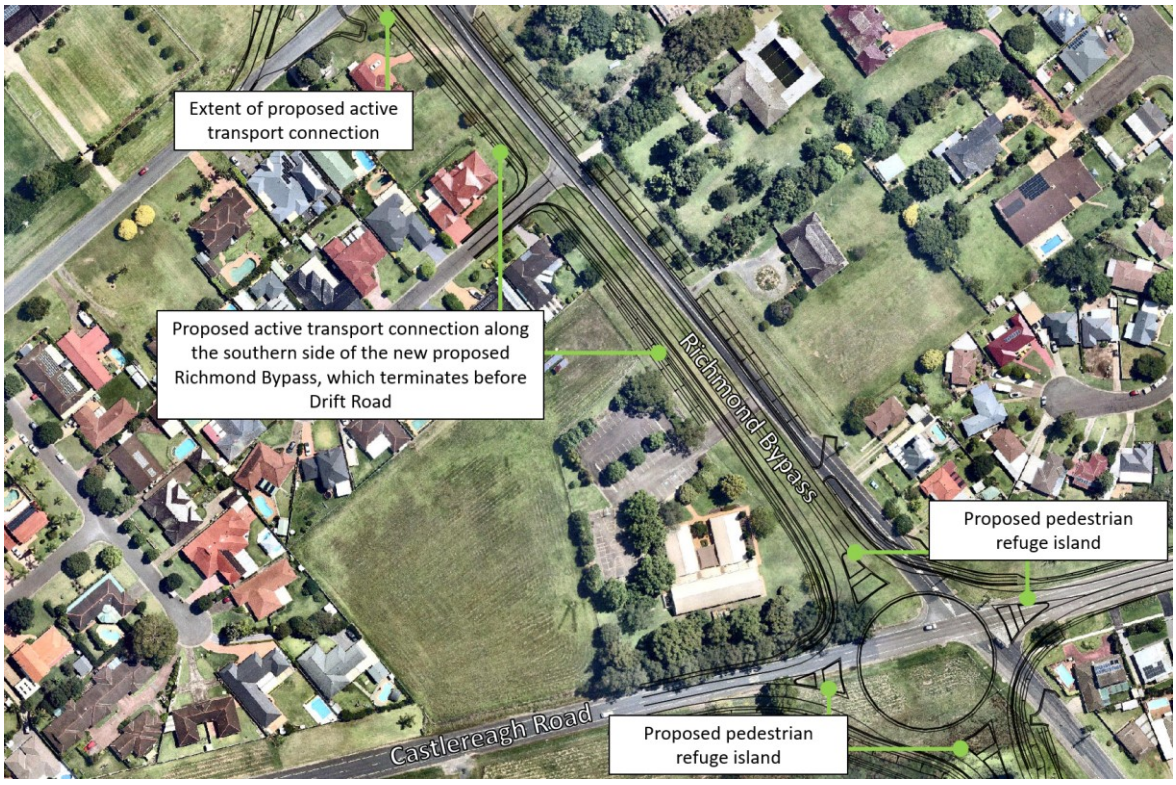


Figure 4-26 Proposed active transport connection at the new proposed Richmond bypass and Castlereagh Road roundabout intersection

Stage 2B

During Stage 2B, the proposal would extend the shared path on the northern side of Bells Line of Road from the Terrace Road / Grose Vale Road intersection to west of Charles Street.

In addition, as part of the extension of the bypass parallel to Southee Road, at the Southee Road / Hill Avenue intersection, there would be a new footpath connection between the new bus stop provided on the southern side of the bypass and Southee Road. A pedestrian refuge island would also be provided along the new bypass to enable safe access to and from the westbound bus stop as shown in Figure 4-27.

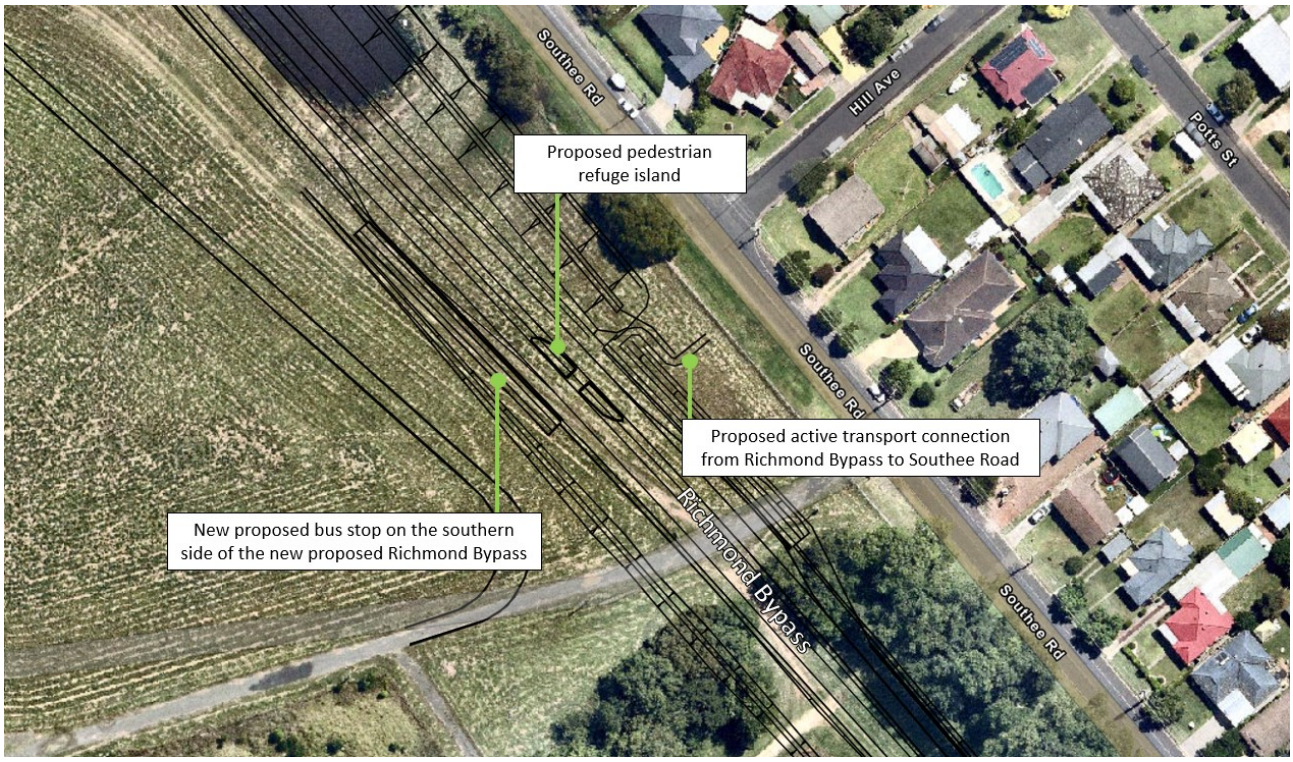


Figure 4-27 Proposed active transport connection along the proposed Richmond bypass

5 Management of impacts

Table 5-1 provides a summary of safeguards and mitigation measures that are recommended for the proposal based on its potential traffic and transport impacts.

Table 5-1 Safeguards and management measures

Impact	Safeguard	Responsibility	Timing
Traffic and transport	A Traffic Management Plan (TMP) will be prepared and implemented as part of the CEMP. The TMP will be prepared in accordance with the latest Transport for NSW *Traffic Control at Work Sites Manual*. The TMP will include: ■ Confirmation of haulage routes ■ Measures to maintain access to local roads and properties. ■ Construction traffic control plans outlining site-specific traffic control measures (including signage) to manage and regulate traffic movement. ■ Measures to maintain pedestrian and cyclist access. ■ Requirements and methods to consult and inform the local community and other affected stakeholders of construction impacts on the local road network and property access. ■ Requirements to consult with the relevant bus operator/s about temporary changes to bus stops within the proposal area and any associated bus services to identify alternate arrangements. ■ Access to construction sites including entry and exit locations, including for oversize overmass vehicles, and measures to prevent construction vehicles queuing on public roads. ■ A response plan for any construction traffic incident. ■ Consideration of other developments that may be under construction to minimise traffic conflict and congestion that may occur due to the cumulative increase in construction vehicle traffic. ■ Monitoring, review and amendment mechanisms	Contractor	Detailed design / pre-construction
Construction site access	Construction site access will be designed and implemented in consideration of: ■ Road design guidelines and turning paths for heavy vehicles, including vehicles required during delivery of bridge girders during Stage 2A ■ Appropriate sight distances and deceleration/acceleration lanes (where required near highly trafficked areas) to allow traffic to safely enter and exit ■ Conspicuous temporary regulatory, warning and guide signs ■ Use of accredited traffic controllers, where appropriate and/or other controls to separate, slow down or temporarily stop traffic for safe entry/exit. ■ Minimising use of local roads, where practical ■ Minimising the size of heavy vehicles that would use local roads to access construction zones ■ Safe arrangements for pedestrians and/or cyclists.	Contractor	Detailed design / construction
Traffic impacts	Further traffic modelling will be carried out during detailed design following confirmation of the construction methodology and traffic staging to confirm the potential for traffic impacts and identify whether any additional mitigation measures or traffic control measures would be required.	Contractor	Detailed design
Bus stops	Transport and the Contractor will consult with the relevant bus operator/s about temporary and permanent changes to bus stops within the proposal area.	Transport / Contractor	Detailed design

Impact	Safeguard	Responsibility	Timing
Parking	During detailed design, Transport and the Contractor will consider opportunities to minimise the number of parking spaces that need to be removed for the project.	Transport / Contractor	Detailed design
Parking	The Beaumont Avenue compensatory parking will be installed in the early stages of Stage 2A construction prior to the removal of parking spaces on Bells Line of Road.	Contractor	Construction
Damage to local roads	A Road Dilapidation Report will be prepared by a suitably qualified person for regional and local roads proposed to be used by heavy vehicles, before the commencement of use of the roads during construction. This report must be developed in consultation with Hawkesbury City Council. Any damage to the regional or local road network identified to be caused by construction vehicles for the proposal will be remediated by the contractor to be similar to the existing road condition or compensation will be paid to the relevant road authority.	Contractor	Pre-construction / Construction
Impacts on active transport movement	During detailed design, an active transport detour strategy would be prepared and implemented to minimise any temporary impacts on pedestrians and cyclists during construction. At a minimum, this will include consideration of detours along Bells Line of Road in North Richmond, Hanna Park in North Richmond and near the Kurrajong Road / Chapel Street intersection in Richmond.	Contractor	Detailed design / pre-construction / construction
Traffic management measures	Any temporary traffic diversions, clearways and road closures will be implemented in accordance with Transport Management Centre (TMC) requirements	Contractor	Construction
Property access	Property access will be maintained at all times where feasible and reasonable. Property owners will be consulted before starting any work that may temporarily restrict or control access.	Contractor	Construction
Local road access	Local road access will be maintained at all times. Where detours are required to maintain access, Council will be consulted to identify suitable mitigation measures such as detour routes.	Contractor	Construction
Emergency services	Notification would be issued to emergency services about changes in traffic conditions.	Contractor	Construction
Construction worker parking	Off-road parking for construction vehicles will be provided within the identified ancillary facilities.	Contractor	Construction
Traffic existing condition changes prior to Stage 2B construction/	Prior to commencement of construction for Stage 2B, Transport and the contractor will review the traffic, pedestrian and cyclist management measures implemented during construction of Stage 2A. The management measures will be adjusted for Stage 2B to minimise potential for impacts during construction of Stage 2B. This will focus on the Bells Line of Road / Grose Vale Road / Terrace Road intersection and Bypass / Castlereagh Road / Southee Road intersection.	Transport / Contractor	Detailed design/Pre-construction

6 Conclusion

Transport for NSW (Transport) proposes to upgrade Bells Line of Road / Kurrajong Road between Crooked Lane, North Richmond and Old Kurrajong Road, Richmond and construct a new bypass south of Richmond town centre. The proposal would be delivered in two stages, known as Stage 2A and Stage 2B.

Stage 2A of the proposal includes a new four-lane bridge over the Hawkesbury River about 30 metres downstream of the existing Richmond Bridge, widening of Bells Line of Road through North Richmond to provide two lanes in each direction between the new bridge and the Terrace Road / Grose Vale Road intersection and a new bypass to the south of the Richmond town centre. Stage 2A would also provide an active transport corridor between North Richmond and Richmond. Stage 2B of the proposal includes widening of Bells Line of Road between the Terrace Road / Grose Vale Road intersection and west of Charles Street and at its intersection with Crooked Lane and extending the bypass from Castlereagh Road to Londonderry Road.

A review of the existing traffic conditions without the proposal shows the following key network constraints:

- The Bells Line of Road / Kurrajong Road / Old Kurrajong Road intersection performs unsatisfactorily at LOS F during the AM and PM peak hours, driven by delays experienced by vehicles on Old Kurrajong Road wishing to cross or turn onto Bells Line of Road / Kurrajong Road.
- The Bells Line of Road / Grose Vale Road / Terrace Road intersection performs unsatisfactorily at LOS F during the AM peak hours due to queuing and delays caused by limited capacity at the intersection and insufficient capacity further east of the on Bells Line of Road. This intersection would improve to LOS D but near capacity during the PM peak, acting as a bottleneck for westbound traffic.

The proposal is therefore required to:

- reduce congestion and improve travel times between Richmond and North Richmond during peak periods
- cater for future traffic growth, including future residential development and freight growth in the Hawkesbury region and for freight movements
- improve road safety and connectivity between Bells Line of Road and the arterial road network
- improve flood resilience of the connection between Richmond and North Richmond.

During construction of both stages of the proposal, there would be additional traffic on the road network, including construction worker vehicles, light construction vehicles and heavy vehicles delivering plant, equipment and materials. The proposal area is well serviced by a road network suitable for heavy vehicles and is expected to be able to accommodate the vehicles required during construction. Construction vehicles accessing the proposal area are not expected to result in substantial impacts to the existing traffic movements near the proposal due to the relatively low number of vehicle movements compared to the existing traffic volumes.

During construction of Stage 2A, the northern leg of Old Kurrajong Road would be closed to traffic during construction and permanently converted to an emergency access gate. During AM peak, about 130 vehicles are expected to be redirected to the March Street / Bosworth Street intersection. Without the proposal in 2029, the intersection's performance would change to LOS D during both AM peak hours, and LOS D and LOS E respectively during the first and second PM peak hour. This suggests the intersection has some capacity during the peak periods to cater for additional traffic demand.

The operational traffic performance of the proposal has been assessed using Aimsun traffic modelling software. The future year models have been developed for 2029 (for Stage 2A) and 2039 (for Stage 2B) scenario years, with and without the proposal.

Overall, the proposal would alleviate congestion between Richmond and North Richmond during peak periods and would redistribute traffic onto the new bypass. There would be lower total vehicle hours travelled, higher network speeds and less vehicles queuing and unable to enter the proposal area compared to without the proposal.

During the AM and PM peak periods, the proposal would improve the performance of the road at most key intersections within the traffic and transport study area. Substantial improvements in traffic flow are expected at the Bells Line of Road / Grose Vale Road / Terrace Road intersection and Bells Line of Road / Kurrajong Road / Old Kurrajong Road intersection. The bypass / Castlereagh Road intersection would perform at LOS D with Stage 2A in 2029 due to high traffic volumes travelling along the bypass. This would improve to LOS B with Stage 2B in 2039 due to the addition of a second land on the roundabout.

The proposal would also improve travel time for motorists between Richmond and North Richmond. The greatest travel time benefits would be during the PM peak, when the dominant direction of travel is westbound. Motorists travelling westbound along the bypass in the PM peak between Richmond and North Richmond would experience a reduction in travel time of between about two and four minutes in 2029 and 2039 compared to without the proposal. There would also be travel time savings of about three minutes and for westbound traffic travelling between Hobart Street, Richmond and Crooked Lane, North Richmond in both 2029 and 2039. These results indicate that the existing road network would be unable to cope with increasing traffic demand in future years.

The proposal would result in the relocation of several bus stops close to their existing location to tie in with the new road alignment. This includes bus stops:

- along Bells Line of Road in North Richmond, near Pitt Lane (Stage 2A)
- at Bells Line of Road intersection with Kurrajong Road and Old Kurrajong Road (Stage 2A)
- at Bells Line of Road intersection with Crooked Lane (Stage 2B)
- at Londonderry Road intersection with Southee Road, and with Vines Drive (Stage 2B)
- at Southee Road intersection with Hill Avenue (Stage 2B)

Given the localised nature of bus stop relocation, the relocated bus stops would remain accessible to public transport users. One bus route (school bus route 5014) would need to be re-routed to adapt to the new road network due to the Yarramundi Lane / Inalls Lane access arrangement changes. Overall, the proposal would not have a substantial impact on bus services within the traffic and transport study area.

As part of Stage 2A, an upgraded active transport connection between the Bells Line of Road / Grose Vale Road / Terrace Road intersection in North Richmond and Kurrajong Road / Chapel Street intersection in Richmond would be provided. This would new shared paths along Bells Line of Road in North Richmond, conversion of the existing Richmond Bridge to an active transport connection (with all traffic on the new bridge) and a shared path on the southern side of Kurrajong Road through to Richmond. The new connection would connect with the existing active transport network in Hanna Park and in Richmond to enhance the ability for pedestrians and cyclists to move between Richmond and North Richmond. During Stage 2B, the shared path on the northern side of Bells Line of Road would be extended further west to further enhance the active transport connectivity through North Richmond town centre.

Stage 2A of the proposal would also impact a total of 23 on-street parking spaces. To compensate the loss of 15 parking spaces on Bells Line of Road in North Richmond, nine new on-street unrestricted parking spaces would be provided on the northern side of Beaumont Avenue. While there would be a net loss of parking spaces, the provision of these new spaces would minimise the impacts to motorists wishing to park in North Richmond. The other parking spaces would be removed on Drift Road, Inalls Lane and Southee Road, in areas with general on-street availability, meaning that the impact of the removal of these spaces on availability of parking would be negligible.

Appendices

Appendix A – Calibration and validation report

To	**Transport for New South Wales (TfNSW)**	From	**Aurecon**
Copy	**-**	Reference	**P523584**
Date	**2023-08-11**	Pages (including this page)	**75**
Subject	**New Richmond Bridge Stage 2 – Base Traffic Model Calibration and Validation**		

Table of Contents

1 Introduction

1.1 Project overview

1.1.1 Background

Richmond is a town in the Local Government Area (LGA) of the City of Hawkesbury. It is located 19 metres above sea level on the alluvial Hawkesbury River flats, at the foot of the Blue Mountains on the Cumberland Plain. It is about 65 km by road from Sydney and about 78 km by road from Lithgow.

The existing Richmond Bridge connects Richmond and North Richmond over the Hawkesbury River. It currently operates at capacity, with 2,400 and 2,500 vehicles per hour (both directions) crossing the bridge during the AM and PM peak hours respectively. Traffic demand in the study area is expected to increase by 44% between 2019 and 2046 during peak periods, with a forecast of an additional 2,000 dwellings west of the Hawkesbury River. Additionally, the Bridge currently faces less than 1 in 2-year probability flood event level, which has resulted in bridge closures for minor flooding events. The Richmond Bridge is not part of a flood evacuation route.

In addition to the network congestion and connectivity issues, there are crash clusters on the approaches to Richmond Bridge, in Richmond town centre and at key intersections along the Driftway. Between 2016 to 2020, 202 crashes were recorded, with three fatalities and 172 injured crashes.

The NSW and Australian Government have committed to implement a new bridge between Richmond and North Richmond, as well as improve traffic and safety conditions within the area. This new bridge across the Hawkesbury River, with a 1 in 20-year flood resilience, would complement the existing bridge by providing more reliable access between Richmond and North Richmond during flood events. Additionally, proposed road and intersection upgrades between Bells of Line Road, North Richmond to The Driftway, and Londonderry will bypass the Richmond Town Centre, providing more direct access to Kurrajong, Windsor and North Richmond.

The project is being carried out in two stages. Stage 1 involves The Driftway upgrade and is being delivered separately to this Stage 2, which aims to enhance the road network resilience, cater for congestion ahead of Richmond's anticipated growth and improve road safety and efficiency along the corridor for motorists, cyclists and pedestrians.

1.1.2 Status

Aurecon has been engaged by TfNSW to undertake the Concept Design and REF for the New Richmond Bridge and traffic improvements Stage 2 (the project). The services for the design only contract (Contract No: 20.0000303662.1339) are to be carried out in accordance with the PS200 series specifications (Services Brief).

1.2 Project objectives

The project specific objectives, as defined in Annexure PS201 Annexure A5 are to:

- Improve travel times, journey time reliability, and cater for future demand for private, public, active and freight transport between North Richmond, Richmond and the connecting arterial road network,
- Reduce the frequency and severity of crashes on key road corridors between Richmond and North Richmond,
- Improve connectivity between Bells Line of Road and Sydney's arterial road network,
- Improve flood resilience to 1 in 20 or better for the entire alignment, and
- Support economic development, improved liveability, and Council's long-term vision for the town centres of Richmond and North Richmond.

In doing this TfNSW will reserve a road corridor that aims to:

- Improve connections to the Central West of NSW as the alternative connection to the Great Western Highway,
- Maintain the historical significance of the area, and
- Best fit with the built fabric and natural patterns of the area.

1.3 Purpose of this technical memorandum

As part of the Concept Design's development and associated traffic assessment, Aurecon was required to update the existing 2018 microsimulation traffic model, including the recalibration and revalidation of the model, towards 2023 traffic conditions.

The objective of this technical memorandum is to outline the changes made to the existing traffic model, whilst updating it to current traffic conditions, as well as to present the updated traffic model's calibration and validation results.

The methodology and guidelines followed for the existing traffic model update were aligned to:

- Roads and Maritime – Traffic Modelling Guidelines (Version 1.0, February 2013),
- Roads and Maritime – Technical Direction Traffic Management: Operational Modelling Reporting Structure (May 2017), and
- Roads and Maritime – Technical Direction Traffic modelling: Traffic Signal in Microsimulation Modelling (November 2018).

It is noted that this technical memorandum does not include a discussion of the future project options to be evaluated. The various options and corresponding analysis and results will be outlined as part as the Traffic and Transport Assessment Report.

1.3.1 Previous traffic model

An Aimsun traffic model was previously developed by AECOM, as part of the Richmond Bridge Duplication and Traffic Improvements study. The traffic model was developed and calibrated to 2018 traffic conditions. The traffic model was used as the basis to evaluate the possible upgrading options on the corridor including intersection improvements, a bridge duplication and a bypass.

The 2018 base traffic model was made available to Aurecon by TfNSW and was used as the origin for the development of the New Richmond Bridge traffic model.

1.3.2 Modelled study area

The base model road network broadly consists of the following key road corridors:

- East-West corridors:
  - Hawkesbury Valley Way / Windsor Street / Kurrajong Road / Bells Line of Road, extending from Richmond to North Richmond,
  - Blacktown Road / Lennox Street, in Richmond,
  - Southee Road, south of Richmond,
  - The Driftway, south of Richmond,
- North-South corridors:
  - Londonderry Road, south of Richmond,
  - Castlereagh Road / Bosworth Street, south of Richmond,
  - Old Kurrajong Road / Yarramundi Lane, west of Richmond, and

– Grose Vale Road / Terrace Road, in North Richmond.

Figure 1 presents the extent of the study area and the model road network, as agreed with TfNSW.

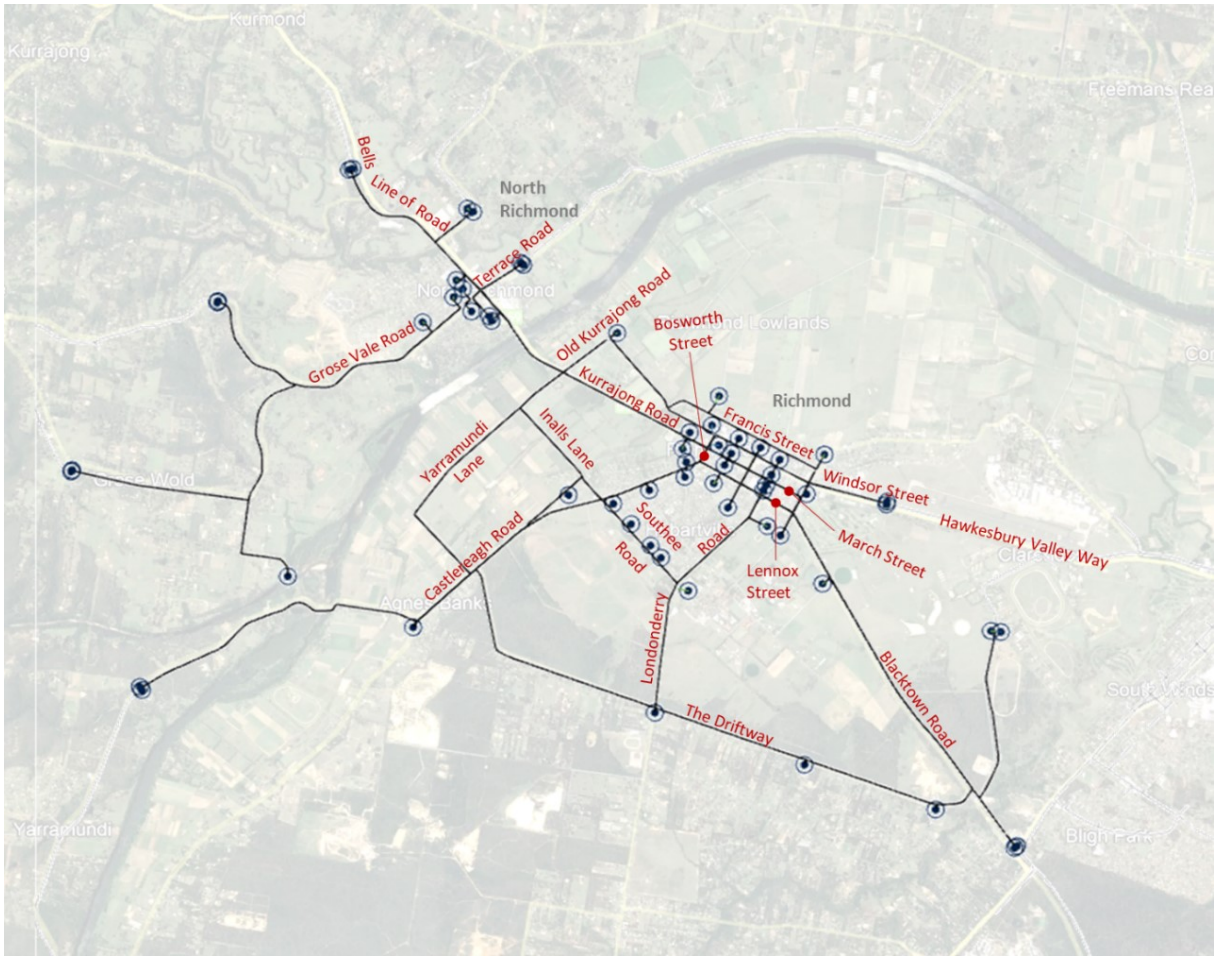


Figure 1: New Richmond Bridge Stage 2 modelled study area (Background source: Google Earth)

1.3.3 Modelling assumptions and limitations

It is noted that the following non-exhaustive list of assumptions and limitations are applicable in relation to the recalibration and revalidation of the existing year microsimulation model:

- The existing conditions model for 2023 has been developed from the previous Aimsun Microsimulation traffic model developed in 2018 (Section 1.3.1). It is assumed that the 2018 model along with its assumptions and limitations were acceptable,
- Traffic survey data provided by TfNSW is a true and accurate representation of existing 2023 normal traffic conditions,
- SCATS data, including detector counts, signal history and offset data; provided by TfNSW is correct and reflects a normal day's operations,
- The scope of developing the Aimsun model is limited to the agreed model boundary and the model does not take into account the impacts of network bottlenecks outside the model boundary,
- Traffic model development has been limited to key road corridors and intersections that have significant impact on the performance of the overall network and does not cover all roads within the study area, and
- The aerial photography sourced from Nearmap was a true and accurate representation of 2023 Road geometry.

2 Traffic data collection and existing situation

2.1 Model input data

Model development involved an extensive data collection process. Table 1 summarises the various data inputs, their sources and application in the existing model development. Additional discussion is further presented in the following sub-sections for some specific data types.

Table 1: Model input data

Data Type	Item	Source	Collection date	Application
Network Geometry	Existing traffic model (2018)	TfNSW	Mar-23	Used as the starting point for model network development
	Nearmap aerial imagery	Nearmaps, TfNSW	May-23	Latest aerial imagery – used for network refinement and coding
	Imagery, street views, site visit	Google Earth, Google Maps	May-23	Posted speed limits, road network geometry, school zones, etc.
		Open Street Maps		
		Site visit		
Traffic Signals	SCATS phasing plots and history data	TfNSW	Feb-23	For model signal coding including, phasing, coordination
Public Transport	Bus routes, stops and timetables	https://transportnsw.info/	Feb-23	Public transport network coding
Heavy Vehicle Access Routes	Freight routes	TfNSW	Feb-23	Network coding and traffic assignment
Traffic Count Data	Intersection classified traffic counts	Video surveys by Matrix Traffic and Transport Data, TfNSW	Tue,7 Feb 2023	Model recalibration and demand estimation
	Mid-block counts	Automatic traffic counts (ATC) by Matrix Traffic and Transport Data, TfNSW	Tue,7 Feb 2023 to Mon, 13 Feb 2023	
	SCATS detector counts	TfNSW	Tue,7 Feb 2023	Count verification
Traffic Distribution - Origin Destination (OD) data	OD survey data	Vehicle number plate survey by Matrix Traffic and Transport Data, TfNSW	Tue,7 Feb 2023	Trip distribution and demand estimation
	OD demand data	Existing 2018 traffic model	Mar-2023	
Travel Time	Travel time and speed data	Floating car travel time survey by Matrix Traffic and Transport Data, TfNSW	Tue,7 Feb 2023	Model revalidation
Intersection congestion conditions	Intersection approach queue lengths	Queue length survey by Matrix Traffic and Transport Data, TfNSW	Tue,7 Feb 2023	Model revalidation

2.1.1 Road network data

The road geometry was checked using GIS aerial photography, Google map street view images and site visit records to ensure that the model coding correctly reflected the current road network. Key features in the study area that have been considered in the model recalibration and revalidation process, from a road network perspective, included:

- Intersection layouts, including lane configuration, lane length and turn bans,
- Posted speed limits, including at school zones,
- On-street parking,
- Heavy vehicle restrictions, and
- Bus lanes and bus stops.

2.1.2 Traffic signal operations

A detailed map of traffic signal locations with TCS numbers is presented in Figure 2. There are eight (8) signalised intersections within the study area, which are also listed in Table 2. SCATS traffic signal operation data, including graphics, plans, LX files and historic data for the survey day, were provided by TfNSW for all signalised intersections. The phase sequence, cycle times, inter-greens, subsystem and offsets for each TCS are provided in Appendix A. The SCATS traffic signal data was used to simulate signal operation in the microsimulation model. The following SCATS traffic signal data was coded into the traffic model:

- Phase settings, sequence of phases and pivoting phase,
- Average phase and cycle time (by One-hour interval), and
- Signal offsets.

Table 2: Study area signalised intersections

TCS No.	Intersection
1645	Windsor Street / East Market Street
1644	March Street / East Market Street
2614	Lennox Street / East Market Street
1027	Lennox Street / Paget Street
1777	Lennox Street / Blacktown Road / Bourke Street
2303	Bells Line of Road / Grose Vale Road / Terrace Road
2595	Bosworth Street / March Street
2762	Windsor Street / Bourke Street

Figure 2: Study area signalised intersection locations, SCATS TCS numbers (Background source: Google Earth)

2.1.3 Traffic count data

Classified intersection turning count and midblock count data were supplied by TfNSW and collected by Matrix Traffic and Transport Data. The intersection traffic surveys were undertaken on Tuesday 7th February 2023 (defined from hereon as the 'survey day') and 7-day ATC surveys were undertaken from 7th February 2023 to 13th February 2023 for midblock counts.

The traffic count data was segmented into five vehicle types (light vehicles, rigid vehicles, articulated vehicles, buses and cycles) and binned into 15-minute intervals from 06:00 to 10:00 in the AM period and from 14:00 to 18:00 in the PM period. Pedestrian count data was also provided for the intersections with pedestrian crossings. The surveyed intersection and midblock count locations are shown in Figure 3 and are listed in Table 3 and Table 4, respectively. Figure 3 also shows the location of signalised intersections in the study area for which SCATS detector count data was made available for the survey day.

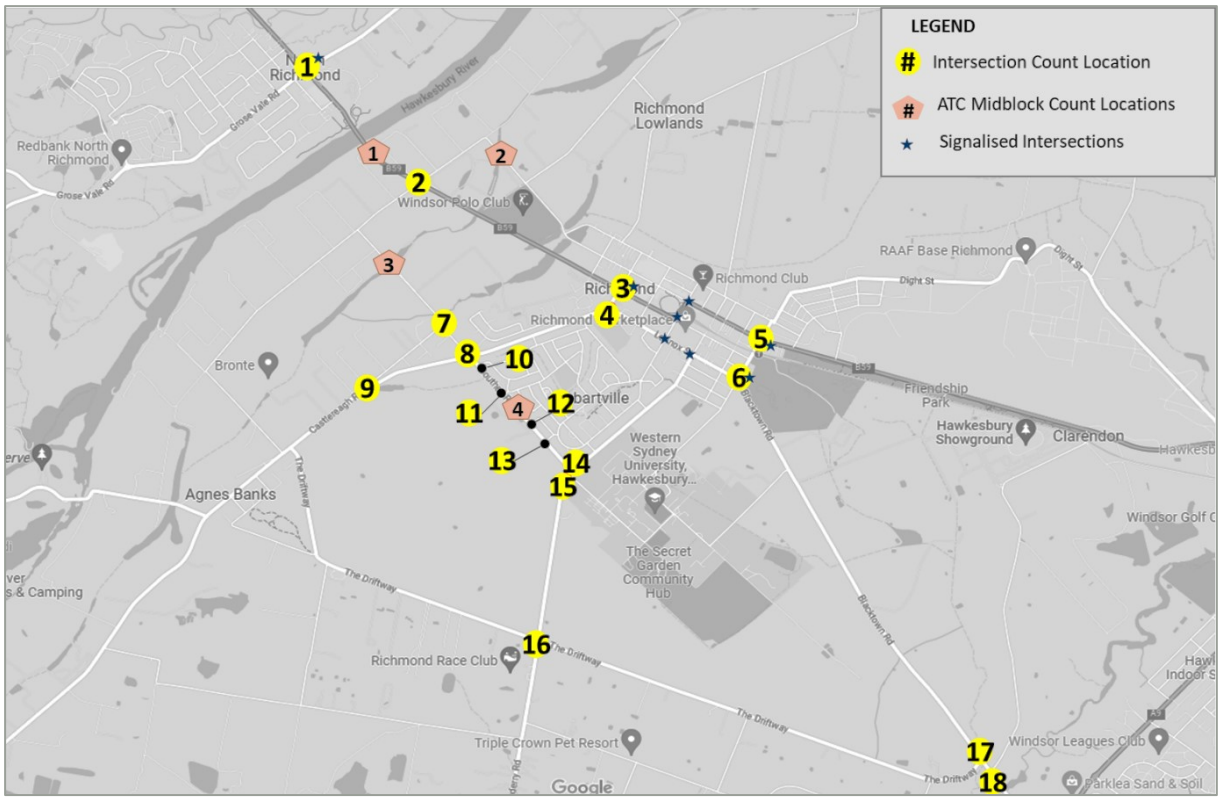


Figure 3: 2023 Traffic count data locations (Background source: Google Earth)

Table 3: 2023 Intersection traffic count locations

Site # (Figure 3)	Intersection Traffic Count Location	Type of Control
1	Bells Line of Road / Grose Vale Road / Terrace Road	Signalised
2	Kurrajong Road / Old Kurrajong Road / Bells Line of Road	Priority
3	March Street / Bosworth Street	Signalised
4	Castlereagh Road / Lennox Street / Bosworth Street	Priority
5	Bourke Street / Windsor Street	Signalised
6	Blacktown Road / Bourke Street / Lennox Street	Signalised
7	Inalls Lane / Drift Road	Priority
8	Castlereagh Road / Inalls Lane / Southee Road	Priority
9	Castlereagh Road / Drift Road	Priority
10	Southee Road / Hughes Avenue	Priority
11	Southee Road / Valder Avenue	Priority
12	Southee Road / Hill Avenue	Priority
13	Southee Road / Anderson Avenue	Priority
14	Southee Road / Londonderry Road	Priority
15	Londonderry Road / Vines Drive	Priority
16	Londonderry Road / The Driftway	Priority
17	Blacktown Road / The Driftway	Priority
18	Blacktown Road / Racecourse Road	Priority

Table 4: 2023 Midblock ATC locations

Site # (Figure 3)	Intersection Traffic Count Location
1	Bells Line of Road at Ease of Richmond Bridge
2	Old Kurrajong Road between Ridges Lane and Pughs Lagoon
3	Inalls Lane between Yarramundi Lane and Drift Road
4	Southee Road between Castlereagh Road and Londonderry Road

2.1.4 Origin - Destination data

Limited Origin - Destination (OD) data was provided by TfNSW and collected by Matrix Traffic and Transport Data in 2023.The data was collected on the survey day along Southee Road between locations OD1 and OD2, as shown in Figure 4. It is noted that for all other ODs, lacking more recent information, it was assumed that the OD distributions used in the 2018 traffic model were still valid.

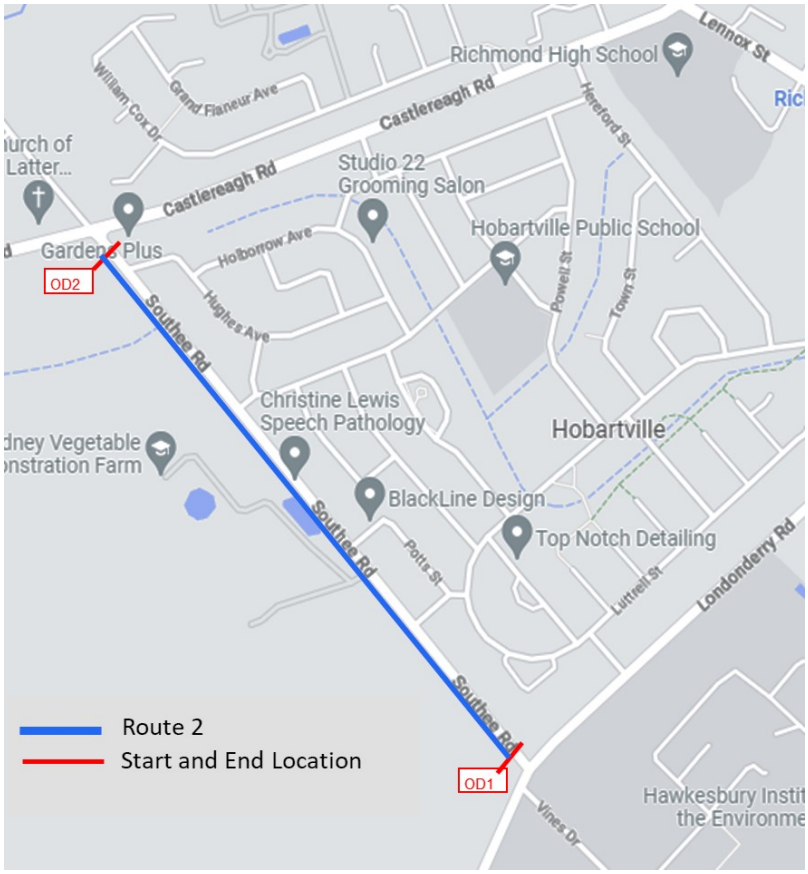


Figure 4: Origin destination survey, 2023 station locations, and travel time survey – Route 2

2.1.5 Travel time data

Travel time data was provided by TfNSW and collected by Matrix Traffic and Transport Data for the survey day. The data was collected between 06:00 to 10:00 hours in the AM period and 14:00 to 18:00 hours in the PM period along the following routes:

- Route 1: Bells Line of Road, Kurrajong Road, March Street, East Market Street, Windsor Street: Between Crooked Lane and Hobart Street, as shown on Figure 5, and
- Route 2: Southee Road between marked OD Station locations, as shown above on Figure 4.

The travel time routes were segmented into sections between major intersections, as shown in Figure 5. The data was provided on a per segment, per direction and per hourly basis.

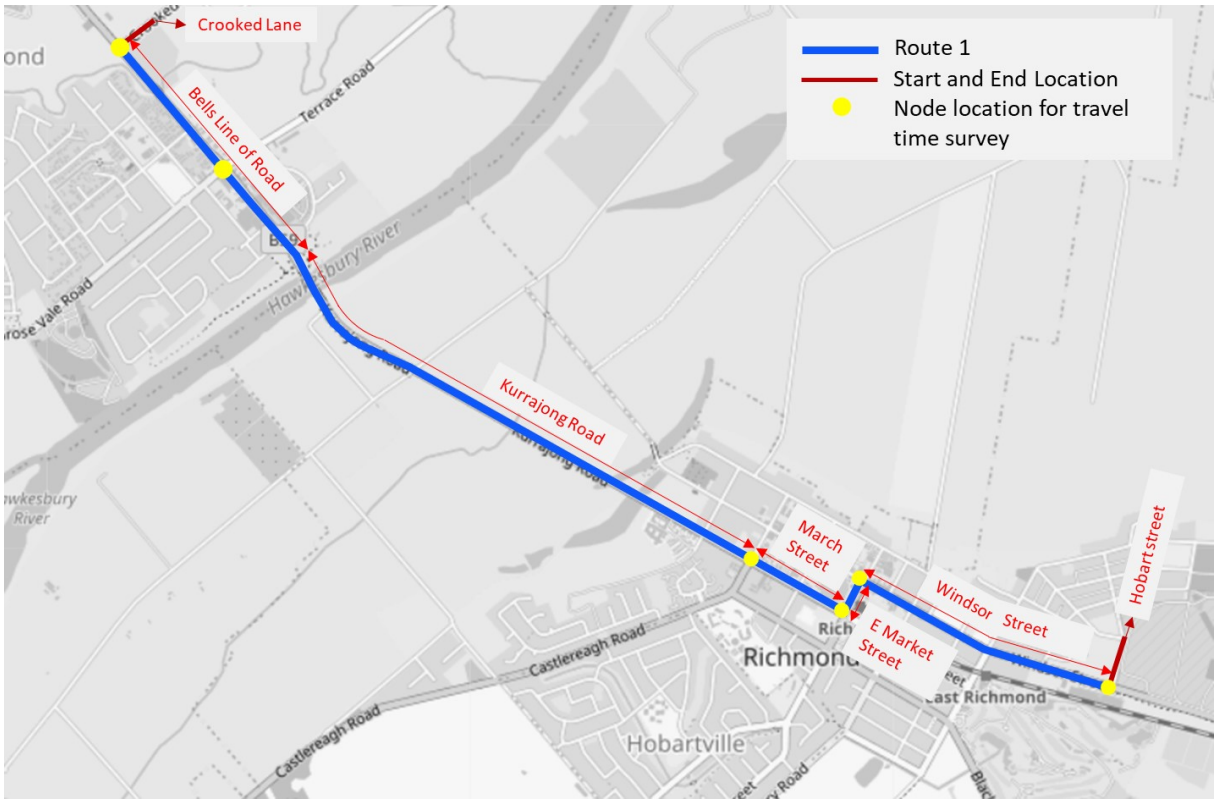


Figure 5: 2023 Travel time survey – Route 1

2.1.6 Queue length data

Queue length data was provided by TfNSW and collected by Matrix Traffic and Transport Data at the intersections indicated in Table 3. The queue length data was collected in two-minute intervals for most of the intersection approaches from 06:00 to 10:00 hours in the AM period and from 14:00 to 18:00 hours in the PM period. Queue length data was used to identify the congestion hotspots and to qualitatively validate the model queues.

2.2 Existing 2023 traffic conditions

A site visit was conducted in Richmond and North Richmond on Thursday 4th May 2023 between 07:30 and 09:30; and between 15:30 and 17:30, to understand the traffic conditions in the modelled study area during the morning and afternoon peaks.

During the site visit, the AM and PM peak period traffic conditions were observed, with a focus on identifying congestion originators, driving behaviour, traffic diversion routes, signal timings, intersection layouts and queueing at intersections. Figure **6** shows the main intersections at which observations were taken. Details on the site visit is noted in **Error! Reference source not found.**.

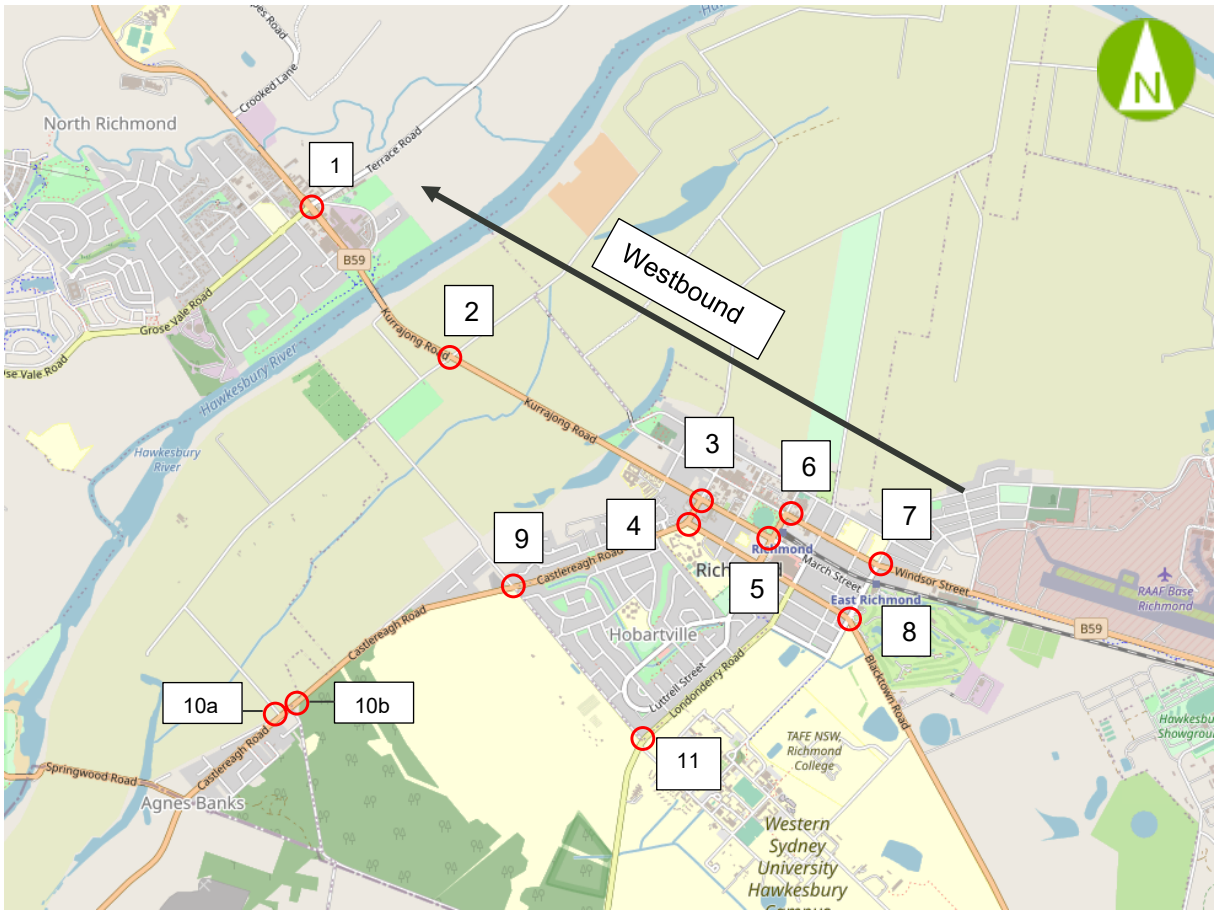


Figure 6**: Study area (Background source: Open Street Maps)**

3 2023 Existing conditions model development

As previously noted, the previous Aimsun model which was calibrated and validated to 2018 conditions, was made available to Aurecon for use in this project. For the development of the 2023 traffic model initial inputs such as network geometry and trip distribution were adopted from the 2018 model. The model development then involved the refinement of the network, demands and various model parameters, to yield a model which presents 2023 conditions. These elements of the model development are discussed in the sub-sections that follow.

3.1 Modelling software and version

The New Richmond Bridge microsimulation model has been developed using the Aimsun software suite. Aimsun Next version 22.0.2, which was the latest available version when modelling commenced, was used to update and rebase the 2023 traffic model.

3.2 Modelled time periods

Traffic data, as described in Section 2.1, was used to recalibrate and revalidate the model to represent a typical 2023 weekday.

An initial analysis was undertaken to identify the AM and PM peak hours from the available traffic data. For the purpose of this analysis, data from the following intersections was selected to represent the main east-west model traffic corridor:

- Bourke Street / Windsor Street intersection,
- Castlereagh Road / Lennox Street / Bosworth Street intersection,
- March Street / Bosworth Street intersection,
- Kurrajong Road / Old Kurrajong Road / Bells Line of Road intersection, and
- Bells Line of Road / Terrace Road / Grose Vale Road intersection.

Figure 7 and Figure 8 present the aggregated hourly volumes in one-hour intervals for the AM and PM periods, respectively. These were used to identify two peak hours for both AM and PM periods:

- Morning (AM) period: 07:30 – 09:30 hours, and
- Afternoon (PM) period: 15:30 – 17:30 hours.

In addition, a 30-minute warm-up was added to the above time periods.

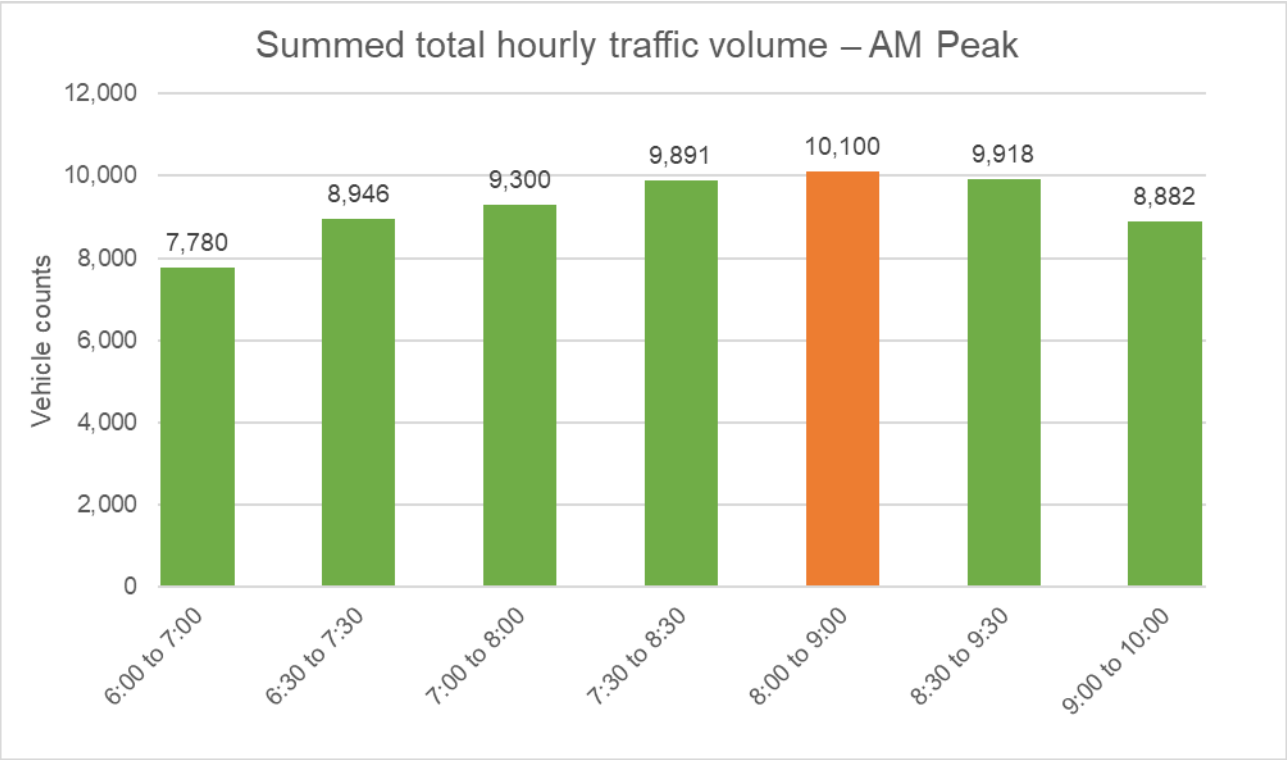


Figure 7: Summed total hourly traffic volume – AM Peak

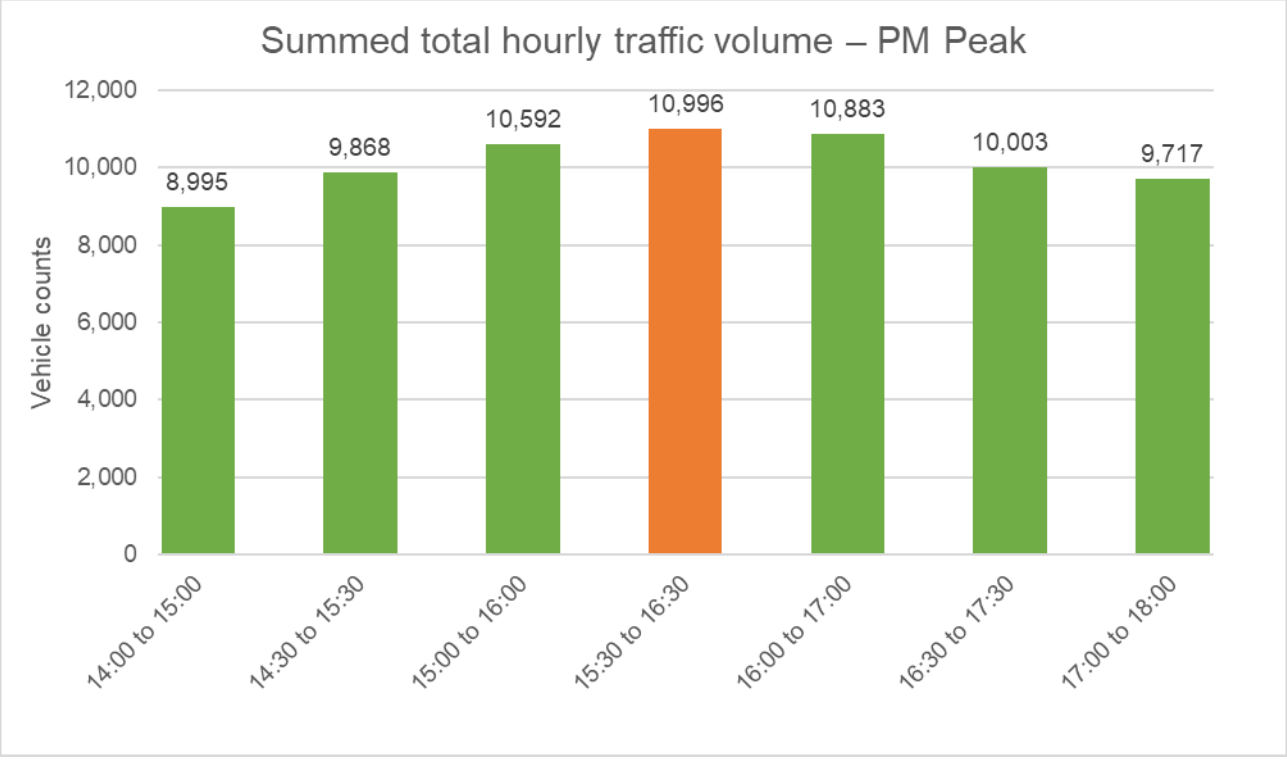


Figure 8: Summed total hourly traffic volume – PM Peak

3.3 Network changes

The modelled network of the study area was initially based on the 2018 Aimsun traffic model, which included a road hierarchy, comprising different road types and geometry details, public transport, and traffic signals. To reflect the 2023 conditions, the 2018 Aimsun traffic model was reviewed and updated accordingly. The following paragraphs discuss the network modifications.

To consider the 2023 road network, the following intersections were updated in the 2018 model:

- Bells Line of Road / Terrace Road / Grose Vale Road intersection and surrounds (Figure 9 shows the comparison of intersection coding for 2018 and 2023 Aimsun model)
  - Dedicated left turn lane on Terrace Road to Bells Line of Road (west),
  - Additional right turn lane on Grose Vale approach to Bells Line of Road (east),
  - Additional westbound lane from Pitt Lane to intersection on Bells Line of Road,
  - Dedicated right turn lane on Riverview Street to Grose Vale Road, and
  - Upgrade of the intersection of Grose Vale Road/ Sunnyside Crescent to a roundabout.

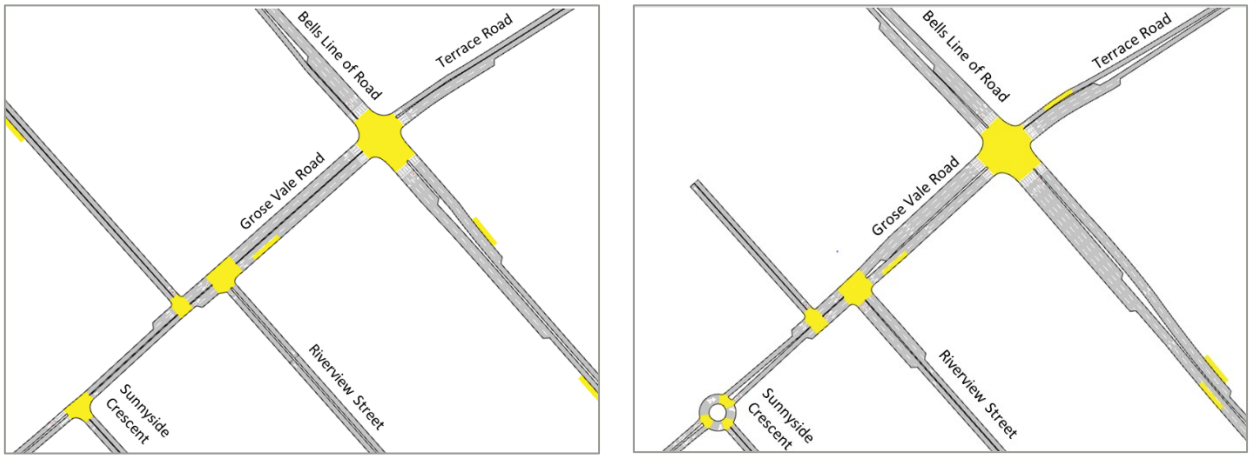


Figure 9: Bells Line of Road / Terrace Road / Grose Vale Road intersection model coding, 2018 Aimsun model on left and 2023 Aimsun model on right

- March Street / Bosworth Street intersection (Figure 10 shows the comparison of intersection coding for 2018 and 2023 Aimsun model)
  - Dedicated right turn lane from March Street to Bosworth Street (south), and
  - Right turn ban from March Street to Bosworth Street (north).

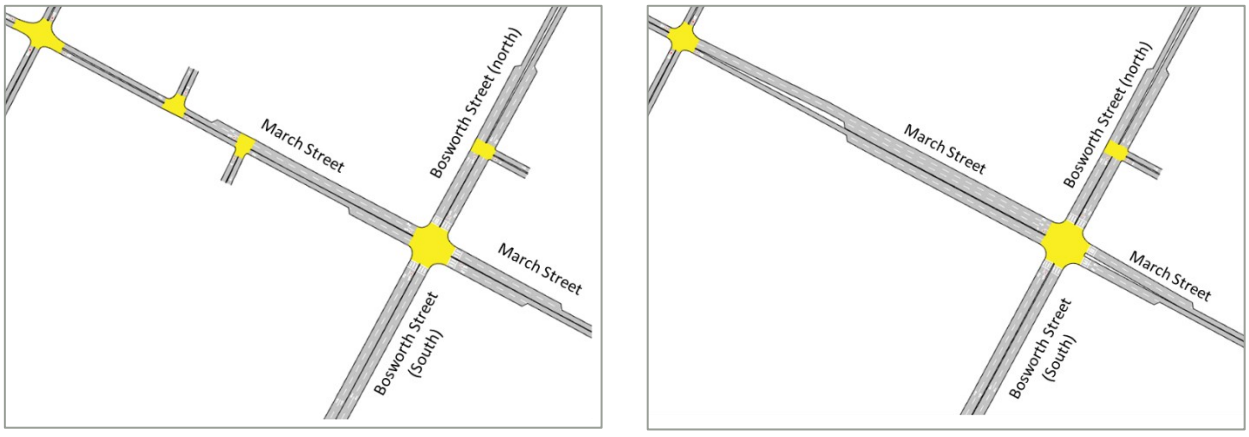


Figure 10: March Street / Bosworth Street intersection model coding, 2018 Aimsun model on left and 2023 Aimsun model on right

In addition to the above, in the Richmond and North Richmond CBD the road network was simplified to eliminate potential illogical route choices, and along Southee Road several intersections were added to better assess the project changes in the area. The final 2023 traffic model base network is presented in Figure 11.

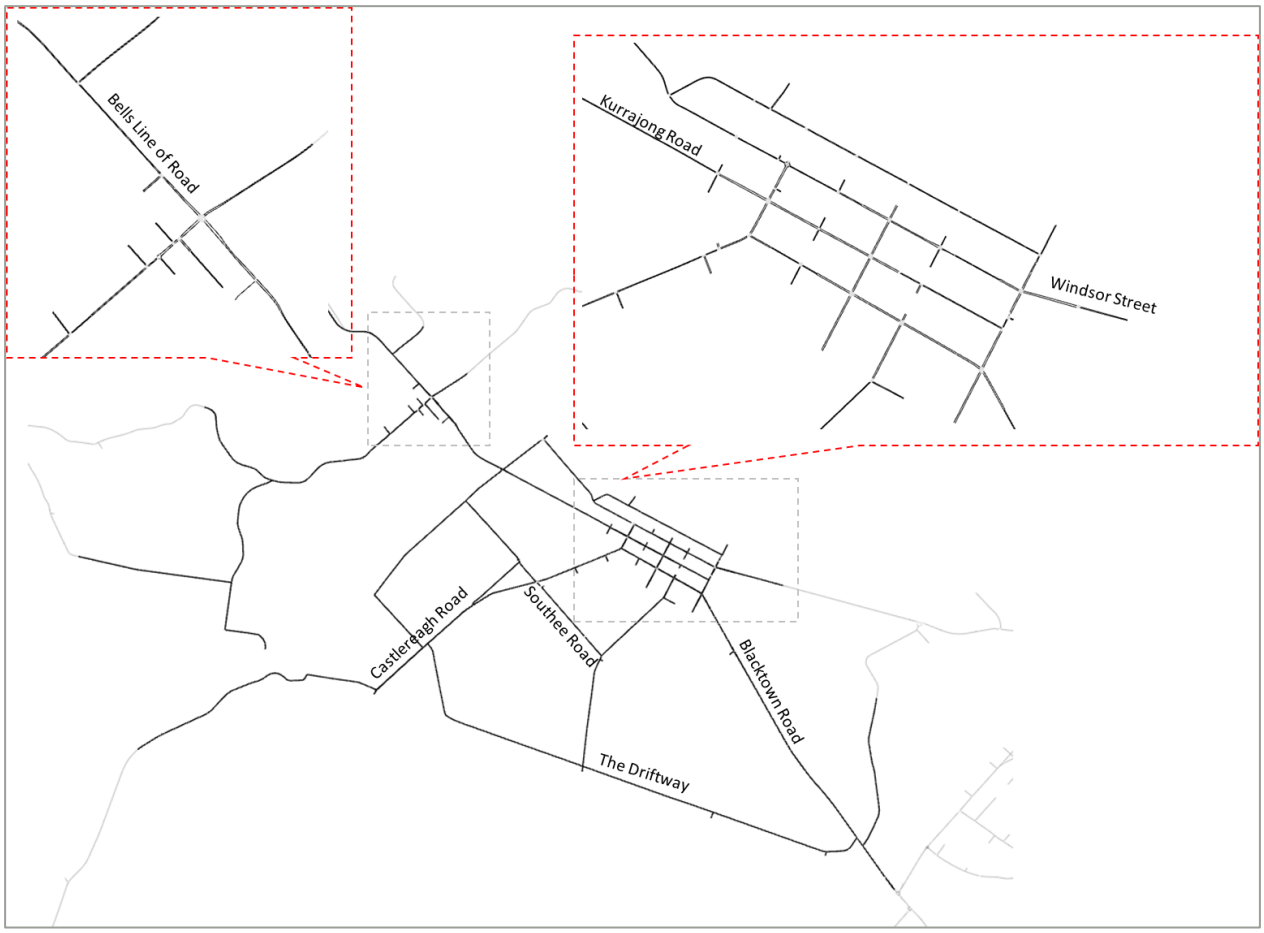


Figure 11: New Richmond Bridge 2023 Model – Network

The network update also included the review of, and the necessary changes to, the road network coding based on aerial imagery, and other input data such us public transport data and SCATS data. These sources were used to review and update the following key network items:

- Number of lanes,
- Turn restrictions per vehicle type, especially heavy vehicles,
- Intersection layouts and lane arrangements,
- Traffic signals,
- Speed limits,
- School speed zones,
- Bus stops, routes, and timetables, including school services, and
- On-street parking.

It should be noted that the simplification of the road network affected the itinerary of several bus routes. In order to avoid separating bus routes where there was a break in the road sections' connectivity, some road network segments were retained and reserved for public transport usage only. These sections were placed in a separate layer for convenience, which has been hidden to avoid any confusion. An example of how these additional road segments were coded is shown in Figure 12.

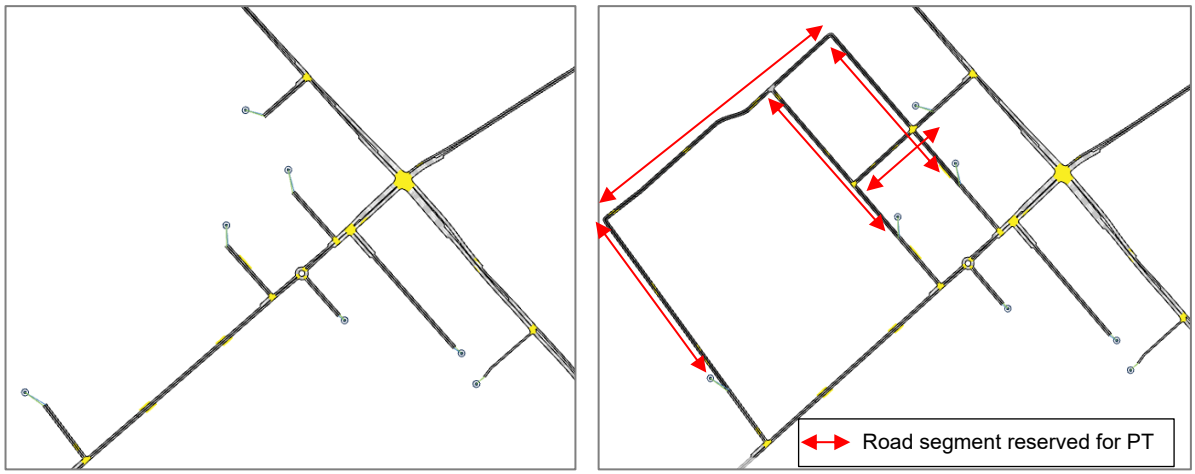


Figure 12: On left – North Richmond 2023 model road network, On right – Additional road segments coded for public transport use

Another upgrade from the 2018 Aimsun model includes the coding of the level crossing located on Bourke Street. The level crossing includes a boom closure, which stops vehicle traffic for approximately one minute when T1 and T5 rail services travels between Richmond Station and East Richmond Station.

To model the level crossing, a traffic signal was coded on Bourke Street. The T1 and T5 timetables indicate that there is a T1 service approximately every 30 minutes during the AM and PM time periods in each direction, and no T5 service. Table 5 provides a summary of the rail services during modelled periods, resulting in the level crossing being activated nine times during the AM peak and eight times during the PM peak.

Table 5: Rail services for Richmond station passing though level crossing on Bourke Street

Rail services	AM Peak	PM peak
T1 – Richmond to City	7:11, 7:41, 8:11, 8:41, 9:11	15:51, 16:11, 16:41, 17:11
T5 – Richmond to Leppington	-	-
T1 – City to Richmond	7:24, 7:54, 8:24, 8:54, 9:24	15:54, 16:24, 16:54, 17:24
T5 – Leppington to Richmond	-	-

3.4 Traffic demand development

The road network changes discussed in Section 3.3 resulted in a modified zoning system that involved aggregation and disaggregation of certain zones. In this process, the zoning system naming convention was also simplified. Figure 13 presents applied zone changes, with blue dots representing proposed new zones and red crosses deleted zones. A comparison of the 2018 and 2023 zoning system and their naming is also presented in Table 6.

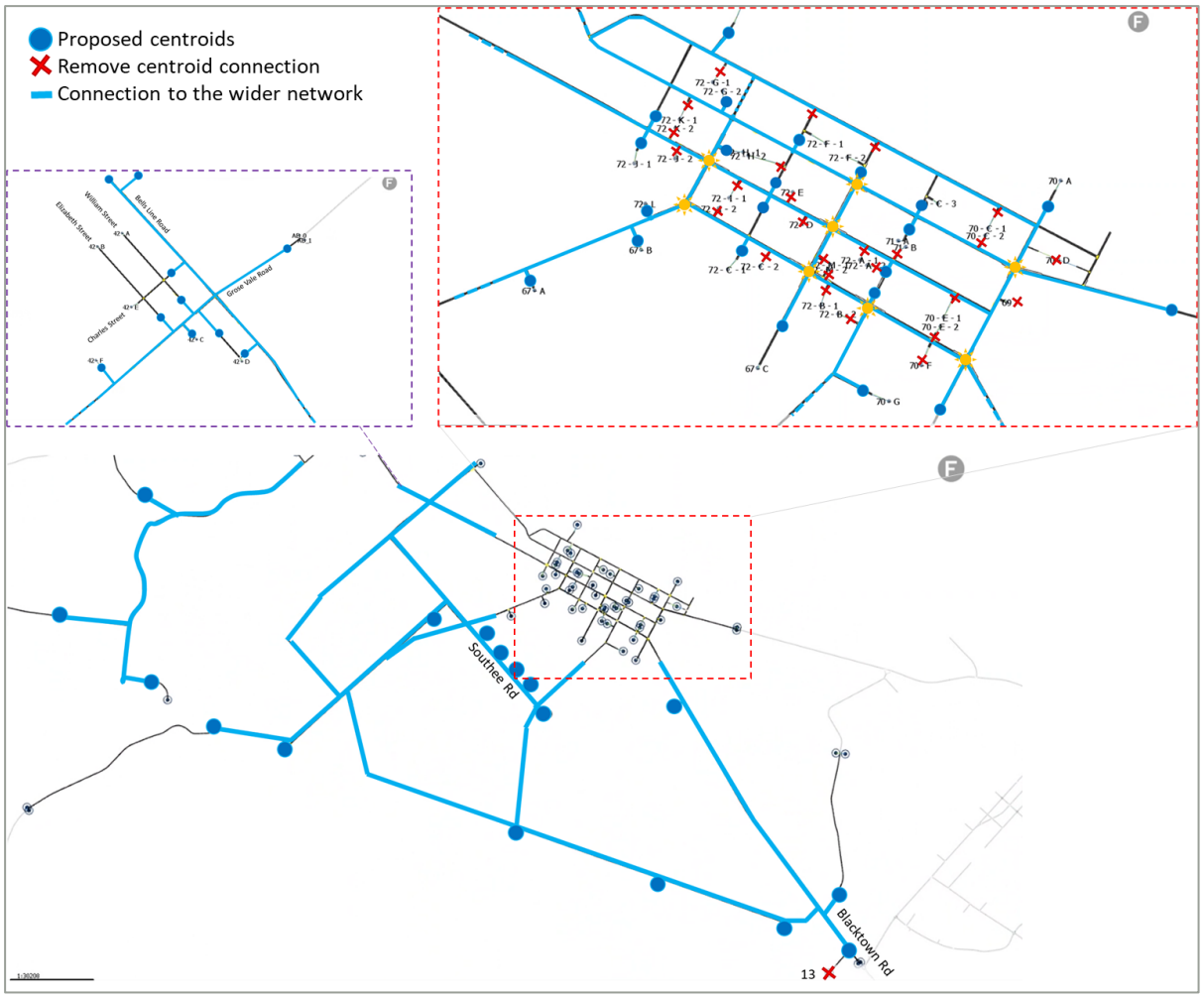


Figure 13: Changes made to 2018 model zoning system

Table 6: New Richmond Bridge 2023 model – 2018 versus 2023 zoning system naming convention

2023 Zone No.	2018 Zone/s equivalent	Representative zone area	2023 Zone No.	2018 Zone/s equivalent	Representative zone area
1	42 - A	William Street	31	72 - F - 2	East Market Street Carpark
2	42 - B	Elizabeth Street	32	72 - F - 1	West Market Street Carpark
3	42 - C	Sunnyside Crescent	33	72 - G - 2	Windsor Street
4	42 - D	Riverview Street	34	72 - H -1	Bosworth Street
5	42 - D	Riverview Street	35	72 - H -2, 72 - E	Musson Lane, Richmond Park
6	42 - E	Charles Street	36	72 - D, 72 - I - 1	March Street
7	42 - F	Pecks Road	37	70-E-1, 72-A-2, 72-A-1	Moray Street, Richmond Marketplace
8	7	Grose River Road	38	72-M-1, 72-M-2, 70-E-2	Richmond Marketplace

2023 Zone No.	2018 Zone/s equivalent	Representative zone area	2023 Zone No.	2018 Zone/s equivalent	Representative zone area
9	8	Ivory Place	39	Use 67 - A, B, C distribution	Distribution from zones representing Long Street, Hereford Street and E Market Street
10	9	Castlereagh Road	40	Use 67 - A, B, C distribution	
11	10	Londonderry Road	41	Use 67 - A, B, C distribution	
12	11	Luxford Road	42	Use 67 - A, B, C distribution	
13	12	Reynolds Road	AA_0	AA_0	Crooked Lane
14	68 - A	Campus Drive	AA_1	AA_1	Crooked Lane
15	68 - B	Vines Drive	AB_0	AB_0	Terrace Road
16	68 - C	Bourke Street	AB_1	AB_1	Terrace Road
17	70 - G	College Street	AC_0	AC_0	Windsor Street
18	67 - C, 72-B-1, 72-B-2	E Market Street, Gibson Street, Ridge Place	AC_1	AC_1	Windsor Street
19	72 - C -1, 72 - C - 2	West Market Street and Grose Street	AD_0	AD_0	Springwood Road
20	67 - B	Hereford Street	AD_1	AD_1	Springwood Road
21	67 - A	Long Street	AE_0	AE_0	Blacktown Road
22	72 - L	John Tebbutt Place	AE_1	AE_1	Blacktown Road
23	72 - J - 1, 72 - J - 2	Chapel Street, March Street	AF_0	AF_0	Grose Vale Road
24	72 - K - 1, 72 - K - 2	Windsor Street, March Street	AF_1	AF_1	Grose Vale Road
25	73 - B	Ridges Lane	AG_0	AG_0	Bells Line of Road
26	73 - A	Onus Lane	AG_1	AG_1	Bells Line of Road
27	70 - A	Jersey Street	AH_0	AH_0	Racecourse Road
28	69	East Richmond Station	AH_1	AH_1	Racecourse Road
29	70 - C - 1,70 - C - 2,70 - C - 3	Moray Street	AI_0	AI_0	Grose Wold Road
30	71 - A, 71-B	Paget Street	AI_1	AI_1	Grose Wold Road

Travel demand matrices for the 2023 zoning system were obtained by the careful aggregation and disaggregation of the 2018 demand zoning system. The total demand originating from all 2018 zones as well as the trip distribution patterns were retained, to ensure an accurate correlation between both models.

Matrices obtained resulting from the zoning system changes were then updated to the 2023 modelling year following an iterative process. The final demand extends over the two hour peak periods with a warmup period of 30 minutes, for both the AM and PM peak periods, and separated into 15-minute intervals for both light and heavy vehicles.

3.5 Traffic assignment process

After the 2023 traffic demand was developed, the same traffic assignment process was followed as the 2018 Aimsun traffic model. As shown in Figure 14, this comprised an initial Static assignment, followed by a Dynamic User Equilibrium (DUE) process and finished with a Stochastic Route Choice (SCR) assignment with five different random seeds.

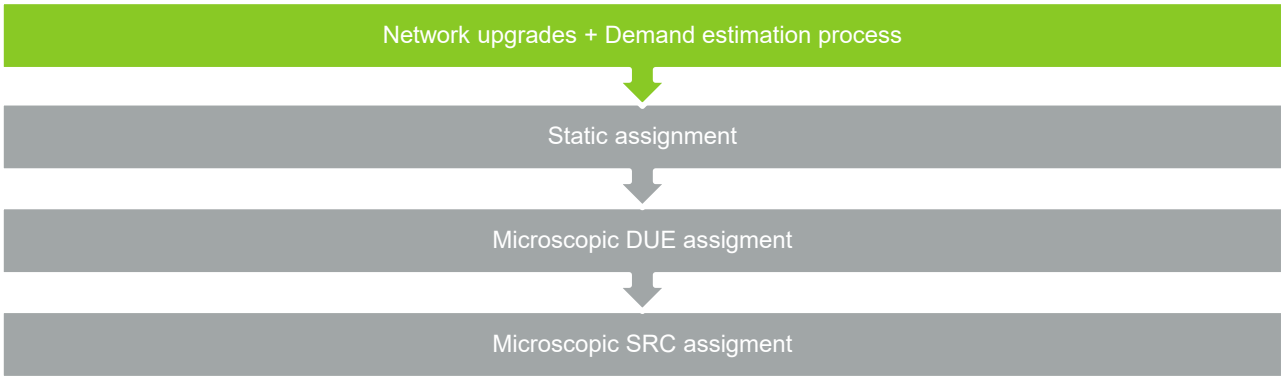


Figure 14: Traffic assignment process

4 Model calibration and validation

4.1 Overview

The 2023 existing conditions model development was undertaken with the aim to achieve the calibration and validation criteria as indicated in the Roads and Maritime Services Traffic modelling Guidelines, 2013.

The calibration of the model was based on the hourly turning movement counts over the two-hour periods, during both the AM and PM peak periods. The validation of model was based on the observed travel times along the travel time surveyed routes and observed queues.

The process of model calibration and validation is a highly iterative process which involved network verification and fine-adjustment of both appropriate model parameters and the origin-destination matrices. The aim of this process was to produce a model that could closely replicate the existing traffic conditions within the modelled area.

The model calibration and validation results are discussed in the following sub-sections, with details on the model convergence and stability included in Appendix C.

4.2 Model calibration

The model calibration process included model adjustments, such as geometry, parameters, and demand, to ensure the model represents the existing traffic conditions. Details on the model changes undertook during the calibration process can be found in Appendix D.

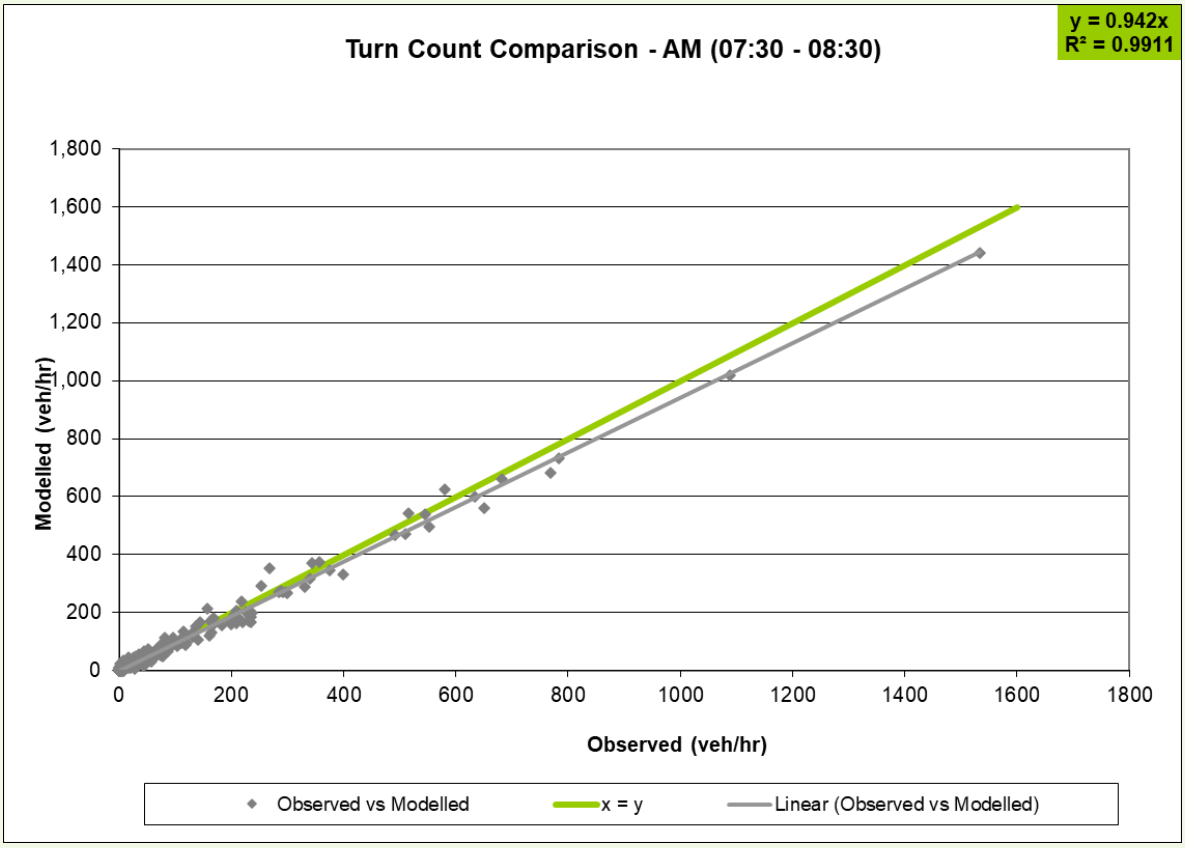
4.2.1 AM peak calibration results

Table 7 and Table 8 show a summary of the model calibration results for the AM peak based on an average of five model runs, per peak hour:

- During the AM peak period, 100 per cent of turn flows achieved GEH values of less than 10 for both light and heavy vehicles (GEH <10).
- For light vehicles, 96% (151 of 157) of all movements during the 7:30-8:30 AM, and 97% (153 of 157) of all movements during the 8:30-9:30 AM, achieved GEH values of less than 5 (GEH<5).
- For heavy vehicles, 100% (157 of 157) of all movements during both AM peaks achieved GEH values of less than 5 (GEH<5).
- High modelled R^2 values of 0.991 and 0.987, for all vehicles, were achieved during the 07:30-08:30 AM and 8:30-9:30 AM respectively, demonstrating that a high level of calibration was achieved for the AM peak period.

Table 7: Calibration statistic results – AM Peak (7:30 – 8:30)

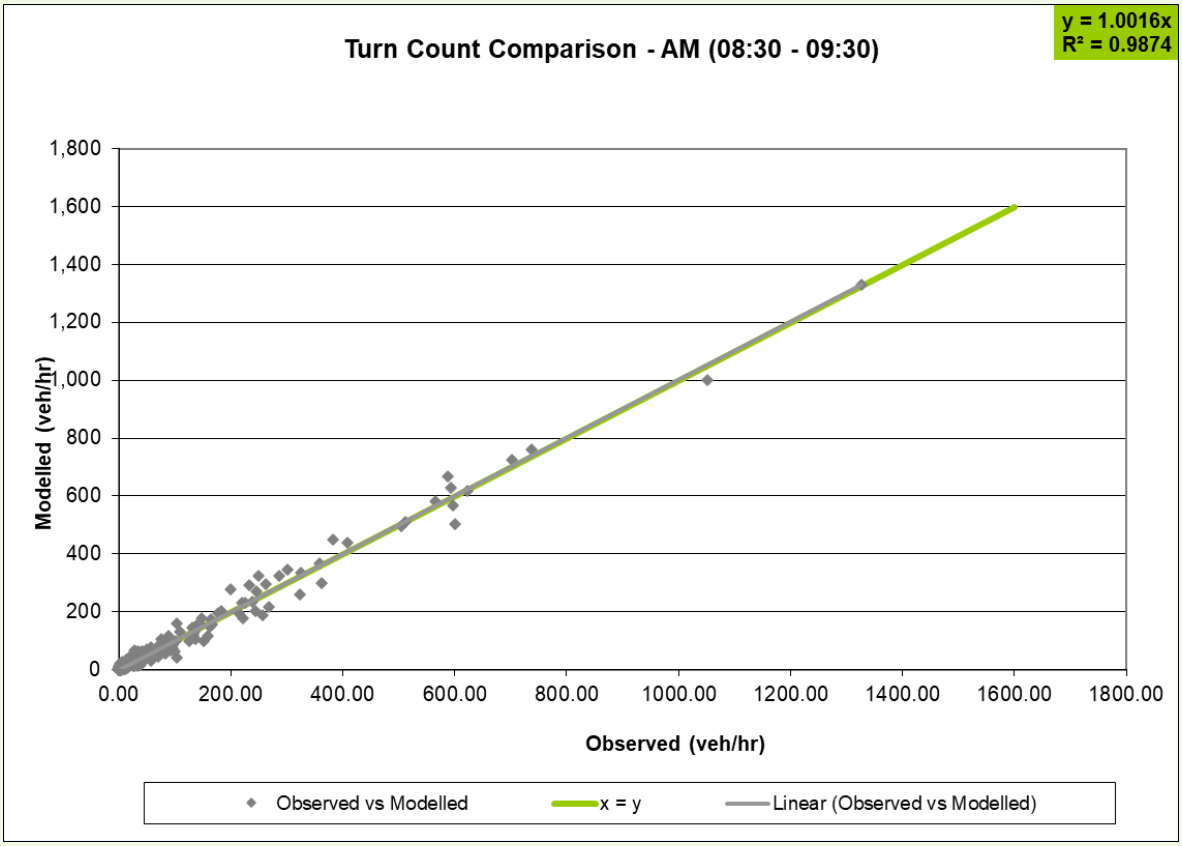
Turn Count R^2 Measure	Criteria	Achieved R^2 Value
R^2 value for modelled versus observed volumes for all individual turns	**> 0.90**	**0.99**



Criteria	Criteria	Observed Total	Modelled Achieved	Achieved (%)
Light Vehicles				
GEH < 5 for individual turn volumes	>85% of cases	157	151	96%
GEH < 10 for individual turn volumes	100% of cases	157	157	100%
Heavy Vehicles				
GEH < 5 for individual turn volumes	>85% of cases	157	157	100%
GEH < 10 for individual turn volumes	100% of cases	157	157	100%

Table 8: Calibration statistic results – AM Peak (8:30 – 9:30)

Turn Count R^2 Measure	Criteria	Achieved R^2 Value
R^2 value for modelled versus observed volumes for all individual turns	**> 0.90**	**0.99**



Criteria	Criteria	Observed Total	Modelled Achieved	Achieved (%)
Light Vehicles				
GEH < 5 for individual turn volumes	>85% of cases	157	153	97%
GEH < 10 for individual turn volumes	100% of cases	157	157	100%
Heavy Vehicles				
GEH < 5 for individual turn volumes	>85% of cases	157	155	99%
GEH < 10 for individual turn volumes	100% of cases	157	157	100%

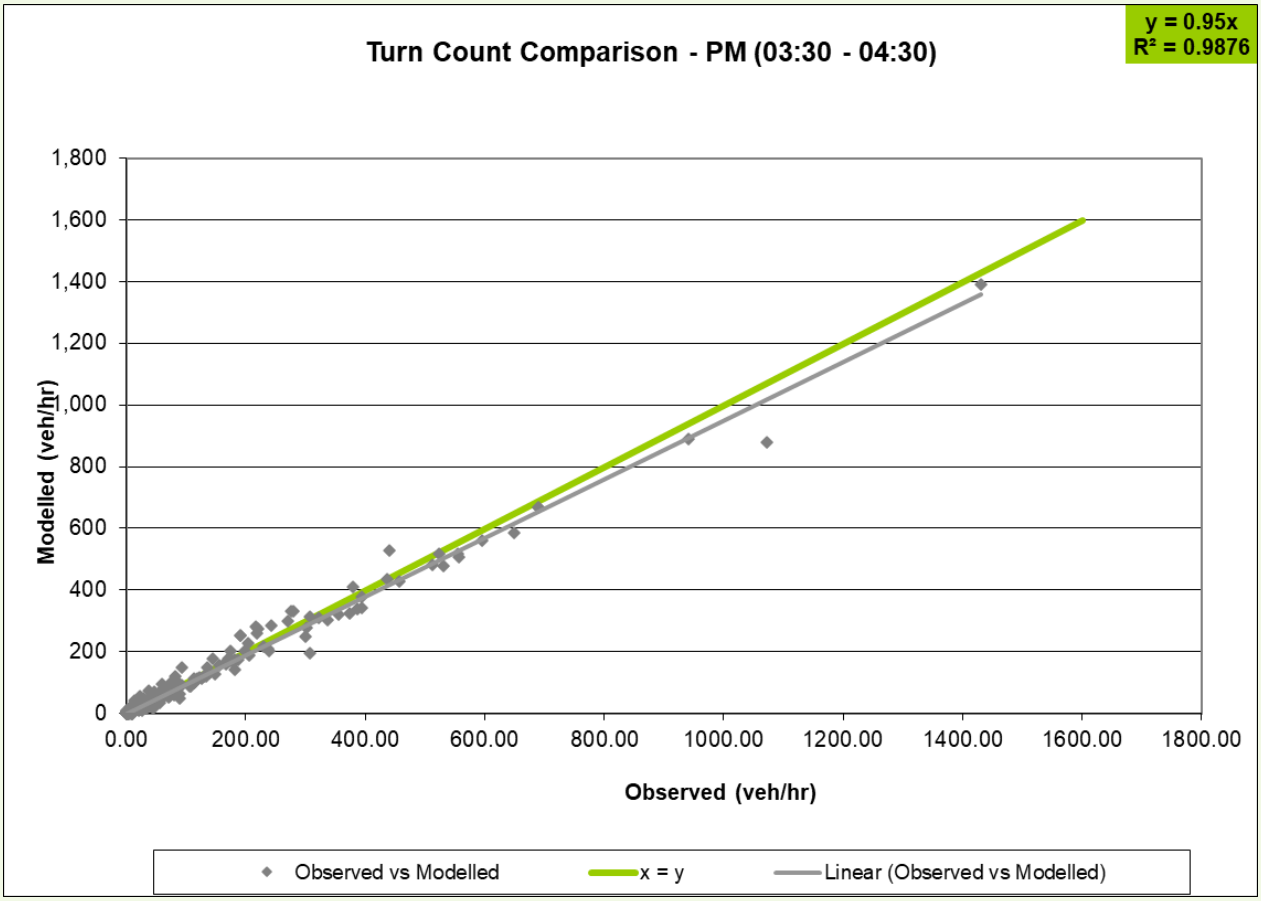
4.2.2 PM peak calibration results

Table 9 and Table 10 shows a summary of the model calibration results for the PM peak based on an average of five model runs, per peak hour.

- During the PM peak period, 100 per cent of turn flows achieved GEH values of less than 10 for both light and heavy vehicles (GEH <10).
- For light vehicles, 96% (151/150 of 157) of all movements during both PM peak hours achieved GEH values of less than 5 (GEH<5).
- For heavy vehicles, 100% (157 of 157) of all movements during the 3:30-4:30 PM, and 99% (156 of 157) of all movements during the 4:30-5:30 PM, achieved GEH values of less than 5 (GEH<5).
- High modelled R^2 values of 0.987 and 0.986, for all vehicles, were achieved during the 03:30-04:30 PM and 4:30-5:30 PM respectively, demonstrating that a high level of calibration was achieved for the PM peak period.

Table 9: Calibration statistic results – PM Peak (3:30 – 4:30)

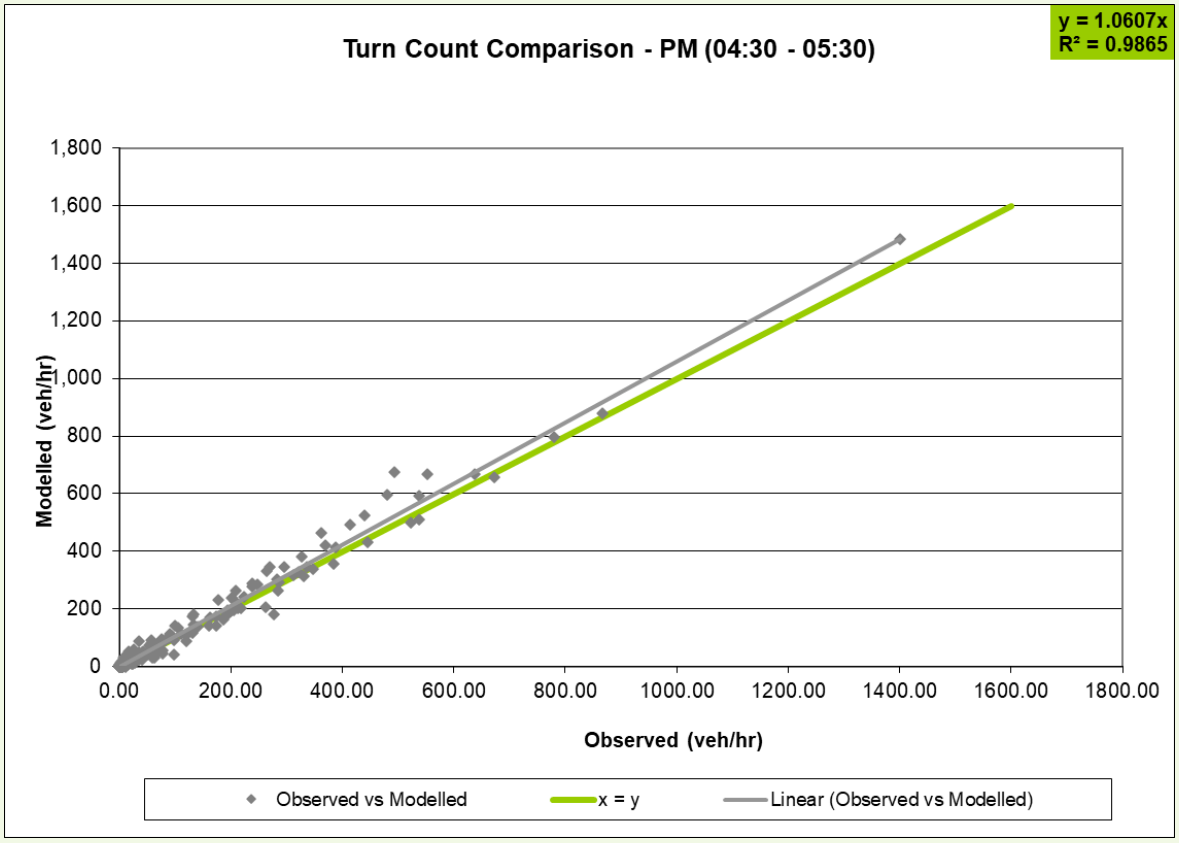
Turn Count R^2 Measure	Criteria	Achieved R^2 Value
R^2 value for modelled versus observed volumes for all individual turns	**> 0.90**	**0.99**



Criteria	Criteria	Observed Total	Modelled Achieved	Achieved (%)
Light Vehicles				
GEH < 5 for individual turn volumes	>85% of cases	157	151	96%
GEH < 10 for individual turn volumes	100% of cases	157	157	100%
Heavy Vehicles				
GEH < 5 for individual turn volumes	>85% of cases	157	157	100%
GEH < 10 for individual turn volumes	100% of cases	157	157	100%

Table 10: Calibration statistic results – PM Peak (4:30 – 5:30)

Turn Count R^2 Measure	Criteria	Achieved R^2 Value
R^2 value for modelled versus observed volumes for all individual turns	**> 0.90**	**0.99**



Criteria	Criteria	Observed Total	Modelled Achieved	Achieved (%)
Light Vehicles				
GEH < 5 for individual turn volumes	>85% of cases	157	150	96%
GEH < 10 for individual turn volumes	100% of cases	157	157	100%
Heavy Vehicles				
GEH < 5 for individual turn volumes	>85% of cases	157	156	99%
GEH < 10 for individual turn volumes	100% of cases	157	157	100%

Appendix E presents a comprehensive set of the calibration results, including a comparison between the observed and modelled traffic flow, and the GEH statistics for each link or turn movement that were considered in the calibration process.

4.3 Model validation

Model validation involves the comparison of observed and modelled traffic performance for datasets that are independent to the datasets used for the model calibration. Model validation is necessary to understand whether a model accurately represents the existing traffic situation and can be used to test options (network, demand, etc.).

4.3.1 Travel time validation

The travel time validation comprised of the comparison of observed and modelled travel time along two routes, namely:

- Route 1 – Both directions along Bells Line of Road, Kurrajong Road, March Street, East Market Street and Windsor Street, and
- Route 2 – Both directions along Southee Road between Castlereagh Road and Londonderry Road.

Table 11 and Table 12 presents the travel time validation results for the AM and PM peak periods respectively. Graphs indicating the same modelled and observed travel times over the various segments of the respective routes, along with the 15% tolerance, are presented in Appendix F.

The following is observed from the travel time validation results:

- The modelling results indicate that the overall modelled travel times for both Route 1 and Route 2, during both the AM and PM peaks, achieved the required model validation criteria.
- For Route 2, the modelled travel time achieved the 15% criteria in the AM peak, however in the PM peak exceeded 15% criteria with the modelled travel time being higher than observed. However, the absolute difference between the observed and modelled travel times were less than one minute in both peak periods. This difference is likely due to the differences between the way the observed and modelled statistics were recorded, with the modelled statistics considering the yield time to cross the intersection, whereas the observed statistics did not consider the yield time. Additionally, as the recorded section lengths for this route were only a few meters, it also contributed to the difficulty in achieving the 15% mark.

Table 11: Travel time validation results – AM Peak

Travel Route	Direction	Time	Observed (mm:ss)	Modelled (mm:ss)	Time Difference (mm:ss)	Time Difference %	Result
Route 1	Eastbound	7:30-8:30 AM	11:05	10:58	00:07	-1%	PASS
	Eastbound	8:30-9:30 AM	10:01	10:32	00:31	5%	PASS
	Westbound	7:30-8:30 AM	08:48	09:27	00:40	8%	PASS
	Westbound	8:30-9:30 AM	09:48	10:23	00:36	6%	PASS
Route 2	Eastbound	7:30-8:30 AM	01:38	01:44	00:06	7%	PASS
	Eastbound	8:30-9:30 AM	01:34	01:43	00:10	10%	PASS
	Westbound	7:30-8:30 AM	01:33	01:47	00:14	15%	PASS
	Westbound	8:30-9:30 AM	01:35	01:50	00:14	15%	PASS
Travel Time Criteria and measure			**Observed Total**		**Modelled**	**Achieved**	**Result**
±15% or one minute (whichever is greater) of average of full length of routes			4		4	100%	PASS

Table 12: Travel time Validation results – PM Peak

Travel Route	Direction	Time	Observed (mm:ss)	Modelled (mm:ss)	Time Difference (mm:ss)	Time Difference %	Result
Route 1	Eastbound	3:30-4:30 PM	08:28	08:27	00:02	0%	PASS
	Eastbound	4:30-5:30 AM	08:35	08:22	00:13	-3%	PASS
	Westbound	3:30-4:30 PM	10:38	12:10	01:31	14%	PASS
	Westbound	4:30-5:30 AM	16:03	15:05	00:57	-6%	PASS
Route 2	Eastbound	3:30-4:30 PM	01:33	01:47	00:15	16%	PASS
	Eastbound	4:30-5:30 AM	01:36	01:47	00:10	11%	PASS
	Westbound	3:30-4:30 PM	01:37	01:56	00:19	20%	PASS
	Westbound	4:30-5:30 AM	01:40	01:57	00:17	17%	PASS
Travel Time Criteria and measure			**Observed Total**		**Modelled**	**Achieved**	**Result**

Travel Route	Direction	Time	Observed (mm:ss)	Modelled (mm:ss)	Time Difference (mm:ss)	Time Difference %	Result
±15% or one minute (whichever is greater) of average of full length of routes			4		4	100%	PASS

4.3.2 *Queue length and congestion hotspot validation*

Based on the queue length survey, and site visit observations, the noteworthy queuing during the AM and PM peaks were as follows:

- AM peak period
  - Queuing on Grose Vale Road on approach toward the Bells Line of Road / Grose Vale Road / Terrace Road intersection, and
  - Intermittent queuing on Bells Line of Road on approach toward the Bells Line of Road / Grose Vale Road / Terrace Road intersection.
- PM Peak period
  - Queuing on Kurrajong Road Westbound, originating from the Kurrajong Road / Old Kurrajong Road intersection's westbound lane merge,
  - Queueing on March Street's Eastern approach, and Bosworth Street's Northern approach, toward the March Street / Bosworth Street intersection, and
  - Queueing on Windsor Street's Eastern approach toward the Bourke Street / Windsor Street intersection.

To qualitatively demonstrate the modelled queue lengths, the modelled sections with modelled speeds lower than 20km/hr were assumed to represent queueing. Figure 15 and Figure 16 presents the modelled queueing for the AM and PM peaks respectively, with consideration to the 20km/hr assumption. Good alignment is seen when comparing the observed queueing against the modelled queueing, which again supports the validation of the traffic model.

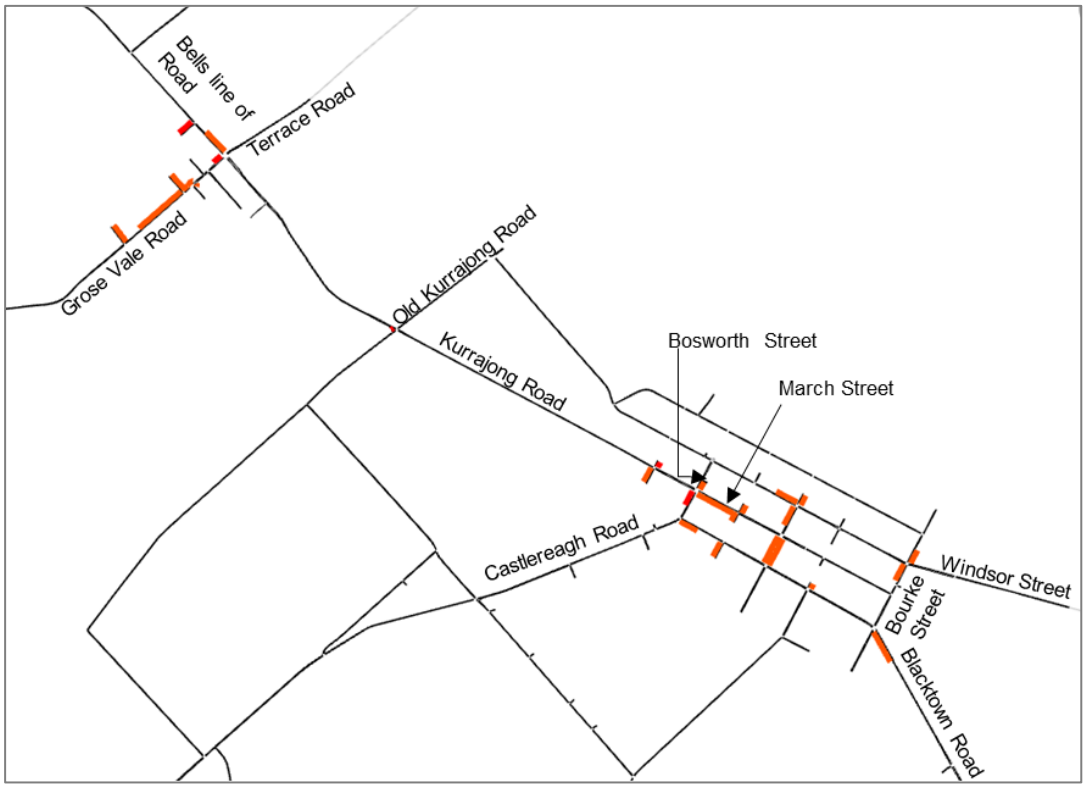


Figure 15: Modelled queues – AM peak period

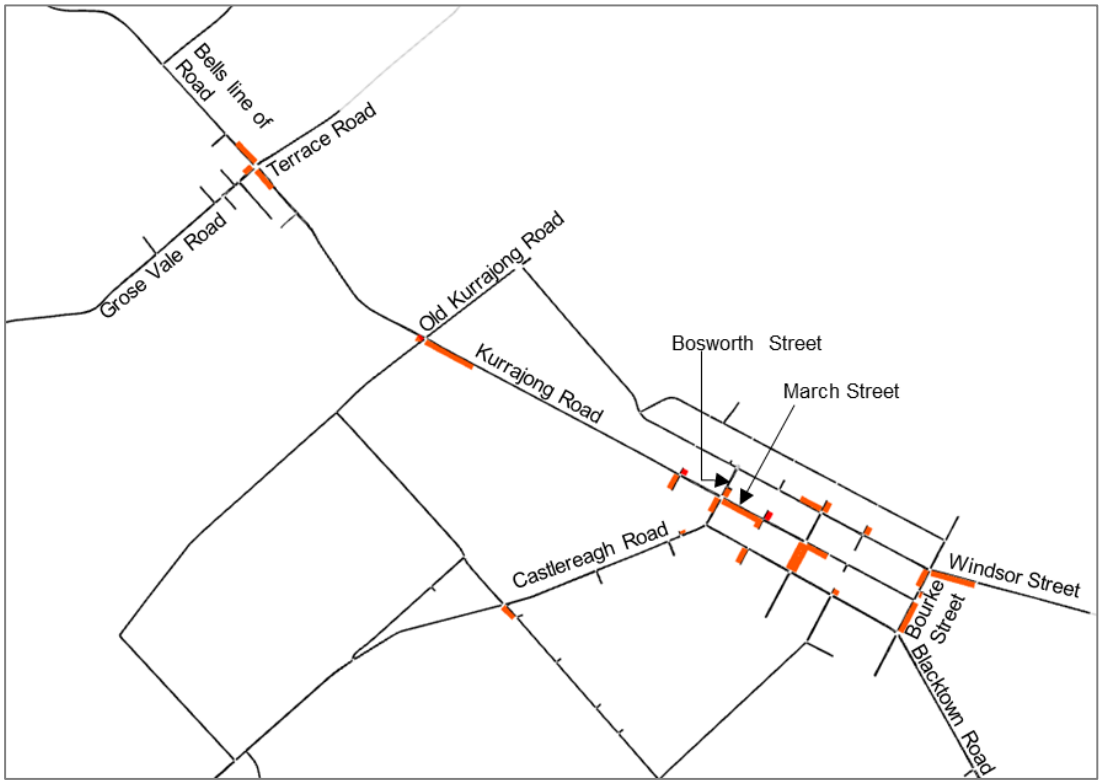


Figure 16: Modelled queues – PM peak period

4.4 Model verification

It is noted that the recalibrated and revalidated AM and PM peak microsimulation traffic models have been reviewed and verified internally by Aurecon, in accordance with the Roads and Maritime verification standards. Feedback received from the review and verification of model was considered and incorporated into the microsimulation models. Both AM and PM peak microsimulation models are considered acceptably calibrated and validated for use in future option testing.

5 Summary and conclusions

Aurecon has been commissioned by TfNSW to develop the New Richmond Bridge and Traffic Improvements Stage 2 (NRBS2) Concept Design and REF. As part of the Concept Design's development and associated traffic assessment, Aurecon was required to update an existing (2018) microsimulation traffic model, and recalibration and revalidation the model towards 2023 traffic conditions.

The 2018 traffic model was adopted along with its network, demand, parameters, as well as all other assumptions that were applied for the model's original calibration and validation. During the 2023 existing conditions model's development, modifications were made, where necessary, to aspects such as the network geometry, traffic control strategies, traffic demand and model parameters, to represent 2023 traffic conditions.

The 2023 existing traffic model has been recalibrated and revalidated to 2023 surveyed and observed traffic conditions for a typical weekday, for both the morning (7:30 AM to 9:30 AM) and evening (3:30 PM to 4:30 PM) peak periods. All reporting on the 2023 existing conditions traffic model performance, is done from five different seed value runs, from which averaged results were taken.

Both AM and PM peak models of the 2023 existing conditions traffic model were found to be acceptably calibrated and validated against the required Roads and Maritime Services Traffic modelling Guidelines, 2013 criteria, by achieving the following:

- Both models achieved convergence, with the AM peak model achieving convergence within nine iterations, and the PM peak model achieving convergence within eight iterations,
- Model stability between the five seed runs was established by calculating the Coefficient of Variance (CoV) statistic and by comparing the VHT (Vehicle Hours Travelled), VKT (Vehicle Kilometre Travelled) and NV (Number of Vehicles outside the network) statistics for both the AM and PM peak models,
- Both AM and PM peak models were acceptably calibrated, achieving the following calibration results:
  - 100% of GEH values being smaller than 10 (GEH<10),
  - A minimum of 96% of GEH values being smaller than 5 (GEH<5) for light vehicles,
  - A minimum of 99% of GEH values being smaller than 5 (GEH<5) for heavy vehicles, and
  - A minimum R^2 value of 0.986 for all vehicles.
- Both AM and PM peak models were acceptably validated by achieving:
  - Modelled journey times on Route 1 and Route 2 that were within 15%, or one minute (whichever was greater), of the average observed journey times, and
  - Good alignment between the modelled and observed queuing.

The recalibrated and revalidated AM and PM peak microsimulation traffic models have been reviewed and verified internally by Aurecon, in accordance with the Roads and Maritime verification standards.

Both AM and PM peak microsimulation models are considered acceptably calibrated and validated for use in future option testing.

Appendix A Signal Data

Intersection	TCS No.	Phase Sequence		Inter Green (s)	Cycle Length (s)		Cycle Length adopted (s)		SS	Offset Plan		Link Plan		Offsets	
		AM	PM		AM	PM	AM	PM	0	AM	PM	AM	PM	AM	PM
Windsor Street / East Market Street	1645	ABC	ABC	6	92	106	110	110	S#=6	PP4=0,0^A!	PP2=0,0^A!	LP4=10, 10^B1644!	LP2=-10, -10^B1644!	A with A(1644)+10	A(1644)-10
March Street / East Market Street	1644	ABCD	ABCD	6	92	107	110	110	S#=8	PP4=0,0^B!	PP2=0,0^B!	0	0	0	0
Lennox Street / East Market Street	2614	ACB	ACB	6	76	77	110	110	S#=5	PP4=0,0^A!	PP2=0,0^B!	0	0	0	0
Lennox Street / Paget Street	1027	AB	AB	6	70	72	110	110	S#=36	PP4=0,0B!	PP2=0,0B!	LP4=27, 28C2614!	LP2=-14, -14C2614!	B with C(2614)+28	B with C(2614)-14
Lennox Street / Blacktown Road / Bourke Street	1777		ACB	6	0	90	110	110	S#=37	PP4=0,0C!	PP2=0,0B!	LP4=22, 21B1027!	LP2=-34, -34B1027!	C with B(1027)+21	B with B(1027)-34
Bells Line of Road / Grose Vale Road / Terrace Road	2303	ADEG	ADEG	7	126	105	120	120	S#=7	PP4=0,0^A!	PP2=0,0^A!	0	0	0	0
Kurrajong Road / Bosworth Street / March Street	2595	ABDCE	ABDCE	7	106	110	120	120	S#=18	PP4=0,0^A!	PP2=0,0^A!	0	0	0	0
Windsor Street / Bourke Street	2762	AB	AB	6	91	91	100	100	S#=0	PP4=0,0^A!	PP2=0,0^A!	0	0	0	0

Signal time validation has been provided for the intersections of Bells Line of Road with Terrace Road and March Street with Bosworth Street. These two intersections are the only ones located within the core of the study area.

Bells Line of Road, Grose Vale Road and Terrace Road intersection

During the first hour AM peak, additional green time was required for Phase E for the calibration and queue validation of the model. Observed queues at Grose Vale Road during this time reached over Pecks Road. Although modelled phase times are higher, the model represents observed queues, has GEH < 5 for all tunning movements within the intersection, and other phase times are within the validation criteria. Also, there is no other route for vehicles travelling along Grose Vale Road.

During the second AM peak hour, reduced green time was required for Phase G for the calibration and travel time validation of the model. This time was added to Phase A. Observed queues at Bells Line of Road during the second AM hour reached Colo High Shool and travel times were faster than those observed during the first hour. Although modelled phase times are lower for Phase G, the model represents observed queues and travel times, has GEH < 5 for all tunning movements within the intersection, and other phase times are within the validation criteria.

Cycle time required to be adapted in all time periods to other intersections to ensure correct coordination. This resulted in differences of up to 20 seconds. In the case of the second hour of the PM peak, this difference is higher than the required 10%. It should be notes that for this time period, al phases are within the validation criteria.

Peak hour	Phase	Total phase time SCATS	Total phase time Modelled	Absolute difference	Relative difference
7:30 to 8:30	A	1331	1260	-71	-5%
	D	1183	1170	-13	-1%
	E	501	600	99	20%
	G	585	570	-15	-3%
	Cycle time	**132**	**120**	**-12**	**-9%**
8:30 to 9:30	A	1170	1290	120	10%
	D	1080	1080	0	0%
	E	692	660	-32	-5%
	G	658	570	-88	-13%
	Cycle time	**121**	**120**	**-1**	**-1%**
15:30 to 16:30	A	1137	1200	63	6%
	D	855	810	-45	-5%
	E	731	780	49	7%
	G	877	810	-67	-8%
	Cycle time	**109**	**120**	**11**	**10%**
16:30 to 17:30	A	1141	1110	-31	-3%
	D	887	900	13	1%
	E	758	780	22	3%
	G	814	810	-4	-1%
	Cycle time	**101**	**120**	**19**	**19%**

March Street and Bosworth Street intersection

- Phase A considers eastbound - westbound, plus right turning movement from Kurrajong Road
- Phase B and Phase E are the same, which consider all turning movements from the western approach
- Phase C considers all southbound turning movements
- Phase D considers all northbound - southbound movements

During the AM peak, phase time balancing was required between Phase A and Phases B-E to calibrate the eastbound - westbound turning movements.

Also, the cycle time required to be adapted to ensure correct coordination with other intersections.

During the PM peak, phase time balancing was required between Phase A and Phase D, during the first hour, and between Phase A and Phase C, during the second hour, to achieve calibration and travel time validation.

Also, Phase E was not considered in the PM peak.

Peak hour	Phase	Total phase time SCATS	Total phase time Modelled	Absolute difference	Relative difference
7:30 to 8:30	A	1016	900	-116	-11%
	C	943	870	-73	-8%
	D	518	540	22	4%
	B + E	1122	1290	168	15%
	Cycle time	**104**	**120**	**16**	**15%**
8:30 to 9:30	A	1115	930	-185	-17%
	C	919	900	-19	-2%
	D	575	570	-5	-1%
	B + E	991	1200	209	21%
	Cycle time	**107**	**120**	**13**	**12%**
15:30 to 16:30	A	1362	1200	-162	-12%
	B	682	750	68	10%
	C	831	840	9	1%
	D	687	810	123	18%
	Cycle time	**124**	**120**	**-4**	**-3%**
16:30 to 17:30	A	1288	1080	-208	-16%
	B	689	750	61	9%
	C	812	960	148	18%
	D	812	810	-2	0%
	Cycle time	**109**	**120**	**11**	**10%**

Appendix B Site visit note

A site visit to understand the existing traffic conditions during the morning and afternoon peaks was conducted in Richmond and North Richmond on Thursday 4th May 2023 between 07:30 and 09:30; and between 15:30 and 17:30.

During the site visit, the AM and PM peak period traffic conditions were observed, with a focus on identifying congestion originators, driving behaviour, diversion routes, signal timings, intersection layouts and queueing at intersections. Figure 1 shows the main observed intersections – note that for the purpose of describing travel directions, the Windsor Street to Kurrajong Road corridor was assumed to be orientated Westbound.

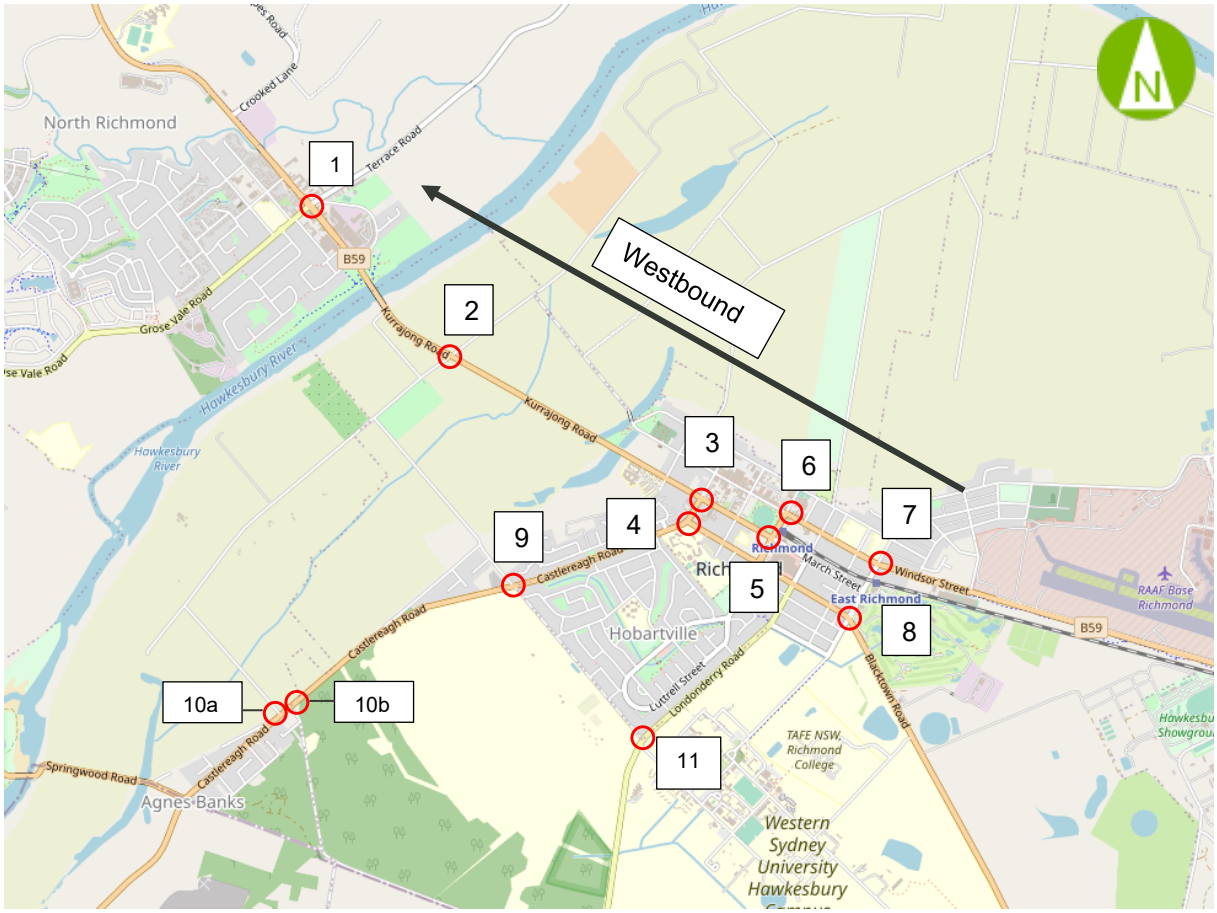


Figure 1: Observed intersections

General observations

In general, whilst the traffic was heavy during both peak periods along the whole network, congestion concentrated along the Hawkesbury River Bridge – Bells Line of Road / Kurrajong Road / March Street corridor.

During the morning peak period, the main traffic movement was in the eastbound direction where queuing were observed on the western and the southern approaches at Intersection 1 (Bells Line of Road with Terrace Road / Grose Vale Road intersection). These queues were largely caused by a lane merge located downstream on the Bells Line of Road on the Eastbound direction. After the merging point, vehicles were moving slowly towards Intersection 2 (Kurrajong Road and Old Kurrajong Road intersection), with the gap between vehicles gradually increasing towards Intersection 3 (Bosworth Street and March Street intersection). Figure 2 shows the congested road sections during the AM peak.

Figure 2: Congestion observed during the AM peak period

In the afternoon peak, the congestion formed in the westbound direction which originated at Intersection 2 (Kurrajong Road and Old Kurrajong Road intersection), with queues at times extending back towards Intersection 3 (Bosworth Street and March Street intersection) in Richmond. This congestion was observed to mainly result from the merging point on Kurrajong Road Westbound where the westbound mainline traffic on Kurrajong Road give way to the merging traffic from Old Kurrajong Road. Furthermore, during the PM peak westbound traffic entering Richmond was heavy on Windsor Street and Blacktown Road, resulting in long queues on especially the Bourke Street approach to Intersection 8 (Lennox Street/Bourke Street /Blacktown Road intersection). Figure 3 shows the observed queues during the PM peak.

Figure 3: Congestion observed during the PM peak period

In addition, during the PM peak several diversion movements were also observed, which is believed to be alternative routes taken by the local drivers who are familiar with the peak period congestion within the study area, or those that are utilising GPS based navigation systems. Figure 4 shows the likely observed diversion routes.

Figure 4: Potential diversion routes observed during PM peak

School zones

There are four educational institutions in the study area, three located within the Richmond and North Richmond town areas and one located north of North Richmond.

The site inspection identified that out-of-town the speed limit variation time due to the presence of schools is different to the school zone time limits located in-town. Figure 5 shows the out-of-town school zone speed limits when travelling towards Colo High School, which is located approximately 1.8 kilometres (km) north of Intersection 1 (Bells Line of Road with Terrance Road and Grose Vale Road intersection).

Figure 6 shows in the in-town school zone speed limits when travelling towards Richmond North Public School, located in North Richmond.

The different school zone speed limits are as follows:

- Out-of-town: 07:30 – 09:00 in the AM and 14:00 – 15:30 in the PM
- In-town: 08:00 – 09:30 in the AM and 14:30 – 16:00 in the PM

The out-of-town school zone speed limits therefore starts and ends 30 minutes earlier than the in-town school zone speed limits.

Figure 5: Out-of-town school zone speed limits located near Colo High School

Figure 6: In-town school zone speed limits located near Richmond North Public School

On-street parking

It was noted during the site visit that several on-street vehicle parking spaces in Richmond and North Richmond were available, with varying parking restrictions. It was also observed that the on-street parking spaces were not fully utilised during the peaks. Figure 7 shows the parking utilisation in North Richmond along Terrace Road, whereas Figure 8 shows the parking utilisation in Richmond along Bourke Street.

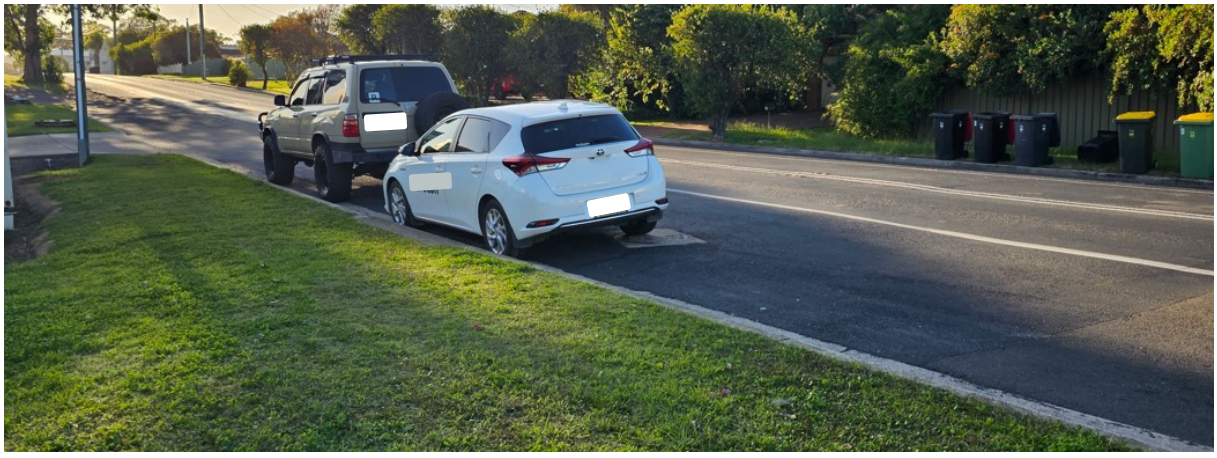


Figure 7: Parking utilisation in North Richmond along Terrace Road

Figure 8: Parking utilisation in Richmond along Bourke Street

Heavy Vehicles

Although the Richmond and North Richmond areas are not recognised for having a high presence of heavy vehicles, during the site visit, several different types of heavy vehicles were observed within the study area, with a higher presence during AM than the PM. Figure 9 to Figure 11 show some of the heavy vehicles observed during the site visit.

Figure 9: Rigid truck and trailer combination (3-axle truck and 4-axle dog trailer)

Figure 10: Articulated delivery truck

Figure 11: Articulated tanker truck

Relevant intersections and routes

Intersection 1 – Bells Line of Road / Grose Vale Road

Figure 12 shows the observed queuing on the approaches to Intersection 1 (Bells Line of Road / Grose Vale Road) during the morning and evening peak.

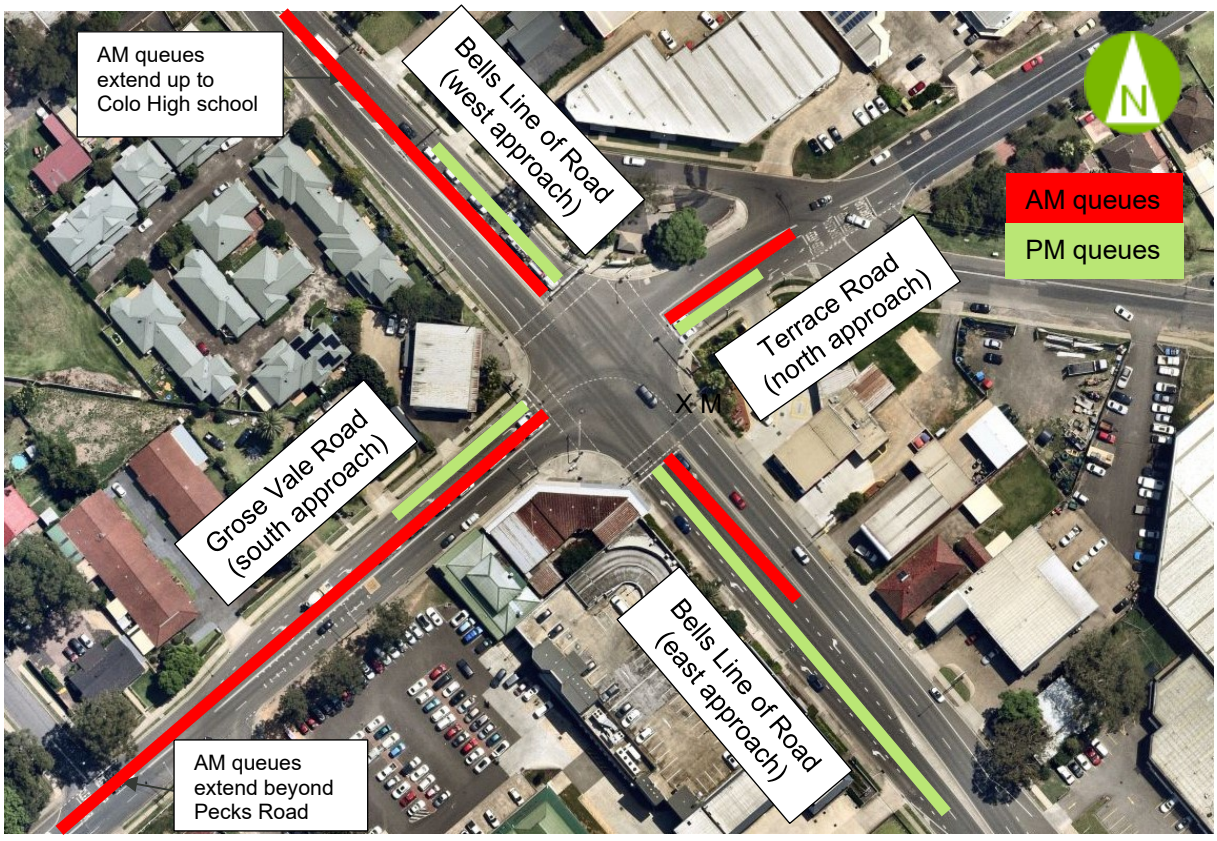


Figure 12: Overview of queuing at Intersection 1 (Bells Line of Road / Grose Vale Road) during AM and PM peak

During the AM peak period, the western approach through traffic on Bells Line of Road, and the right turning traffic on the southern approach of Grose Vale Road, experienced long delays and struggled crossing the intersection. Queues on the southern approach of Grose Vale Road extended beyond Pecks Road (7:50 AM) as shown in Figure 13, and queues on the western approach of Bells Line of Road extended to Colo High School (9:30 AM) as shown in Figure 14.

Figure 13: Observed queuing on Grose Vale Road (southern approach) during the AM peak

Figure 14: Observed queuing on Bells Line of Road (western approach) during the AM peak

These were observed to be caused by the intersection capacity, but primarily because of the downstream lane merge on Bells Line of Road, which is located approximately 200 m east of the intersection. This merge acts as a bottle neck (refer to Figure 15), propagating the congestion upstream. Beyond the merging lane, vehicles were observed to travel freely.

Figure 15: Observed queuing on Bells Line of Road (eastern departure) at lane merge, with bus turning out of service road and obstructing both traffic lanes, during the AM peak

It was also observed that buses exiting the bus bay at Bells Line of Road could not access the mainstream easily. Buses were required to wait for a gap to be able to turn into Bells Line of Road, which required general traffic to stop along Bells Line of Road.

On the northern approach of Terrace Road, eastbound traffic (left turn) experienced delays, resulting in short queues (refer to Figure 16), owing to the congestion downstream on Bells of Line Road. Traffic on the eastern approach of Bells Line of Road operated acceptably during the morning peak.

Figure 16: Observed queuing on Terrace Road (northern approach) during the AM peak

In the PM peak, the dominant traffic volume is located on the eastern approach of Bells Line of Road, with queues on all movements on this approach. Observations showed that right turning traffic into Terrace Road would often exceed the right turn bay capacity as shown in Figure 17. Westbound traffic travelled freely once it has crossed the intersection.

Delays on the other three approaches were lower than during the morning peak. Figure 17 shows the observed queuing along Bells Line of Road and Figure 18 along Grose Vale Road during the PM peak.

Figure 17: Observed queuing on Bells Line of Road (eastern approach) during the PM peak

Figure 18: Observed queuing on Grose Vale Road (southern approach) during the PM peak

Intersection 2 – Kurrajong Road / Old Kurrajong Road

Old Kurrajong Road's south-to-west movement into Kurrajong Road is via a left turn slip lane, which then merges into Kurrajong Road at approximately 70m downstream of the intersection. Figure 19 presents Intersection 2's (Kurrajong Road and Old Kurrajong Road) layout, along with an overview of the observed queuing at the intersection during morning and evening peak.

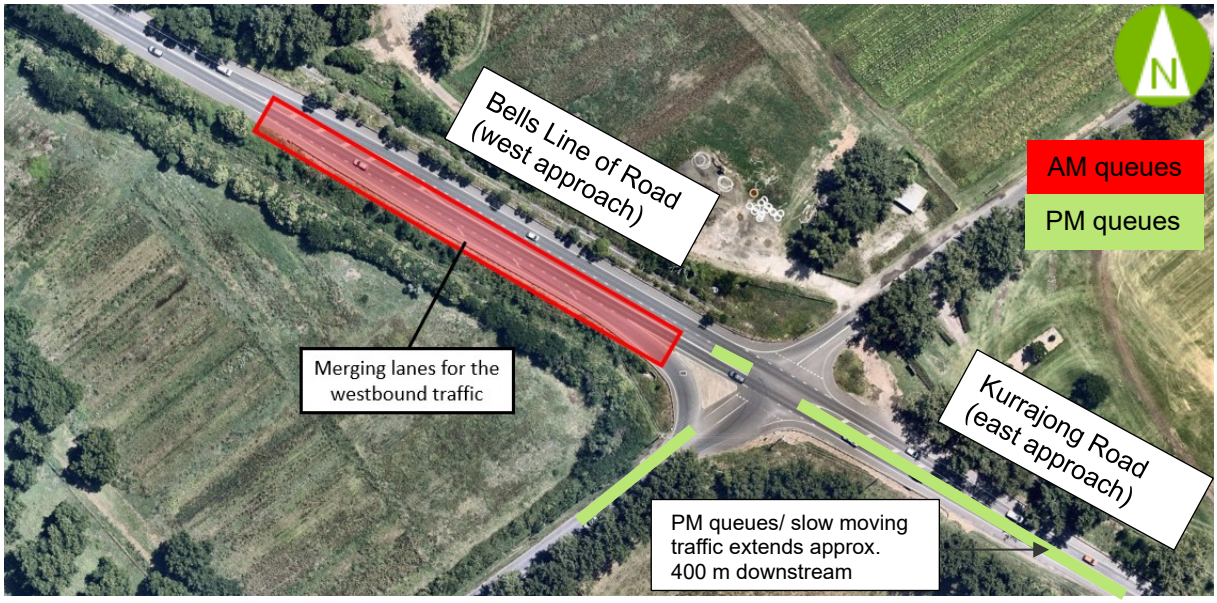


Figure 19: Overview of queuing at Intersection 2 (Kurrajong Road and Old Kurrajong Road) during AM and PM peak

During AM peak, no noteworthy queuing was observed at the intersection, and operated satisfactorily as shown in Figure 20.

Figure 20: No observed queuing along Kurrajong Road during the AM peak

However, in the PM peak, the merging lane acts as a bottle neck for vehicles travelling along Kurrajong Road and Old Kurrajong Road, as vehicles merge into one lane. As a result, vehicles on the main lane slow down, allowing the vehicles in the merging lane to merge into the main lane, creating queues that were observed to extend for approximately 400 m along Kurrajong Road (refer to Figure 21). Once the vehicles travelled through the lane merge, even though through traffic was heavy, vehicles travelled comparatively freely until the downstream Intersection 1 (Bells Line of Road with Terrace Road and Grose Vale Road).

Figure 21: Observed queuing on Kurrajong Road (eastern approach) during the PM peak

Intersection 3 (March Street / Bosworth Street)

Intersection 3 (March Street / Bosworth Street) is a signalised intersection that operates on a four-phase cycle, where the eastbound and westbound movements on March Street are the primary movements. Figure 22 shows an overview of the queuing that were observed at the intersection during morning and evening peak.

Figure 22: Overview of queuing at Intersection 1 (March Street/ Bosworth Street) during AM and PM peak

During the AM peak period, traffic mainly travels in the eastbound direction, with queues observed on the through and right turn lanes of both the southern approach on Bosworth Street and the western approach on March Street, as shown in Figure 23 and Figure 24. The allocated green time within the cycle were observed to be adequate to clear the queues on the eastern approach on March Street, but not on the southern approach on Bosworth Street.

Figure 23: Observed queuing on Bosworth Street (southern approach) during the AM peak

Figure 24: Observed queuing on March Street (western approach) during the AM peak

In the PM peak, since traffic is mainly traveling in the westbound direction, queues were observed on Bosworth Street on the right turn lane of the northern approach, as well as the left turn lane of the southern approach (refer to Figure 25), as well as on March Street's eastern approach (refer to Figure 26). The queueing is mainly owing to a capacity constraint at the intersection, with vehicles on these approaches struggling to cross the intersection during their respective green times.

It is also noted that traffic diversions were observed during the PM peak, with some vehicles from the eastern approach of March Street, that were travelling to North Richmond, turning left onto Bosworth Street and then following an alternative route (Bosworth Street – Castlereagh Road – Inalls Lane - Yarramundi Lane) to reach Intersection 2 (Kurrajong Road / Old Kurrajong Road). Travel time as per a GPS based navigation system indicates that the travel time along the alternative route could be up to two minutes faster than the direct route via Kurrajong Road.

Figure 25: Observed queuing on Bosworth Road (southern approach) during PM peak

Figure 26: Observed queuing on March Street (eastern approach) during PM peak

Intersection 4 (Lennox Street / Castlereagh Road / Bosworth Street)

Intersection 4 (Lennox Street / Castlereagh Road / Bosworth Street) is a priority-controlled intersection, with no observed issues during either the AM or PM peaks.

Intersection 5 (March Street / E Market Street)

Intersection 5 (March Street / E Market Street) is a signalised intersection, with no observed issues during either the AM or PM peaks.

Intersection 6 (East Market Street / Windsor Street)

Intersection 6 (East Market Street / Windsor Street) is a signalised intersection, with no observed issues during either the AM or PM peaks.

Intersection 7 (Windsor Street / Bourke Street)

Intersection 7 (Windsor Street / Bourke Street) is a signalised intersection operating with two phases, one along Windsor Street (east-west), which has a higher allocated capacity, and a second one along Bourke Street (north-south). Both phases have filtered right turns.

Figure 27 shows the observed queues at Intersection 7's (Windsor Street / Bourke Street) approaches during morning and evening peak.

Figure 27: Overview of queuing at Intersection 7 (Windsor Street/ Bourke Street) during AM and PM peak

In AM peak, the main traffic movement is in the eastbound direction, with queues observed on both the eastern and the western approaches along Windsor Street, Figure 28shows the queues on Windsor Street's eastern approach. The signal phasing arrangement, in combination with a high right turning volume during the AM peak, also results in queuing along Bourke Street's southern approach, as can be seen in Figure 29.

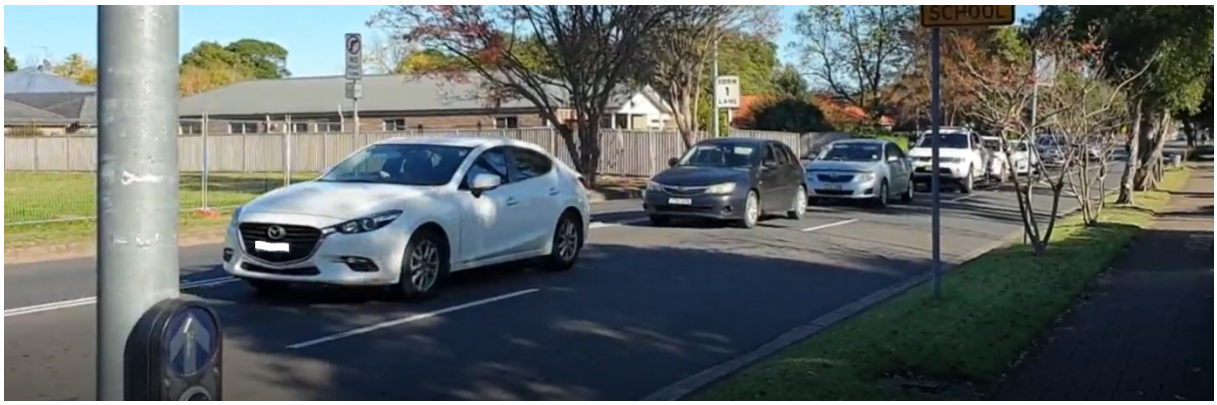


Figure 28: Observed queuing on Windsor Street (eastern approach) during AM peak

Figure 29: Observed queuing on Bourke Street (southern approach) right turn during AM Peak

During the PM peak, the main traffic movement is in the eastbound direction, as vehicles leave Richmond along Windsor Street. The main delays were therefore observed on the western approach, along Windsor Street (refer to Figure 30), as well as on the left turn from Bourke Street's southern approach (refer to Figure 31).

Figure 30: Observed queuing on Windsor Street (western approach) during PM peak

Figure 31: Observed queuing on Bourke Street (southern approach) during PM peak

Intersection 8 (Blacktown Road / Lennox Street / Bourke Street)

Intersection 8 (Blacktown Road / Lennox Street / Bourke Street) is a signalised intersection operating with two phases, one along Blacktown Road- Lennox Street (east-west), which has a higher allocated capacity, and a second one along Bourke Street (north-south). Figure 32 shows the observed queues at Intersection 8's approaches during morning and evening peak.

Figure 32: Overview of queuing at Intersection 8 (Blacktown Road / Lennox Street / Bourke Street) during AM and PM peak

Intersection 8 was observed to operate acceptably during the AM peak, with the dominant movements being in the eastbound and westbound directions.

During the PM peak, the main traffic movements were also on the eastbound and westbound directions, together with the left turning movement from Bourke Street's northern approach into Blacktown Road. Long queues were observed on Bourke Street's northern approach, where the kerbside lane was observed to be fully utilised.

Instances were also observed during the PM peak where Bourke Street's northern approach through and right turn traffic volumes resulted in queuing that extended beyond the left turn's short lane and blocking the use of the short lane. This may in-part be because of insufficient green time for Bourke Street's northern approach (i.e. unoptimized phasing), resulting in queued traffic not being able to clear.

Heavy left turning and though traffic from Blacktown Road (eastern approach) was also observed during the PM peak, as shown in Figure 33. The Blacktown Road (eastern approach) however had sufficient green time to clear queuing on this approach.

Figure 33: Observed queuing on Blacktown Road (eastern approach) during PM peak

Intersection 9 (Castlereagh Road / Southee Road / Inalls Lane)

Figure 34: Intersection 9 (Castlereagh Road / Southee Road / Inalls Lane) operation during AM Peak

Intersection 9 (Castlereagh Road / Southee Road / Inalls Lane) is a priority-controlled intersection, with no observed performance issues during either the AM or PM peaks.

During the evening peak period, a higher number of right turning vehicles from Castlereagh Road into Inalls Lane was observed. This is believed to form part of an alternative route used by drivers to avoid congestion along Kurrajong Road westbound.

Intersection 10a (Castlereagh Road / Crowleys Lane)

Intersection 10a (Castlereagh Road / Crowleys Lane) is a priority-controlled intersection, with no observed performance issues during either the AM or PM peaks.

During the AM peak a high number of right tuning vehicles from Crowleys Lane to Castlereagh Road was observed, with the inverse being observed during the PM peak with a high number of left turning vehicles from Castlereagh Road to Crowleys Lane (refer to Figure 35). This is potentially a diversion route, attempting to avoid congestion along Kurrajong Road.

Figure 35: Location of high right turning volume from Crowleys Lane to Castlereagh Road during PM peak

Intersection 10b (Castlereagh Road / The Driftway)

Intersection 10b (Castlereagh Road / The Driftway) is a priority-controlled intersection, with no observed performance issues during either the AM or PM peaks. The general flow of traffic during AM peak was observed to be northbound, and the inverse on the southbound during PM peak.

Southee Road

During AM and PM peak periods, low traffic volumes were observed along Southee Road. The side streets intersecting with Southee Road, that provide access to the Hobartville residential area, operate on priority basis. No issues were observed during either of the peaks.

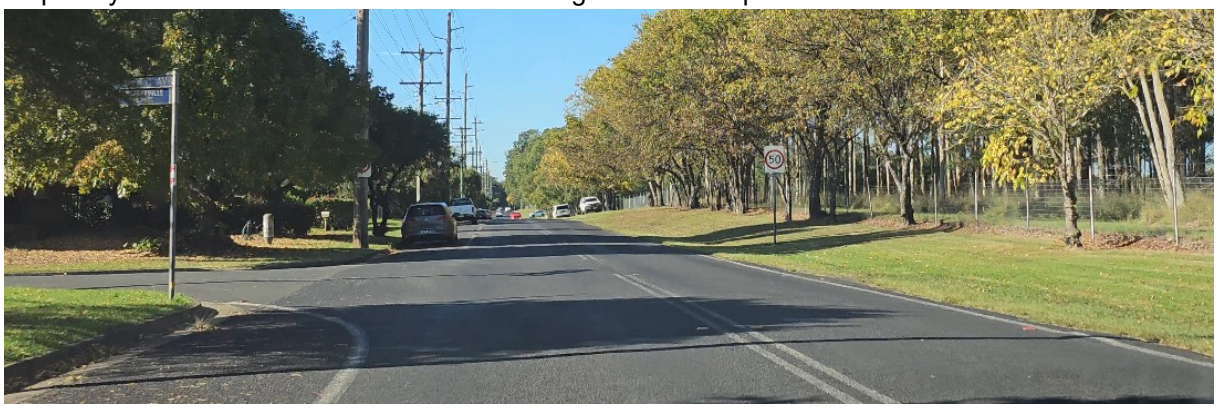


Figure 36: Southee Road / Vander Avenue intersection operation during AM peak

Figure 37: Southee Road / Anderson Avenue operation during AM peak

Level crossing on Bourke Street

Rail services for the T1 and T5 lines originates and terminates at the Richmond Station and passes through the Bourke Street level crossing. However, during weekday AM and PM peaks, only the T1 line service interacts with Richmond Station, with two services per hour in each direction.

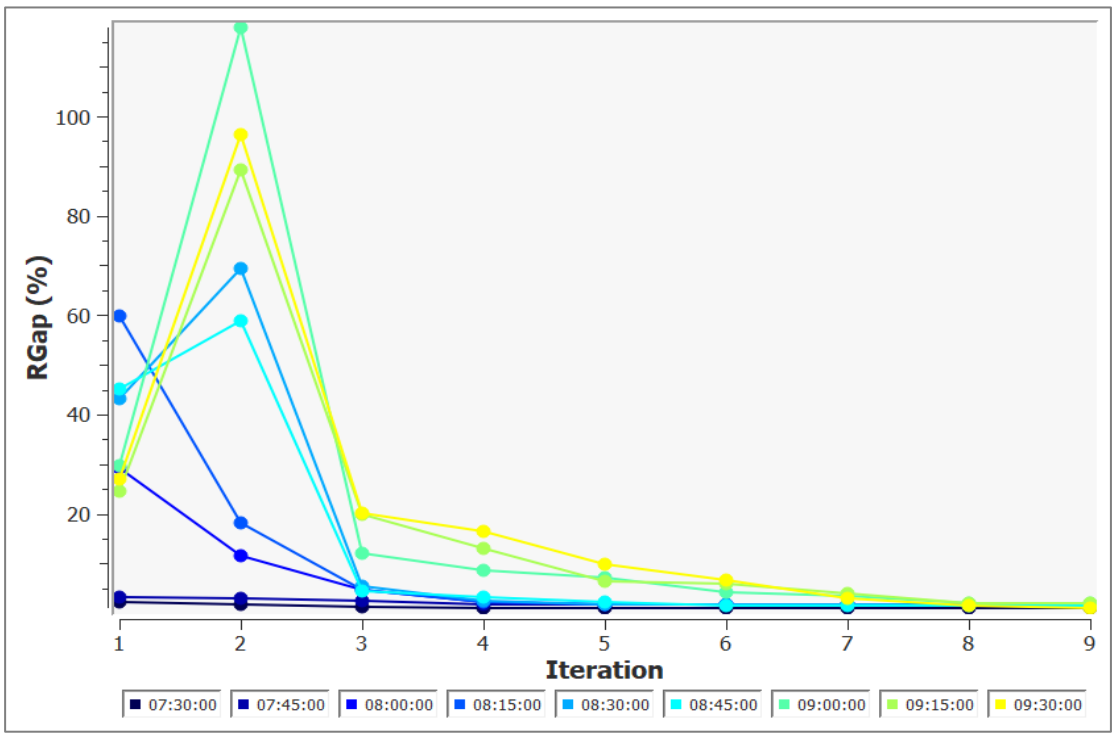
The operation cycle of the level crossing, including boom closure and boom opening times, lasts approximately one minute. Figure 38 shows the observed level crossing operation during the AM peak.

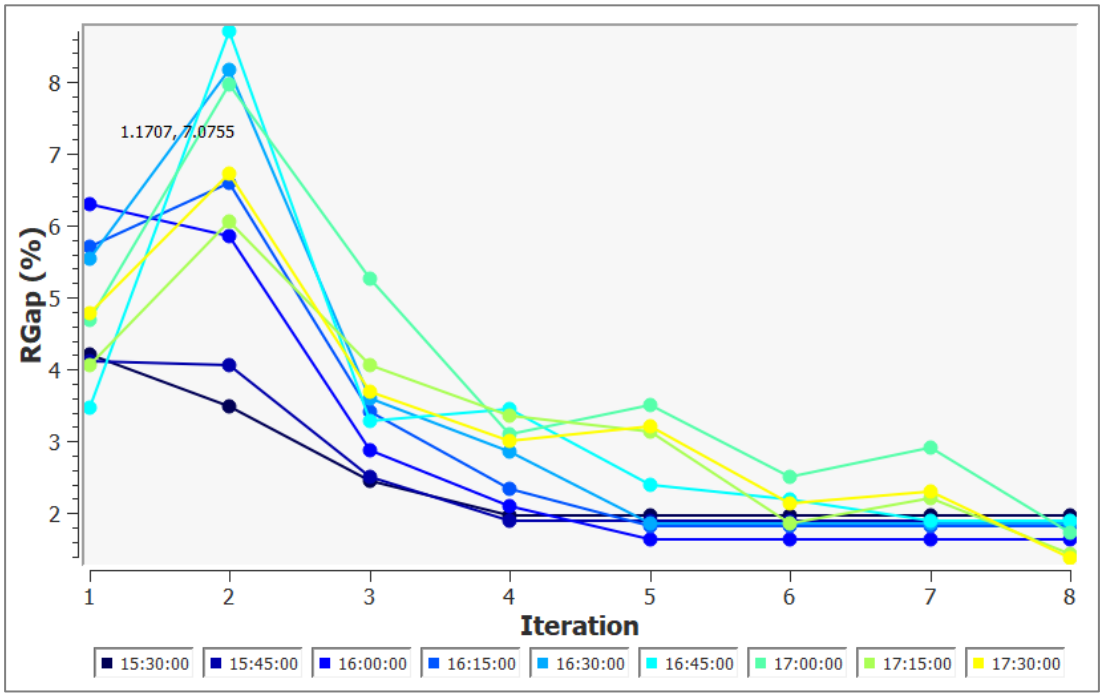
Figure 38: Level crossing operation on Bourke Street during AM peak

Appendix C Model convergence and stability

Model convergence

A summary of the microscopic DUE convergence for the 2023 existing conditions traffic model is shown in figures below. Convergence for the AM peak was achieved in nine iterations, and for the PM peak convergence was achieved in eight iterations, without recurring spikes. This indicates adequate convergence and stability of the 2023 base traffic model.





Model stability

The model stability was assessed using modelled Vehicle Hours Travelled (VHT), Vehicle Kilometre Travelled (VKT) and Number of Vehicles outside the network (NV), by analysing descriptive statistics over the traffic model's total set of runs. The AM and PM seed values were 560, 28, 7771, 86524 and 2849.

Table 1 and Table 2 below summarise the statistics based on each model set run and provide the Coefficient of Variance (CoV) for both peaks, indicating good model stability between various seed values used.

Table 1: New Richmond Bridge 2023 model – Model stability in AM peak

Measurement	Seed 560	Seed 28	Seed 7771	Seed 86524	Seed 2849	CoV
VKT	66,095	66,495	66,679	66,585	67,640	1%
VHT	1,636	1,608	1,658	1,647	1,773	4%
Completed Trips	12,383	12,368	12,564	12,448	12,536	1%

Table 2: New Richmond Bridge 2023 model – Model stability in PM peak

Measurement	Seed 560	Seed 28	Seed 7771	Seed 86524	Seed 2849	CoV
VKT	71,913	72,589	72,334	71,925	72,181	0%
VHT	1,812	1,740	1,768	1,789	1,712	2%
Completed Trips	14,600	14,684	14,648	14,503	14,524	1%

Stability plots for VKT, VHT and Completed Trips are also presented Figure 1 to Figure 3, indicating the variability between the various model runs.

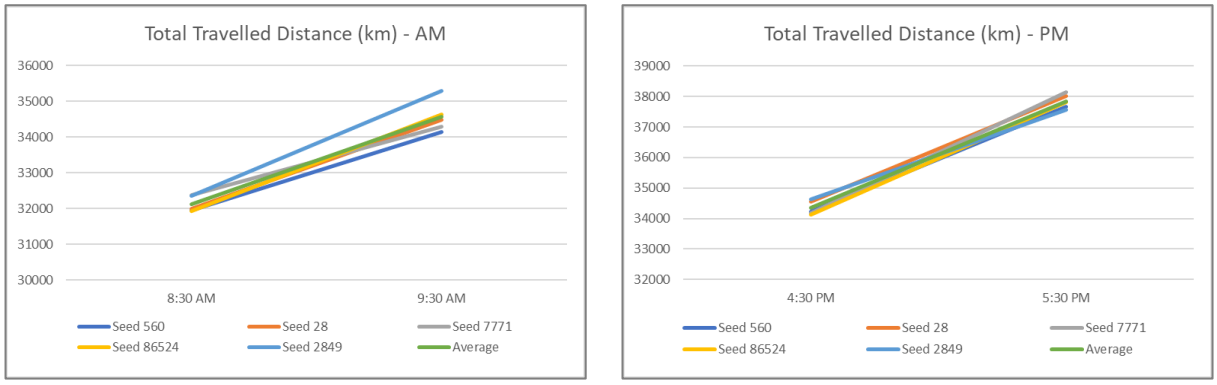


Figure 1: AM and PM Model Stability – Total Travelled Distance (kilometre)

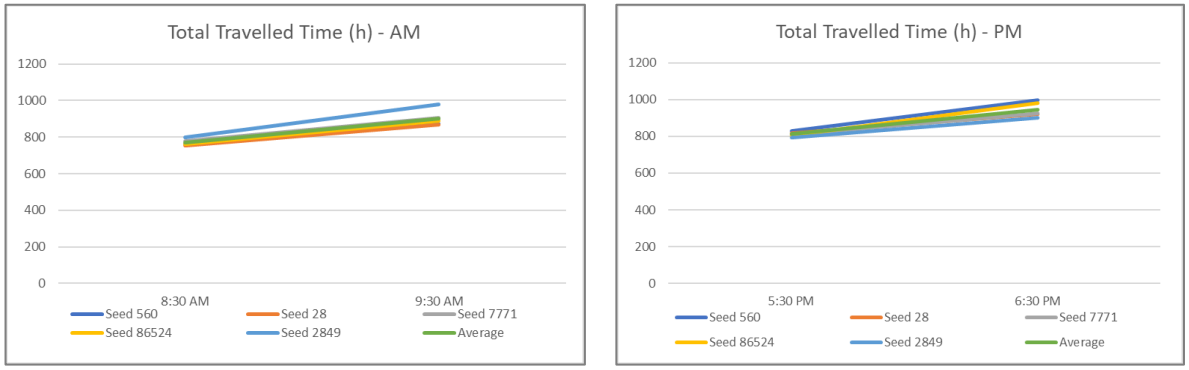


Figure 2: AM and PM Model Stability – Total Travel Time (hours)

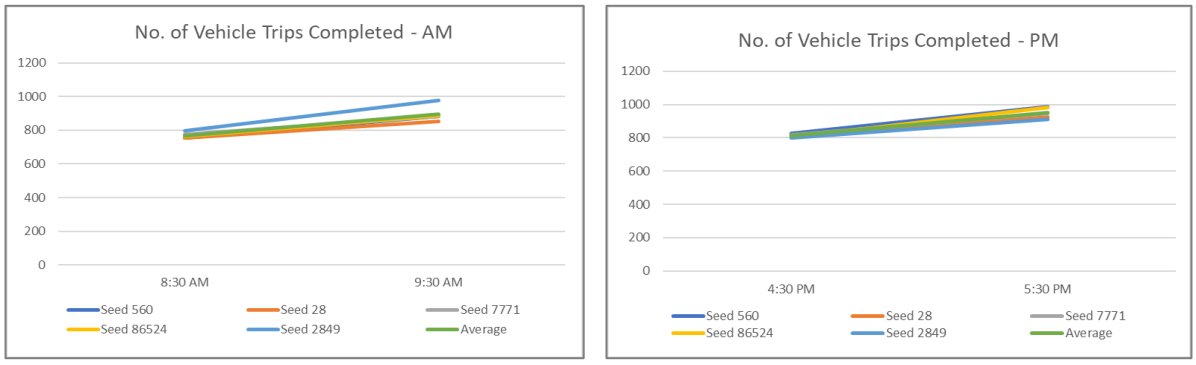


Figure 3: AM and PM Model Stability – Number of vehicle trips completed

Appendix D Model calibration changes

During the development and recalibration of the 2023 existing conditions traffic model, some microscopic parameters required modifications. These were introduced in the model using 'Attribute Overrides' and traffic management strategies.

Implemented attribute overrides are described in tables below. Traffic management strategies were used to consider school zones, on-street parking as well as to avoid illogical turns.

Attribute overrides

Attribute overrides - AM and PM

Behavioural Attributes	Default values	New values	Requirement
Vehicle microscopic Model – Gap (Car and Truck)	Mean: 0s Minimum: 0s Maximum: 0s Deviation: 0s	Mean: 2s Minimum: 0s Maximum: 3s Deviation: 1s	To increase headway between vehicles in congested areas
Vehicle microscopic Model – Headway Aggressiveness (Car and Truck)	Mean: 0 Minimum: -1 Maximum: 1 Deviation: 0	Mean: -1 Minimum: -3 Maximum: 1 Deviation: 1	

Attribute overrides - AM only

Turn Attributes	Default values	New values	Requirement
Attractiveness	0 - 600	50 – 1,000	To influence route choice
User defined cost	0 - 100	0 – 200	To influence route choice
Dynamic cost function	Default	50, 100, 250, 350, 500, 750, 1000	To influence route choice
Speed	34.8 Km/h	50 km/h	To influence queue discharge
Initial safety margin	3	2 – 5	To influence vehicle aggressive ness on a give- way sign
Final safety margin	1	0.5 – 2	
Initial yield time factor	1	0.5 – 2	
Final yield time factor	2	3	

Section Attributes	Default values	New values	Requirement
User defined cost	0-100	0-100	To influence route choice
Lane-changing cooperation	50%	50%	To influence cooperation from vehicles in main line to merging vehicles
Imprudent lane changing	False	True	To allow vehicles to change lane in short gaps on merging areas
Side lane marge: First vehicle on is first vehicle off	True	False	The first vehicle in the merge need not to be the first one in enter the main lane.
Acceleration factor	1	1 – 3	To influence queue discharge rate

Attribute Overrides - PM

Turn Attributes	Default values	New values	Requirement
Attractiveness	10-480	20 – 500	To influence route choice
User defined cost	0 - 1000	0 – 1000	To influence route choice
Dynamic cost function	Default	50, 100, 250, 350, 500, 750, 1000	To influence route choice
Initial safety margin	3	2 - 4	To influence vehicle aggressive ness on a give- way sign
Initial yield time factor	1	0.5, 2	

Section Attributes	Default values	New values	Requirement
User defined cost	100 – 500	0 – 100	To influence route choice
Acceleration factor	1	0.5 – 0.8	To influence queue discharge rate
Imprudent lane changing	False	True	To allow vehicles to change lane in short gaps on merging areas
Side lane merging distance	Default	30m	To influence how vehicles merge in main line.
Side lane cooperation distance	Whole lane	30m	
Lane changing cooperation	50%	50% - 85%	To influence lane changing behaviour
Lane changing Aggressiveness	0%	0%	
Side lane marge: First vehicle on is first vehicle off	True	True	The first vehicle in the merge need not to be the first one in enter the main lane.
Additional reaction time at stop	0s	1s	To influence queue discharge rate

Turn ban PM peak – Centroid 11 to Centroid 37

For the PM scenario, a turn ban was applied for traffic from centroid 11 to centroid 37 to avoid illogical routing. Initially, adjustment of turn cost, section cost and attractiveness were tested for the most logical route choice but the route choice for the OD pair was not coherent, which led to the requirement to implement a turn ban using a traffic management strategy. Figure shows the scenario for route choice between centroid 11 to centroid 37. The turn shown in blue is not available on road network, the route adopted by the vehicles in the absence of the turn ban is shown in red. Implementation of the left turn ban resulted in the logical route choice shown in green.

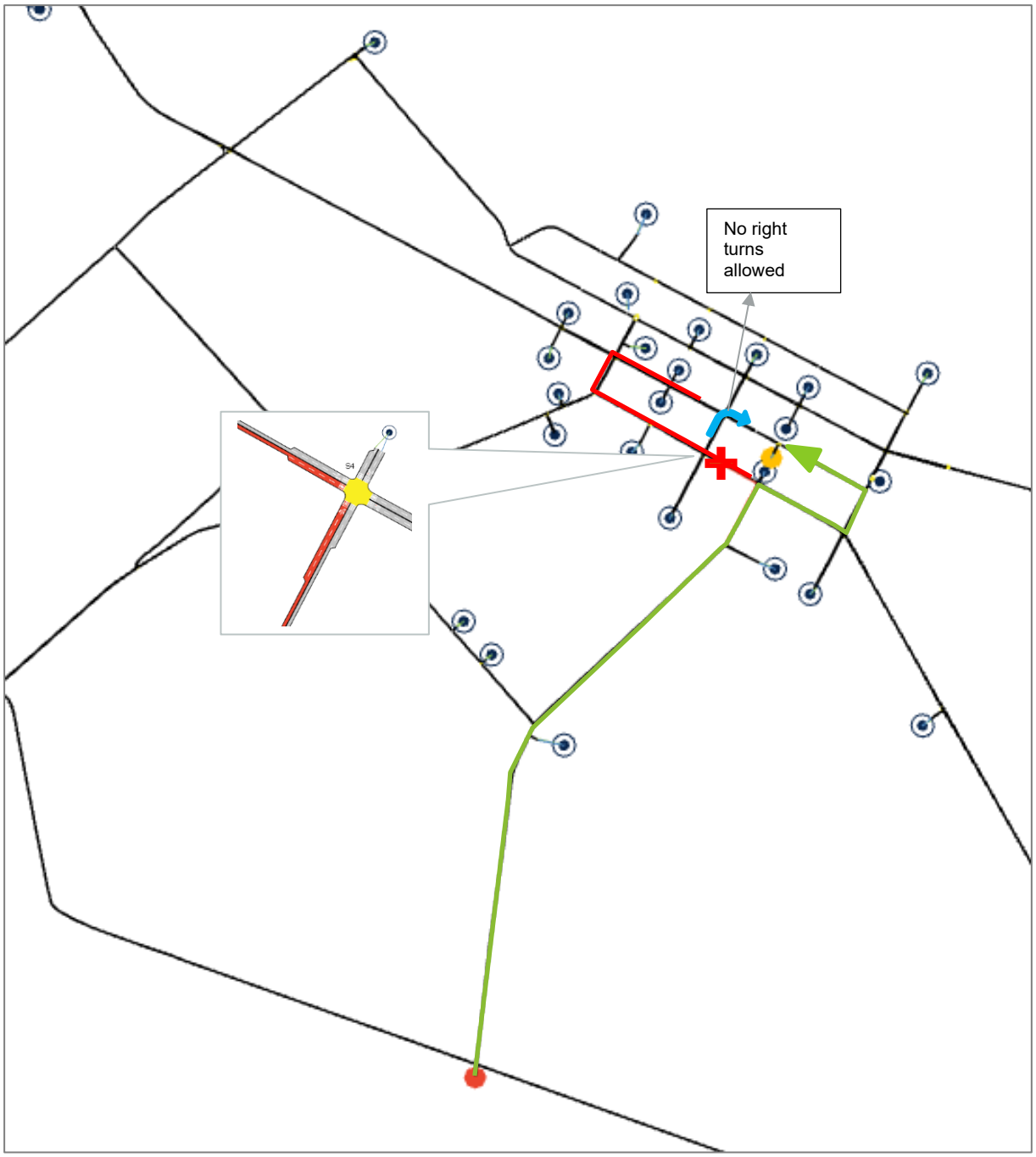


Figure 1: Turn ban - Traffic management strategy implemented in PM peak

Appendix E Calibration results

AM calibration results

S no.	Name / Description	Approach Road	Approach Direction	Turn	07:30 AM- 08:30 AM										08:30 AM- 09:30 AM									
					Light Vehicles					Heavy Vehicles					Light Vehicles					Heavy Vehicles				
					Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH
1	Bells Line of Rd / Grose Vale Rd / Terrace Rd	Bells of Line Rd	West	L	44	48	4.2	9.5%	0.62	2.0	6	3.8	190.0%	1.92	52.00	50	-1.80	-3.5%	0.25	2.00	4	2.20	110.0%	1.25
		Bells of Line Rd	West	T	783	734	-49.2	-6.3%	1.79	37.0	52	15.0	40.5%	2.25	600.00	505	-95.20	-15.9%	4.05	32.00	42	10.20	31.9%	1.67
		Bells of Line Rd	West	R	53	68	14.8	27.9%	1.90	3.0	7	3.8	126.7%	1.72	74.00	61	-12.80	-17.3%	1.56	3.00	7	3.80	126.7%	1.72
		Terrace Rd	North	L	169	182	13.4	7.9%	1.01	4.0	17	13.2	330.0%	4.05	164.00	175	11.00	6.7%	0.84	6.00	16	10.00	166.7%	3.02
		Terrace Rd	North	T	50	41	-8.6	-17.2%	1.27	5.0	2	-3.4	-68.0%	1.87	81.00	80	-1.00	-1.2%	0.11	4.00	1	-3.00	-75.0%	1.90
		Terrace Rd	North	R	41	39	-1.8	-4.4%	0.28	3.0	2	-0.6	-20.0%	0.37	39.00	42	3.20	8.2%	0.50	3.00	4	1.20	40.0%	0.63
		Bells of Line Rd	East	L	218	237	18.8	8.6%	1.25	28.0	30	2.2	7.9%	0.41	245.00	269	23.80	9.7%	1.48	31.00	38	7.20	23.2%	1.22
		Bells of Line Rd	East	T	284	270	-14.2	-5.0%	0.85	38.0	52	13.8	36.3%	2.06	325.00	336	11.00	3.4%	0.61	28.00	66	38.40	137.1%	5.59
		Bells of Line Rd	East	R	114	115	1.4	1.2%	0.13	11.0	5	-5.8	-52.7%	2.04	135.00	133	-2.20	-1.6%	0.19	10.00	5	-5.40	-54.0%	2.00
		Grose Vale Rd	South	L	37	49	11.6	31.4%	1.77	1.0	2	1.2	120.0%	0.95	43.00	52	9.00	20.9%	1.31	4.00	1	-3.00	-75.0%	1.90
		Grose Vale Rd	South	T	58	32	-26.0	-44.8%	3.88	6.0	0	-5.6	-93.3%	3.13	58.00	32	-26.40	-45.5%	3.94	3.00	1	-2.20	-73.3%	1.60
		Grose Vale Rd	South	R	633	601	-32.0	-5.1%	1.29	18.0	27	8.8	48.9%	1.86	588.00	668	79.60	13.5%	3.18	31.00	34	3.00	9.7%	0.53
3	Kurrajong Rd / Old Kurrajong Rd / Bells Line Of Rd	Bells of Line Rd	West	L	87	88	1.0	1.1%	0.11	3.0	1	-2.0	-66.7%	1.41	101.00	98	-3.20	-3.2%	0.32	0.00	0	0.20	0.0%	0.63
		Bells of Line Rd	West	T	1089	1,018	-70.8	-6.5%	2.18	52.0	74	21.6	41.5%	2.73	1051.00	1,000	-51.00	-4.9%	1.59	58.00	78	19.80	34.1%	2.40
		Bells of Line Rd	West	R	399	330	-68.8	-17.2%	3.60	7.0	19	11.6	165.7%	3.24	238.00	236	-2.40	-1.0%	0.16	10.00	17	6.60	66.0%	1.81
		Old Kurrajong Rd	North	L	1	15	13.8	1380.0%	4.91	1.0	7	5.6	560.0%	2.87	1.00	12	11.00	1100.0%	4.31	1.00	6	4.80	480.0%	2.60
		Old Kurrajong Rd	North	T	0	4	4.2	0.0%	2.90	0.0	2	1.8	0.0%	1.90	0.00	7	7.40	0.0%	3.85	0.00	2	1.80	0.0%	1.90
		Old Kurrajong Rd	North	R	0	2	2.0	0.0%	2.00	2.0	3	0.6	30.0%	0.40	0.00	4	4.20	0.0%	2.90	0.00	4	4.40	0.0%	2.97
		Bells of Line Rd	East	L	1	0	-1.0	-100.0%	0.00	1.0	0	-1.0	######	0.00	3.00	0	-2.80	-93.3%	2.21	0.00	0	0.00	0.0%	0.00
		Bells of Line Rd	East	T	491	467	-24.0	-4.9%	1.10	69.0	66	-2.6	-3.8%	0.32	596.00	567	-29.40	-4.9%	1.22	64.00	70	6.20	9.7%	0.76
		Bells of Line Rd	East	R	0	1	1.2	0.0%	1.55	0.0	1	1.0	0.0%	1.41	1.00	5	3.80	380.0%	2.23	0.00	1	0.80	0.0%	1.26
		Old Kurrajong Rd	South	L	205	193	-12.4	-6.0%	0.88	12.0	23	11.4	95.0%	2.71	178.00	194	16.20	9.1%	1.19	13.00	32	18.80	144.6%	3.97
		Old Kurrajong Rd	South	T	0	9	8.6	0.0%	4.15	0.0	0	0.2	0.0%	0.63	0.00	9	8.80	0.0%	4.20	0.00	1	0.60	0.0%	1.10
		Old Kurrajong Rd	South	R	0	1	1.0	0.0%	1.41	0.0	0	0.0	0.0%	0.00	0.00	3	3.40	0.0%	2.61	0.00	0	0.20	0.0%	0.63
4	March St / Bosworth St	March St	West	L	92	86	-6.2	-6.7%	0.66	2.0	1	-1.2	-60.0%	1.01	152.00	99	-53.20	-35.0%	4.75	2.00	1	-1.20	-60.0%	1.01
		March St	West	T	546	538	-7.6	-1.4%	0.33	28.0	36	8.2	29.3%	1.45	566.00	583	17.40	3.1%	0.73	28.00	36	7.60	27.1%	1.35
		March St	West	R	375	347	-27.6	-7.4%	1.45	20.0	35	14.8	74.0%	2.83	262.00	296	33.80	12.9%	2.02	25.00	42	16.60	66.4%	2.88
		Bosworth St	North	L	5	18	13.0	260.0%	3.83	0.0	1	1.0	0.0%	1.41	14.00	4	-10.00	-71.4%	3.33	0.00	0	0.00	0.0%	0.00
		Bosworth St	North	T	81	113	32.0	39.5%	3.25	4.0	6	2.2	55.0%	0.97	96.00	84	-12.40	-12.9%	1.31	2.00	5	3.20	160.0%	1.69
		Bosworth St	North	R	68	74	6.2	9.1%	0.74	7.0	6	-0.8	-11.4%	0.31	133.00	121	-11.60	-8.7%	1.03	4.00	4	-0.20	-5.0%	0.10

S no.	Name / Description	Approach Road	Approach Direction	Turn	07:30 AM- 08:30 AM										08:30 AM- 09:30 AM									
					Light Vehicles					Heavy Vehicles					Light Vehicles					Heavy Vehicles				
					Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH
		March St	East	L	30	48	18.0	60.0%	2.88	4.0	5	0.6	15.0%	0.29	27.00	48	20.60	76.3%	3.37	0.00	8	8.00	0.0%	4.00
		March St	East	T	253	293	40.2	15.9%	2.43	34.0	30	-4.0	-11.8%	0.71	301.00	347	45.60	15.1%	2.53	27.00	40	13.40	49.6%	2.31
		Bosworth St	South	L	183	156	-26.8	-14.6%	2.06	30.0	41	10.6	35.3%	1.78	215.00	197	-18.00	-8.4%	1.25	34.00	39	4.60	13.5%	0.76
		Bosworth St	South	T	144	167	23.4	16.3%	1.88	4.0	13	9.2	230.0%	3.14	182.00	203	20.60	11.3%	1.49	5.00	18	13.20	264.0%	3.88
		Bosworth St	South	R	67	72	5.4	8.1%	0.65	1.0	3	1.8	180.0%	1.31	57.00	62	4.60	8.1%	0.60	1.00	4	3.00	300.0%	1.90
5	Castlereagh Rd / Lennox St / Bosworth St	Bosworth St	North	L	357	375	17.8	5.0%	0.93	15.0	36	20.8	138.7%	4.13	249.00	325	76.20	30.6%	4.50	18.00	36	18.20	101.1%	3.50
		Bosworth St	North	T	130	128	-2.2	-1.7%	0.19	11.0	10	-1.0	-9.1%	0.31	137.00	105	-32.00	-23.4%	2.91	10.00	18	8.00	80.0%	2.14
		Lennox St	East	L	119	89	-30.2	-25.4%	2.96	4.0	6	2.2	55.0%	0.97	77.00	97	20.00	26.0%	2.14	4.00	8	3.80	95.0%	1.56
		Lennox St	East	R	157	214	57.0	36.3%	4.19	23.0	34	11.0	47.8%	2.06	199.00	278	78.80	39.6%	5.10	28.00	34	5.60	20.0%	1.01
		Castlereagh	South	T	234	185	-48.8	-20.9%	3.37	11.0	22	11.4	103.6%	2.79	256.00	186	-69.60	-27.2%	4.68	12.00	28	16.00	133.3%	3.58
		Castlereagh	South	R	214	176	-38.2	-17.9%	2.74	11.0	14	2.8	25.5%	0.80	148.00	178	30.00	20.3%	2.35	5.00	13	8.00	160.0%	2.67
6	Bourke St / Windsor St	Windsor St	West	L	11	18	7.2	65.5%	1.88	4.0	0	-4.0	-400%	0.00	6.00	20	14.20	236.7%	3.92	2.00	0	-2.00	-100.0%	0.00
		Windsor St	West	T	510	470	-40.2	-7.9%	1.82	26.0	46	19.6	75.4%	3.28	512.00	510	-1.80	-0.4%	0.08	36.00	48	12.40	34.4%	1.91
		Windsor St	West	R	22	21	-0.8	-3.6%	0.17	4.0	1	-2.6	-65.0%	1.58	38.00	16	-21.60	-56.8%	4.14	2.00	3	1.00	50.0%	0.63
		Bourke St	North	L	8	14	6.2	77.5%	1.86	0.0	3	2.6	0.0%	2.28	12.00	12	-0.20	-1.7%	0.06	1.00	2	1.00	100.0%	0.82
		Bourke St	North	T	78	49	-29.0	-37.2%	3.64	4.0	1	-3.2	-80.0%	2.07	99.00	64	-35.20	-35.6%	3.90	2.00	0	-1.80	-90.0%	1.72
		Bourke St	North	R	8	35	27.2	340.0%	5.85	1.0	2	0.6	60.0%	0.53	13.00	25	12.00	92.3%	2.75	0.00	0	0.20	0.0%	0.63
		Windsor St	East	L	169	158	-10.6	-6.3%	0.83	9.0	3	-5.6	-62.2%	2.25	244.00	202	-42.00	-17.2%	2.81	10.00	5	-4.60	-46.0%	1.66
		Windsor St	East	T	267	355	87.6	32.8%	4.97	33.0	43	10.4	31.5%	1.68	359.00	366	7.20	2.0%	0.38	18.00	43	25.00	138.9%	4.53
		Windsor St	East	R	3	7	3.6	120.0%	1.64	1.0	1	0.2	20.0%	0.19	3.00	5	1.80	60.0%	0.91	0.00	1	1.40	0.0%	1.67
		Bourke St	South	L	36	55	19.0	52.8%	2.82	3.0	0	-3.0	-300%	0.00	79.00	60	-19.20	-24.3%	2.30	0.00	0	0.00	0.0%	0.00
		Bourke St	South	T	121	95	-25.6	-21.2%	2.46	3.0	2	-1.4	-46.7%	0.92	93.00	66	-26.80	-28.8%	3.00	4.00	1	-3.00	-75.0%	1.90
		Bourke St	South	R	237	198	-39.0	-16.5%	2.64	9.0	2	-7.0	-77.8%	2.98	222.00	177	-44.60	-20.1%	3.16	11.00	4	-6.80	-61.8%	2.47
7	Blacktown Rd / Bourke St / Lennox St	Lennox St	West	L	97	90	-6.8	-7.0%	0.70	8.0	0	-7.6	-95.0%	3.71	79.00	97	18.40	23.3%	1.96	7.00	1	-6.40	-91.4%	3.28
		Lennox St	West	T	552	497	-54.8	-9.9%	2.39	31.0	38	7.0	22.6%	1.19	408.00	439	31.40	7.7%	1.53	21.00	39	17.60	83.8%	3.22
		Lennox St	West	R	6	26	20.4	340.0%	5.07	0.0	8	8.4	0.0%	4.10	5.00	29	23.80	476.0%	5.79	0.00	4	3.80	0.0%	2.76
		Bourke St	North	L	86	67	-19.4	-22.6%	2.22	6.0	2	-3.6	-60.0%	1.76	104.00	41	-63.00	-60.6%	7.40	3.00	2	-1.40	-46.7%	0.92
		Bourke St	North	T	68	56	-12.4	-18.2%	1.58	2.0	2	0.4	20.0%	0.27	95.00	94	-1.40	-1.5%	0.14	4.00	1	-3.00	-75.0%	1.90
		Bourke St	North	R	37	48	11.0	29.7%	1.69	6.0	0	-5.8	-96.7%	3.29	41.00	63	22.40	54.6%	3.10	4.00	1	-3.20	-80.0%	2.07
		Blacktown Rd	East	L	20	28	8.4	42.0%	1.71	1.0	4	3.4	340.0%	2.07	30.00	30	0.40	1.3%	0.07	2.00	6	4.20	210.0%	2.07
		Blacktown Rd	East	T	343	371	28.2	8.2%	1.49	30.0	33	2.8	9.3%	0.50	382.00	451	69.20	18.1%	3.39	36.00	41	4.80	13.3%	0.77
		Blacktown Rd	East	R	118	95	-23.2	-19.7%	2.25	6.0	2	-3.8	-63.3%	1.88	134.00	131	-3.00	-2.2%	0.26	4.00	5	1.00	25.0%	0.47
		Bourke St	South	L	2	25	23.2	1160.0 %	6.29	0.0	3	3.0	0.0%	2.45	2.00	21	19.00	950.0%	5.60	1.00	1	0.40	40.0%	0.37
		Bourke St	South	T	117	121	4.4	3.8%	0.40	2.0	4	2.4	120.0%	1.34	94.00	88	-6.40	-6.8%	0.67	1.00	5	4.20	420.0%	2.39

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		Bourke St	South	R	43	45	2.4	5.6%	0.36	2.0	0	-2.0	-200%	0.00	28.00	20	-7.80	-27.9%	1.59	2.00	0	-2.00	-100.0%	0.00
8	Inalls Ln / Drift Rd	Inalls Ln	West	T	160	120	-40.4	-25.3%	3.42	4.0	11	6.8	170.0%	2.50	88.00	94	5.60	6.4%	0.59	7.00	10	2.60	37.1%	0.90
		Inalls Ln	West	R	79	88	9.0	11.4%	0.98	1.0	6	5.4	540.0%	2.81	36.00	64	28.00	77.8%	3.96	0.00	8	8.20	0.0%	4.05
		Inalls Ln	East	L	10	15	5.2	52.0%	1.46	0.0	0	0.0	0.0%	0.00	13.00	15	2.00	15.4%	0.53	0.00	0	0.00	0.0%	0.00
		Inalls Ln	East	T	86	79	-6.6	-7.7%	0.73	2.0	10	7.6	380.0%	3.16	82.00	67	-15.00	-18.3%	1.74	2.00	20	18.00	900.0%	5.43
		Drift Rd	South	L	49	53	4.2	8.6%	0.59	5.0	7	2.4	48.0%	0.96	31.00	62	31.40	101.3%	4.59	5.00	3	-2.20	-44.0%	1.11
		Drift Rd	South	R	18	14	-3.6	-20.0%	0.89	0.0	0	0.0	0.0%	0.00	18.00	13	-4.60	-25.6%	1.16	1.00	0	-1.00	-100.0%	0.00
9	Castlereagh Rd / Inalls Ln / Southee Rd	Inalls Ln	West	L	28	14	-13.6	-48.6%	2.95	2.0	0	-1.8	-90.0%	1.72	30.00	16	-14.00	-46.7%	2.92	1.00	0	-0.80	-80.0%	1.03
		Inalls Ln	West	T	141	107	-34.4	-24.4%	3.09	3.0	10	6.6	220.0%	2.63	73.00	87	14.00	19.2%	1.57	3.00	9	6.20	206.7%	2.51
		Inalls Ln	West	R	11	12	0.8	7.3%	0.24	0.0	1	1.0	0.0%	1.41	8.00	6	-2.20	-27.5%	0.84	4.00	0	-4.00	-100.0%	0.00
		Castlereagh Rd	North	L	30	44	13.6	45.3%	2.24	1.0	1	0.4	40.0%	0.37	23.00	38	14.80	64.3%	2.68	3.00	1	-1.60	-53.3%	1.08
		Castlereagh Rd	North	T	132	115	-17.0	-12.9%	1.53	7.0	10	2.8	40.0%	0.97	125.00	99	-25.80	-20.6%	2.44	11.00	10	-0.60	-5.5%	0.18
		Castlereagh Rd	North	R	14	16	1.6	11.4%	0.42	0.0	0	0.4	0.0%	0.89	23.00	20	-3.20	-13.9%	0.69	1.00	5	4.20	420.0%	2.39
		Southee Rd	East	L	28	5	-23.0	-82.1%	5.66	5.0	0	-4.8	-96.0%	2.98	26.00	11	-15.00	-57.7%	3.49	1.00	0	-1.00	-100.0%	0.00
		Southee Rd	East	T	79	56	-22.8	-28.9%	2.77	2.0	8	6.2	310.0%	2.75	70.00	46	-24.00	-34.3%	3.15	1.00	14	12.60	1260.0%	4.66
		Southee Rd	East	R	17	45	27.6	162.4%	4.97	0.0	0	0.4	0.0%	0.89	16.00	30	14.40	90.0%	2.99	1.00	1	-0.20	-20.0%	0.21
		Castlereagh Rd	South	L	3	24	20.8	693.3%	5.68	0.0	1	0.8	0.0%	1.26	8.00	16	7.60	95.0%	2.21	0.00	1	1.40	0.0%	1.67
		Castlereagh Rd	South	T	299	268	-30.6	-10.2%	1.82	18.0	29	10.6	58.9%	2.20	233.00	293	60.40	25.9%	3.72	13.00	35	21.60	166.2%	4.43
		Castlereagh Rd	South	R	46	22	-24.4	-53.0%	4.20	2.0	2	0.2	10.0%	0.14	44.00	30	-13.80	-31.4%	2.27	3.00	3	0.00	0.0%	0.00
10	Castlereagh Rd / Drift Rd	Drift Rd	West	L	0	7	7.4	0.0%	3.85	0.0	0	0.0	0.0%	0.00	4.00	6	1.80	45.0%	0.81	0.00	0	0.00	0.0%	0.00
		Drift Rd	West	R	91	86	-4.6	-5.1%	0.49	1.0	5	4.2	420.0%	2.39	42.00	64	22.40	53.3%	3.07	0.00	9	9.40	0.0%	4.34
		Castlereagh Rd	North	T	164	130	-33.8	-20.6%	2.79	11.0	11	0.0	0.0%	0.00	159.00	118	-41.00	-25.8%	3.48	17.00	10	-6.60	-38.8%	1.78
		Castlereagh Rd	North	R	0	0	0.0	0.0%	0.00	0.0	0	0.0	0.0%	0.00	2.00	0	-2.00	-100.0%	0.00	0.00	0	0.00	0.0%	0.00
		Castlereagh Rd	South	L	45	68	22.8	50.7%	3.04	5.0	8	2.6	52.0%	1.04	32.00	47	15.00	46.9%	2.39	6.00	3	-3.40	-56.7%	1.64
		Castlereagh Rd	South	T	340	318	-22.2	-6.5%	1.22	20.0	32	12.2	61.0%	2.39	286.00	325	39.20	13.7%	2.24	16.00	39	22.60	141.3%	4.33
11	Southee Rd / Hughes Ave	Southee Rd	West	L	3	3	0.2	6.7%	0.11	1.0	0	-1.0	-100%	0.00	7.00	5	-2.20	-31.4%	0.91	0.00	0	0.00	0.0%	0.00
		Southee Rd	West	T	219	168	-50.6	-23.1%	3.64	6.0	13	7.2	120.0%	2.32	138.00	151	12.80	9.3%	1.07	9.00	14	4.60	51.1%	1.37
		Hughes Ave	North	L	5	3	-2.0	-40.0%	1.00	0.0	0	0.0	0.0%	0.00	5.00	4	-0.60	-12.0%	0.28	0.00	0	0.00	0.0%	0.00
		Hughes Ave	North	R	11	10	-0.8	-7.3%	0.25	0.0	0	0.0	0.0%	0.00	12.00	12	-0.20	-1.7%	0.06	0.00	0	0.00	0.0%	0.00
		Southee Rd	East	T	111	97	-14.2	-12.8%	1.39	7.0	9	1.8	25.7%	0.64	96.00	75	-20.80	-21.7%	2.25	3.00	14	11.40	380.0%	3.86
		Southee Rd	East	R	3	3	0.0	0.0%	0.00	0.0	0	0.0	0.0%	0.00	0.00	1	1.20	0.0%	1.55	0.00	0	0.00	0.0%	0.00
12		Southee Rd	West	L	16	7	-8.6	-53.8%	2.51	2.0	0	-2.0	-200%	0.00	13.00	12	-1.20	-9.2%	0.34	0.00	0	0.00	0.0%	0.00

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	Southee Rd / Valder Ave	Southee Rd	West	T	209	163	-45.8	-21.9%	3.36	4.0	13	9.2	230.0%	3.14	134.00	144	10.40	7.8%	0.88	9.00	14	4.60	51.1%	1.37
		Valder Ave	North	L	20	10	-9.6	-48.0%	2.46	3.0	0	-3.0	-300%	0.00	12.00	11	-1.20	-10.0%	0.36	2.00	0	-2.00	-100.0%	0.00
		Valder Ave	North	R	10	16	5.6	56.0%	1.57	3.0	3	-0.2	-6.7%	0.12	17.00	12	-5.00	-29.4%	1.31	1.00	2	1.20	120.0%	0.95
		Southee Rd	East	T	103	85	-18.2	-17.7%	1.88	4.0	6	2.2	55.0%	0.97	81.00	64	-16.80	-20.7%	1.97	2.00	12	10.00	500.0%	3.78
		Southee Rd	East	R	6	12	6.0	100.0%	2.00	2.0	0	-2.0	-200%	0.00	10.00	10	0.40	4.0%	0.13	1.00	0	-1.00	-100.0%	0.00
13	Southee Rd / Hill Ave	Southee Rd	West	L	2	2	-0.2	-10.0%	0.15	0.0	0	0.0	0.0%	0.00	4.00	1	-3.40	-85.0%	2.24	0.00	0	0.20	0.0%	0.63
		Southee Rd	West	T	231	170	-60.6	-26.2%	4.28	7.0	13	6.4	91.4%	2.00	144.00	155	11.00	7.6%	0.90	11.00	13	2.20	20.0%	0.63
		Hill Ave	North	L	3	1	-2.2	-73.3%	1.60	0.0	0	0.0	0.0%	0.00	1.00	1	0.20	20.0%	0.19	0.00	0	0.00	0.0%	0.00
		Hill Ave	North	R	1	0	-0.8	-80.0%	1.03	0.0	0	0.0	0.0%	0.00	0.00	1	1.20	0.0%	1.55	0.00	0	0.00	0.0%	0.00
		Southee Rd	East	T	106	97	-9.0	-8.5%	0.89	6.0	6	0.2	3.3%	0.08	90.00	73	-16.80	-18.7%	1.86	3.00	12	8.80	293.3%	3.23
		Southee Rd	East	R	0	1	0.8	0.0%	1.26	0.0	0	0.0	0.0%	0.00	1.00	3	2.00	200.0%	1.41	0.00	0	0.00	0.0%	0.00
14	Southee Rd / Anderson Ave	Southee Rd	West	L	8	6	-1.8	-22.5%	0.68	0.0	0	0.0	0.0%	0.00	8.00	7	-1.20	-15.0%	0.44	1.00	0	-1.00	-100.0%	0.00
		Southee Rd	West	T	234	165	-68.8	-29.4%	4.87	7.0	13	6.4	91.4%	2.00	138.00	150	11.80	8.6%	0.98	10.00	13	3.20	32.0%	0.94
		Anderson Ave	North	L	11	12	1.2	10.9%	0.35	1.0	0	-1.0	-100%	0.00	12.00	10	-1.60	-13.3%	0.48	1.00	0	-1.00	-100.0%	0.00
		Anderson Ave	North	R	10	5	-5.0	-50.0%	1.83	0.0	0	0.0	0.0%	0.00	4.00	3	-0.80	-20.0%	0.42	0.00	0	0.00	0.0%	0.00
		Southee Rd	East	T	96	93	-2.6	-2.7%	0.27	6.0	6	0.2	3.3%	0.08	89.00	72	-16.60	-18.7%	1.85	3.00	12	8.80	293.3%	3.23
		Southee Rd	East	R	9	13	3.8	42.2%	1.15	0.0	0	0.0	0.0%	0.00	11.00	11	0.40	3.6%	0.12	0.00	0	0.00	0.0%	0.00
15	Southee Rd / Londonderry Rd	Southee Rd	West	L	43	15	-27.8	-64.7%	5.15	2.0	2	0.0	0.0%	0.00	21.00	18	-2.60	-12.4%	0.59	2.00	1	-1.40	-70.0%	1.23
		Southee Rd	West	R	200	160	-40.4	-20.2%	3.01	6.0	11	4.8	80.0%	1.66	132.00	144	12.00	9.1%	1.02	9.00	13	4.00	44.4%	1.21
		Londonderry Rd	North	T	162	170	8.4	5.2%	0.65	3.0	7	3.8	126.7%	1.72	162.00	150	-12.40	-7.7%	0.99	9.00	8	-0.80	-8.9%	0.27
		Londonderry Rd	North	R	15	23	8.2	54.7%	1.88	3.0	0	-2.8	-93.3%	2.21	19.00	27	8.20	43.2%	1.71	0.00	0	0.00	0.0%	0.00
		Londonderry Rd	South	L	91	83	-7.6	-8.4%	0.81	3.0	6	3.0	100.0%	1.41	84.00	57	-27.40	-32.6%	3.27	3.00	12	8.80	293.3%	3.23
		Londonderry Rd	South	T	226	203	-22.8	-10.1%	1.56	11.0	17	6.2	56.4%	1.65	268.00	218	-49.80	-18.6%	3.19	14.00	14	-0.20	-1.4%	0.05
16	Londonderry Rd / Vines Dr	Londonderry Rd	North	L	64	60	-4.2	-6.6%	0.53	1.0	3	2.4	240.0%	1.62	68.00	61	-6.80	-10.0%	0.85	2.00	7	4.80	240.0%	2.29
		Londonderry Rd	North	T	298	270	-28.2	-9.5%	1.67	8.0	14	6.0	75.0%	1.81	226.00	232	6.40	2.8%	0.42	16.00	15	-1.40	-8.8%	0.36
		Vines Dr	East	L	14	35	20.6	147.1%	4.18	1.0	2	0.6	60.0%	0.53	5.00	10	4.80	96.0%	1.76	3.00	2	-1.20	-40.0%	0.77
		Vines Dr	East	R	25	17	-7.8	-31.2%	1.70	0.0	0	0.4	0.0%	0.89	28.00	14	-13.60	-48.6%	2.95	0.00	1	1.00	0.0%	1.41
		Londonderry Rd	South	T	292	269	-22.6	-7.7%	1.35	14.0	23	9.0	64.3%	2.09	324.00	261	-63.40	-19.6%	3.71	17.00	24	7.40	43.5%	1.63
		Londonderry Rd	South	R	66	53	-13.0	-19.7%	1.69	1.0	5	3.6	360.0%	2.15	65.00	71	6.40	9.8%	0.77	0.00	3	3.20	0.0%	2.53
17	Londonderry Rd / The Driftway	The Driftway	West	L	19	16	-2.8	-14.7%	0.67	0.0	2	1.6	0.0%	1.79	12.00	19	7.20	60.0%	1.82	0.00	1	0.60	0.0%	1.10
		The Driftway	West	T	74	51	-23.2	-31.4%	2.94	7.0	6	-0.8	-11.4%	0.31	41.00	51	9.80	23.9%	1.45	1.00	6	5.40	540.0%	2.81
		The Driftway	West	R	34	16	-18.4	-54.1%	3.69	2.0	1	-1.2	-60.0%	1.01	33.00	12	-20.60	-62.4%	4.32	3.00	1	-2.20	-73.3%	1.60
		Londonderry Rd	North	L	18	15	-2.8	-15.6%	0.69	2.0	0	-2.0	-200%	0.00	11.00	4	-6.80	-61.8%	2.47	5.00	0	-4.80	-96.0%	2.98

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		Londonderry Rd	North	T	289	273	-16.2	-5.6%	0.97	7.0	16	8.6	122.9%	2.56	219.00	233	13.80	6.3%	0.92	15.00	16	0.60	4.0%	0.15
		Londonderry Rd	North	R	3	12	9.0	300.0%	3.29	0.0	0	0.0	0.0%	0.00	4.00	10	5.60	140.0%	2.15	0.00	0	0.00	0.0%	0.00
		The Driftway	East	L	14	13	-1.0	-7.1%	0.27	0.0	5	4.6	0.0%	3.03	18.00	12	-6.20	-34.4%	1.61	0.00	4	4.00	0.0%	2.83
		The Driftway	East	T	39	26	-13.0	-33.3%	2.28	6.0	2	-4.2	-70.0%	2.13	38.00	37	-0.80	-2.1%	0.13	3.00	5	2.20	73.3%	1.09
		The Driftway	East	R	14	18	3.8	27.1%	0.95	2.0	0	-2.0	-200%	0.00	12.00	16	4.00	33.3%	1.07	0.00	1	1.20	0.0%	1.55
		Londonderry Rd	South	L	32	25	-6.8	-21.3%	1.27	2.0	3	1.4	70.0%	0.85	31.00	27	-4.00	-12.9%	0.74	2.00	4	2.40	120.0%	1.34
		Londonderry Rd	South	T	331	289	-41.6	-12.6%	2.36	13.0	26	13.2	101.5%	2.98	362.00	301	-61.40	-17.0%	3.37	17.00	26	9.20	54.1%	1.98
		Londonderry Rd	South	R	17	21	3.8	22.4%	0.87	1.0	10	8.6	860.0%	3.74	6.00	19	13.20	220.0%	3.72	0.00	9	8.60	0.0%	4.15
18	Blacktown Rd / The Driftway	Blacktown Rd	West	T	650	560	-90.2	-13.9%	3.67	40.0	39	-1.4	-3.5%	0.22	504.00	494	-9.60	-1.9%	0.43	24.00	39	14.60	60.8%	2.61
		Blacktown Rd	West	R	7	0	-7.0	-100.0%	0.00	1.0	0	-1.0	-100%	0.00	13.00	13	-0.40	-3.1%	0.11	4.00	0	-4.00	-100.0%	0.00
		Blacktown Rd	East	L	77	91	14.4	18.7%	1.57	12.0	18	5.6	46.7%	1.46	88.00	116	27.80	31.6%	2.75	4.00	21	17.20	430.0%	4.85
		Blacktown Rd	East	T	516	544	27.8	5.4%	1.21	42.0	43	1.0	2.4%	0.15	623.00	619	-4.00	-0.6%	0.16	47.00	52	5.40	11.5%	0.77
		The Driftway	South	L	7	0	-7.0	-100.0%	0.00	1.0	0	-1.0	-100%	0.00	10.00	0	-9.80	-98.0%	4.34	1.00	0	-1.00	-100.0%	0.00
		The Driftway	South	R	137	151	14.2	10.4%	1.18	14.0	26	12.0	85.7%	2.68	103.00	159	55.80	54.2%	4.88	11.00	26	15.40	140.0%	3.56
19	Blacktown Rd / Racecourse Rd	Blacktown Rd	West	L	16	27	11.0	68.8%	2.37	3.0	5	2.0	66.7%	1.00	16.00	27	10.80	67.5%	2.33	7.00	5	-2.00	-28.6%	0.82
		Blacktown Rd	West	T	769	682	-87.2	-11.3%	3.24	51.0	59	8.4	16.5%	1.13	594.00	627	33.40	5.6%	1.35	28.00	60	32.20	115.0%	4.85
		Racecourse Rd	North	L	55	50	-4.8	-8.7%	0.66	7.0	2	-4.6	-65.7%	2.12	44.00	52	7.60	17.3%	1.10	11.00	1	-10.20	-92.7%	4.20
		Racecourse Rd	North	R	12	12	-0.4	-3.3%	0.12	3.0	3	-0.4	-13.3%	0.24	9.00	10	1.00	11.1%	0.32	2.00	2	0.00	0.0%	0.00
		Blacktown Rd	East	T	580	624	44.4	7.7%	1.81	51.0	58	7.0	13.7%	0.95	702.00	725	22.60	3.2%	0.85	49.00	72	22.60	46.1%	2.91
		Blacktown Rd	East	R	78	74	-4.2	-5.4%	0.48	3.0	10	6.8	226.7%	2.69	90.00	78	-12.40	-13.8%	1.35	14.00	10	-3.80	-27.1%	1.09
20	Bells Line of Rd	Bells Line of Rd	Southbound	Mid block	1533	1,441	-91.8	-6.0%	2.38	80.5	94	13.9	17.3%	1.49	1326.50	1,332	5.30	0.4%	0.15	77.50	93	15.90	20.5%	1.72
21	Old Kurrajong Rd	Old Kurrajong Rd	Southbound	Mid block	4	16	11.6	290.0%	3.71	2.0	2	0.4	20.0%	0.27	4.50	19	14.50	322.2%	4.23	1.00	2	0.80	80.0%	0.68
22	Inalls Ln	Inalls Ln	Southbound	Mid block	209	207	-1.1	-0.5%	0.08	6.0	17	11.2	186.7%	3.29	146.00	157	11.20	7.7%	0.91	5.50	18	12.30	223.6%	3.60
23	Southee Rd	Southee Rd	Southbound	Mid block	197	171	-25.6	-13.0%	1.89	7.0	13	6.2	88.6%	1.95	166.50	156	-10.90	-6.5%	0.86	10.00	14	3.60	36.0%	1.05
24	Bells Line of Rd	Bells Line of Rd	Northbound	Mid block	683	660	-22.9	-3.4%	0.88	75.0	90	15.0	20.0%	1.65	736.50	763	26.30	3.6%	0.96	75.50	108	32.10	42.5%	3.35
25	Old Kurrajong Rd	Old Kurrajong Rd	Northbound	Mid block	96	112	16.5	17.3%	1.62	2.0	2	-0.2	-10.0%	0.15	94.00	72	-21.80	-23.2%	2.39	1.00	2	0.60	60.0%	0.53
26	Inalls Ln	Inalls Ln	Northbound	Mid block	115	133	17.8	15.5%	1.60	11.0	17	6.0	54.5%	1.60	109.50	129	19.90	18.2%	1.82	8.50	23	14.30	168.2%	3.61
27	Southee Rd	Southee Rd	Northbound	Mid block	91	100	9.5	10.5%	0.97	6.0	9	2.8	46.7%	1.03	88.50	76	-12.30	-13.9%	1.36	6.00	14	8.40	140.0%	2.63

PM calibration results

S no.	Name / Description	Approach Road	Approach Direction	Turn	03:30 PM- 04:30 PM										04:30 PM- 05:30 PM									
					Light Vehicles					Heavy Vehicles					Light Vehicles					Heavy Vehicles				
					Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH
1	Bells Line of Rd / Grose Vale Rd / Terrace Rd	Bells of Line Rd	West	L	56.00	36	-20.40	-36.4%	3.01	2.00	2	0.00	0.0%	0.00	46.00	37	-9.40	-20.4%	1.46	0.00	1	1.20	0.0%	1.55
		Bells of Line Rd	West	T	437.00	434	-3.00	-0.7%	0.14	28.00	34	5.60	20.0%	1.01	327.00	383	56.00	17.1%	2.97	24.00	32	7.80	32.5%	1.48
		Bells of Line Rd	West	R	83.00	106	23.40	28.2%	2.40	6.00	6	0.40	6.7%	0.16	75.00	95	20.20	26.9%	2.19	1.00	5	4.20	420.0%	2.39
		Terrace Rd	North	L	139.00	130	-9.40	-6.8%	0.81	6.00	8	1.80	30.0%	0.69	133.00	145	11.80	8.9%	1.00	3.00	5	2.20	73.3%	1.09
		Terrace Rd	North	T	133.00	121	-12.40	-9.3%	1.10	3.00	3	-0.40	-13.3%	0.24	137.00	135	-2.00	-1.5%	0.17	2.00	3	1.40	70.0%	0.85
		Terrace Rd	North	R	59.00	71	12.00	20.3%	1.49	3.00	4	0.80	26.7%	0.43	71.00	66	-5.20	-7.3%	0.63	6.00	4	-2.00	-33.3%	0.89
		Bells of Line Rd	East	L	512.00	483	-28.80	-5.6%	1.29	13.00	18	4.60	35.4%	1.18	440.00	526	86.40	19.6%	3.93	12.00	23	10.60	88.3%	2.55
		Bells of Line Rd	East	T	595.00	562	-33.20	-5.6%	1.38	41.00	39	-2.20	-5.4%	0.35	537.00	593	56.00	10.4%	2.36	19.00	39	20.20	106.3%	3.74
		Bells of Line Rd	East	R	229.00	216	-13.00	-5.7%	0.87	7.00	6	-1.40	-20.0%	0.56	207.00	229	21.60	10.4%	1.46	6.00	8	1.80	30.0%	0.69
		Grose Vale Rd	South	L	65.00	76	10.80	16.6%	1.29	3.00	1	-2.00	-66.7%	1.41	71.00	78	6.80	9.6%	0.79	0.00	2	1.60	0.0%	1.79
		Grose Vale Rd	South	T	83.00	89	5.80	7.0%	0.63	7.00	4	-3.00	-42.9%	1.28	98.00	92	-5.80	-5.9%	0.59	2.00	5	2.80	140.0%	1.52
		Grose Vale Rd	South	R	395.00	341	-54.00	-13.7%	2.81	33.00	16	-17.00	-51.5%	3.43	384.00	358	-25.80	-6.7%	1.34	12.00	18	6.00	50.0%	1.55
3	Kurrajong Rd / Old Kurrajong Rd / Bells Line Of Rd	Bells of Line Rd	West	L	41.00	23	-18.40	-44.9%	3.26	1.00	0	-1.00	-100.0%	0.00	28.00	12	-15.80	-56.4%	3.52	1.00	1	-0.40	-40.0%	0.45
		Bells of Line Rd	West	T	690.00	667	-23.40	-3.4%	0.90	55.00	46	-9.20	-16.7%	1.30	638.00	669	31.00	4.9%	1.21	30.00	45	14.60	48.7%	2.39
		Bells of Line Rd	West	R	206.00	189	-16.80	-8.2%	1.20	8.00	11	3.00	37.5%	0.97	194.00	197	2.80	1.4%	0.20	12.00	10	-2.20	-18.3%	0.67
		Old Kurrajong Rd	North	L	3.00	10	7.40	246.7%	2.86	1.00	0	-1.00	-100.0%	0.00	1.00	1	0.20	20.0%	0.19	0.00	0	0.00	0.0%	0.00
		Old Kurrajong Rd	North	T	0.00	10	10.40	0.0%	4.56	0.00	1	1.40	0.0%	1.67	0.00	4	4.00	0.0%	2.83	0.00	1	0.60	0.0%	1.10
		Old Kurrajong Rd	North	R	2.00	1	-1.40	-70.0%	1.23	0.00	1	1.20	0.0%	1.55	1.00	7	5.60	560.0%	2.87	0.00	1	1.00	0.0%	1.41
		Bells of Line Rd	East	L	3.00	0	-2.80	-93.3%	2.21	0.00	0	0.00	0.0%	0.00	1.00	0	-0.80	-80.0%	1.03	0.00	0	0.20	0.0%	0.63
		Bells of Line Rd	East	T	1072.00	879	-193.40	-18.0%	6.19	48.00	41	-7.00	-14.6%	1.05	780.00	798	17.60	2.3%	0.63	22.00	42	19.60	89.1%	3.48
		Bells of Line Rd	East	R	1.00	4	3.20	320.0%	1.98	0.00	0	0.00	0.0%	0.00	1.00	3	1.60	160.0%	1.19	0.00	0	0.00	0.0%	0.00
		Old Kurrajong Rd	South	L	440.00	530	89.60	20.4%	4.07	17.00	22	5.20	30.6%	1.17	494.00	674	180.20	36.5%	7.46	16.00	27	11.40	71.3%	2.45
		Old Kurrajong Rd	South	T	1.00	0	-0.80	-80.0%	1.03	0.00	0	0.00	0.0%	0.00	0.00	0	0.40	0.0%	0.89	0.00	0	0.00	0.0%	0.00
		Old Kurrajong Rd	South	R	1.00	0	-1.00	-100.0%	0.00	0.00	0	0.00	0.0%	0.00	0.00	0	0.00	0.0%	0.00	0.00	0	0.00	0.0%	0.00
4	March St / Bosworth St	March St	West	L	105.00	88	-17.00	-16.2%	1.73	2.00	3	1.20	60.0%	0.74	79.00	88	9.00	11.4%	0.98	0.00	4	4.00	0.0%	2.83
		March St	West	T	356.00	321	-34.80	-9.8%	1.89	30.00	25	-5.00	-16.7%	0.95	337.00	345	8.40	2.5%	0.45	13.00	21	8.40	64.6%	2.03
		March St	West	R	219.00	261	42.20	19.3%	2.72	20.00	17	-2.60	-13.0%	0.60	224.00	242	18.20	8.1%	1.19	14.00	19	5.00	35.7%	1.23
		Bosworth St	North	L	23.00	16	-7.20	-31.3%	1.63	0.00	0	0.00	0.0%	0.00	19.00	20	1.00	5.3%	0.23	0.00	0	0.00	0.0%	0.00
		Bosworth St	North	T	198.00	202	3.80	1.9%	0.27	3.00	4	1.00	33.3%	0.53	202.00	239	36.80	18.2%	2.48	2.00	6	3.80	190.0%	1.92
		Bosworth St	North	R	280.00	331	51.00	18.2%	2.92	6.00	2	-3.80	-63.3%	1.88	278.00	180	-97.60	-35.1%	6.45	5.00	3	-2.40	-48.0%	1.23
		March St	East	L	28.00	50	21.60	77.1%	3.47	1.00	3	2.40	240.0%	1.62	41.00	42	1.00	2.4%	0.16	2.00	3	1.20	60.0%	0.74
		March St	East	T	524.00	517	-7.20	-1.4%	0.32	16.00	28	12.40	77.5%	2.63	362.00	466	103.60	28.6%	5.09	7.00	31	23.80	340.0%	5.47

S no.	Name / Description	Approach Road	Approach Direction	Turn	03:30 PM- 04:30 PM										04:30 PM- 05:30 PM									
					Light Vehicles					Heavy Vehicles					Light Vehicles					Heavy Vehicles				
					Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH
		Bosworth St	South	L	308.00	194	-114.40	-37.1%	7.22	26.00	20	-6.00	-23.1%	1.25	263.00	205	-58.20	-22.1%	3.81	14.00	15	1.00	7.1%	0.26
		Bosworth St	South	T	136.00	150	14.00	10.3%	1.17	1.00	6	4.60	460.0%	2.53	132.00	174	41.80	31.7%	3.38	6.00	3	-3.00	-50.0%	1.41
		Bosworth St	South	R	38.00	73	35.20	92.6%	4.72	3.00	0	-2.80	-93.3%	2.21	36.00	88	51.60	143.3%	6.56	1.00	1	0.40	40.0%	0.37
5	Castlereagh Rd / Lennox St / Bosworth St	Bosworth St	North	L	204.00	227	22.80	11.2%	1.55	11.00	14	3.20	29.1%	0.90	177.00	233	55.60	31.4%	3.89	7.00	15	8.20	117.1%	2.46
		Bosworth St	North	T	242.00	286	43.80	18.1%	2.70	12.00	11	-1.40	-11.7%	0.42	287.00	291	3.60	1.3%	0.21	10.00	13	2.60	26.0%	0.77
		Lennox St	East	L	191.00	254	63.20	33.1%	4.24	7.00	20	13.40	191.4%	3.62	269.00	346	76.60	28.5%	4.37	11.00	23	12.40	112.7%	2.99
		Lennox St	East	R	301.00	278	-23.20	-7.7%	1.36	21.00	14	-6.80	-32.4%	1.62	238.00	277	39.40	16.6%	2.45	17.00	14	-3.40	-20.0%	0.87
		Castlereagh	South	T	181.00	143	-38.40	-21.2%	3.02	10.00	12	1.80	18.0%	0.55	195.00	186	-8.80	-4.5%	0.64	3.00	6	2.80	93.3%	1.33
		Castlereagh	South	R	93.00	148	55.40	59.6%	5.04	3.00	10	7.40	246.7%	2.86	100.00	142	42.00	42.0%	3.82	5.00	9	3.60	72.0%	1.38
6	Bourke St / Windsor St	Windsor St	West	L	5.00	8	3.00	60.0%	1.18	5.00	0	-5.00	-100.0%	0.00	4.00	9	5.40	135.0%	2.09	0.00	0	0.40	0.0%	0.89
		Windsor St	West	T	386.00	339	-46.60	-12.1%	2.45	33.00	18	-14.60	-44.2%	2.88	370.00	420	49.60	13.4%	2.50	17.00	18	1.00	5.9%	0.24
		Windsor St	West	R	23.00	27	3.60	15.7%	0.72	4.00	0	-3.80	-95.0%	2.62	22.00	27	4.60	20.9%	0.93	2.00	1	-0.80	-40.0%	0.63
		Bourke St	North	L	7.00	9	1.80	25.7%	0.64	0.00	0	0.00	0.0%	0.00	14.00	9	-4.80	-34.3%	1.41	0.00	1	0.80	0.0%	1.26
		Bourke St	North	T	239.00	203	-36.40	-15.2%	2.45	5.00	0	-4.60	-92.0%	2.80	173.00	172	-0.60	-0.3%	0.05	1.00	1	0.40	40.0%	0.37
		Bourke St	North	R	19.00	16	-2.60	-13.7%	0.62	0.00	2	1.80	0.0%	1.90	18.00	19	1.20	6.7%	0.28	0.00	3	3.00	0.0%	2.45
		Windsor St	East	L	276.00	331	55.40	20.1%	3.18	9.00	25	16.00	177.8%	3.88	296.00	346	49.60	16.8%	2.77	11.00	25	13.80	125.5%	3.26
		Windsor St	East	T	531.00	478	-53.00	-10.0%	2.36	20.00	10	-10.00	-50.0%	2.58	537.00	510	-27.20	-5.1%	1.19	14.00	13	-1.20	-8.6%	0.33
		Windsor St	East	R	6.00	2	-4.40	-73.3%	2.26	0.00	0	0.00	0.0%	0.00	1.00	1	-0.20	-20.0%	0.21	0.00	0	0.00	0.0%	0.00
		Bourke St	South	L	50.00	29	-20.80	-41.6%	3.31	1.00	0	-0.80	-80.0%	1.03	62.00	32	-30.00	-48.4%	4.38	1.00	0	-0.80	-80.0%	1.03
		Bourke St	South	T	71.00	54	-17.20	-24.2%	2.18	5.00	0	-4.80	-96.0%	2.98	78.00	45	-33.00	-42.3%	4.21	4.00	1	-3.40	-85.0%	2.24
		Bourke St	South	R	171.00	176	5.40	3.2%	0.41	2.00	7	4.80	240.0%	2.29	187.00	164	-23.40	-12.5%	1.77	3.00	4	1.00	33.3%	0.53
7	Blacktown Rd / Bourke St / Lennox St	Lennox St	West	L	47.00	68	21.40	45.5%	2.82	0.00	1	1.00	0.0%	1.41	58.00	81	22.60	39.0%	2.71	0.00	1	1.40	0.0%	1.67
		Lennox St	West	T	379.00	412	32.80	8.7%	1.65	18.00	24	5.60	31.1%	1.23	413.00	493	80.20	19.4%	3.77	15.00	24	9.20	61.3%	2.08
		Lennox St	West	R	0.00	7	7.40	0.0%	3.85	0.00	0	0.00	0.0%	0.00	6.00	10	3.80	63.3%	1.35	0.00	1	0.60	0.0%	1.10
		Bourke St	North	L	130.00	119	-10.60	-8.2%	0.95	6.00	1	-5.40	-90.0%	2.97	120.00	87	-33.00	-27.5%	3.24	2.00	0	-1.80	-90.0%	1.72
		Bourke St	North	T	156.00	155	-1.00	-0.6%	0.08	3.00	1	-2.40	-80.0%	1.79	141.00	139	-2.00	-1.4%	0.17	2.00	1	-1.00	-50.0%	0.82
		Bourke St	North	R	75.00	97	22.00	29.3%	2.37	6.00	4	-1.80	-30.0%	0.80	97.00	96	-1.40	-1.4%	0.14	8.00	5	-3.20	-40.0%	1.26
		Blacktown Rd	East	L	32.00	26	-6.20	-19.4%	1.15	1.00	0	-0.80	-80.0%	1.03	26.00	31	4.60	17.7%	0.86	2.00	1	-1.40	-70.0%	1.23
		Blacktown Rd	East	T	457.00	428	-28.80	-6.3%	1.37	33.00	28	-4.80	-14.5%	0.87	446.00	432	-14.20	-3.2%	0.68	24.00	27	2.80	11.7%	0.56
		Blacktown Rd	East	R	89.00	50	-39.00	-43.8%	4.68	7.00	2	-4.80	-68.6%	2.24	97.00	41	-55.60	-57.3%	6.68	8.00	0	-7.60	-95.0%	3.71
		Bourke St	South	L	4.00	6	2.40	60.0%	1.05	0.00	2	1.80	0.0%	1.90	2.00	13	11.20	560.0%	4.06	0.00	4	4.00	0.0%	2.83
		Bourke St	South	T	87.00	84	-2.60	-3.0%	0.28	1.00	4	3.00	300.0%	1.90	63.00	66	3.20	5.1%	0.40	0.00	4	3.60	0.0%	2.68
		Bourke St	South	R	19.00	19	0.20	1.1%	0.05	1.00	0	-0.80	-80.0%	1.03	22.00	15	-6.60	-30.0%	1.53	2.00	1	-1.20	-60.0%	1.01
8	Inalls Ln / Drift Rd	Inalls Ln	West	T	89.00	62	-27.00	-30.3%	3.11	4.00	1	-3.20	-80.0%	2.07	78.00	57	-20.60	-26.4%	2.50	4.00	2	-2.40	-60.0%	1.43
		Inalls Ln	West	R	40.00	51	11.00	27.5%	1.63	0.00	6	6.00	0.0%	3.46	43.00	53	10.40	24.2%	1.50	1.00	3	2.40	240.0%	1.62

S no.	Name / Description	Approach Road	Approach Direction	Turn	03:30 PM- 04:30 PM										04:30 PM- 05:30 PM									
					Light Vehicles					Heavy Vehicles					Light Vehicles					Heavy Vehicles				
					Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH
		Inalls Ln	East	L	17.00	19	2.20	12.9%	0.52	0.00	0	0.00	0.0%	0.00	22.00	31	8.60	39.1%	1.68	1.00	0	-1.00	-100.0%	0.00
		Inalls Ln	East	T	174.00	203	28.60	16.4%	2.08	5.00	5	0.00	0.0%	0.00	248.00	286	37.60	15.2%	2.30	10.00	9	-0.60	-6.0%	0.19
		Drift Rd	South	L	76.00	79	3.20	4.2%	0.36	3.00	5	2.40	80.0%	1.17	56.00	47	-9.20	-16.4%	1.28	2.00	4	1.60	80.0%	0.96
		Drift Rd	South	R	9.00	14	5.20	57.8%	1.53	0.00	0	0.00	0.0%	0.00	20.00	16	-4.00	-20.0%	0.94	1.00	0	-1.00	-100.0%	0.00
9	Castlereagh Rd / Inalls Ln / Southee Rd	Inalls Ln	West	L	21.00	17	-3.80	-18.1%	0.87	0.00	0	0.00	0.0%	0.00	22.00	18	-4.00	-18.2%	0.89	1.00	0	-1.00	-100.0%	0.00
		Inalls Ln	West	T	80.00	59	-21.40	-26.8%	2.57	3.00	1	-2.20	-73.3%	1.60	71.00	55	-15.60	-22.0%	1.96	5.00	2	-3.40	-68.0%	1.87
		Inalls Ln	West	R	2.00	0	-2.00	-100.0%	0.00	2.00	0	-2.00	-100.0%	0.00	6.00	0	-6.00	-100.0%	0.00	0.00	0	0.00	0.0%	0.00
		Castlereagh Rd	North	L	22.00	55	33.00	150.0%	5.32	1.00	3	1.80	180.0%	1.31	25.00	58	32.80	131.2%	5.10	2.00	2	-0.40	-20.0%	0.30
		Castlereagh Rd	North	T	270.00	298	27.80	10.3%	1.65	17.00	11	-6.00	-35.3%	1.60	283.00	303	19.80	7.0%	1.16	14.00	17	2.60	18.6%	0.66
		Castlereagh Rd	North	R	60.00	94	34.20	57.0%	3.89	2.00	2	-0.20	-10.0%	0.15	133.00	183	49.60	37.3%	3.95	3.00	5	2.40	80.0%	1.17
		Southee Rd	East	L	44.00	15	-29.00	-65.9%	5.34	0.00	2	1.80	0.0%	1.90	41.00	25	-16.40	-40.0%	2.86	0.00	1	1.00	0.0%	1.41
		Southee Rd	East	T	123.00	117	-6.00	-4.9%	0.55	2.00	3	0.60	30.0%	0.40	131.00	117	-14.20	-10.8%	1.28	6.00	4	-2.20	-36.7%	0.99
		Southee Rd	East	R	14.00	42	27.80	198.6%	5.26	2.00	1	-1.00	-50.0%	0.82	16.00	52	36.40	227.5%	6.22	1.00	2	0.60	60.0%	0.53
		Castlereagh Rd	South	L	13.00	12	-1.00	-7.7%	0.28	0.00	1	0.60	0.0%	1.10	9.00	16	7.20	80.0%	2.03	2.00	0	-1.80	-90.0%	1.72
		Castlereagh Rd	South	T	190.00	251	61.40	32.3%	4.13	10.00	20	10.00	100.0%	2.58	209.00	264	55.40	26.5%	3.60	11.00	14	3.40	30.9%	0.95
		Castlereagh Rd	South	R	26.00	8	-17.60	-67.7%	4.24	0.00	0	0.00	0.0%	0.00	24.00	8	-16.00	-66.7%	4.00	2.00	0	-2.00	-100.0%	0.00
10	Castlereagh Rd / Drift Rd	Drift Rd	West	L	3.00	0	-3.00	-100.0%	0.00	0.00	0	0.00	0.0%	0.00	5.00	0	-5.00	-100.0%	0.00	0.00	0	0.00	0.0%	0.00
		Drift Rd	West	R	37.00	37	0.20	0.5%	0.03	0.00	6	5.80	0.0%	3.41	41.00	36	-4.80	-11.7%	0.77	1.00	4	2.60	260.0%	1.71
		Castlereagh Rd	North	T	308.00	313	4.60	1.5%	0.26	19.00	13	-6.40	-33.7%	1.61	322.00	328	5.80	1.8%	0.32	14.00	18	3.60	25.7%	0.91
		Castlereagh Rd	North	R	2.00	0	-2.00	-100.0%	0.00	0.00	0	0.00	0.0%	0.00	4.00	0	-4.00	-100.0%	0.00	0.00	0	0.00	0.0%	0.00
		Castlereagh Rd	South	L	80.00	63	-17.40	-21.8%	2.06	4.00	5	1.40	35.0%	0.65	61.00	37	-23.60	-38.7%	3.36	2.00	3	1.40	70.0%	0.85
		Castlereagh Rd	South	T	221.00	275	53.80	24.3%	3.42	10.00	20	10.20	102.0%	2.62	238.00	289	50.80	21.3%	3.13	15.00	15	-0.20	-1.3%	0.05
11	Southee Rd / Hughes Ave	Southee Rd	West	L	10.00	9	-1.40	-14.0%	0.46	0.00	0	0.40	0.0%	0.89	8.00	7	-0.60	-7.5%	0.22	1.00	1	-0.20	-20.0%	0.21
		Southee Rd	West	T	118.00	113	-5.00	-4.2%	0.47	4.00	3	-0.80	-20.0%	0.42	110.00	114	4.00	3.6%	0.38	7.00	2	-4.60	-65.7%	2.12
		Hughes Ave	North	L	2.00	0	-2.00	-100.0%	0.00	0.00	0	0.00	0.0%	0.00	1.00	0	-0.80	-80.0%	1.03	1.00	0	-1.00	-100.0%	0.00
		Hughes Ave	North	R	2.00	6	4.00	200.0%	2.00	0.00	0	0.00	0.0%	0.00	2.00	3	1.00	50.0%	0.63	0.00	0	0.00	0.0%	0.00
		Southee Rd	East	T	169.00	169	-0.40	-0.2%	0.03	4.00	5	1.40	35.0%	0.65	195.00	190	-4.80	-2.5%	0.35	7.00	6	-0.60	-8.6%	0.23
		Southee Rd	East	R	3.00	3	0.40	13.3%	0.22	0.00	0	0.00	0.0%	0.00	5.00	5	0.40	8.0%	0.18	0.00	0	0.00	0.0%	0.00
12	Southee Rd / Valder Ave	Southee Rd	West	L	8.00	14	5.80	72.5%	1.76	1.00	0	-0.80	-80.0%	1.03	16.00	15	-1.00	-6.3%	0.25	1.00	1	-0.20	-20.0%	0.21
		Southee Rd	West	T	113.00	98	-15.00	-13.3%	1.46	3.00	3	0.00	0.0%	0.00	89.00	100	11.40	12.8%	1.17	7.00	2	-5.40	-77.1%	2.60
		Valder Ave	North	L	5.00	5	0.00	0.0%	0.00	4.00	5	1.40	35.0%	0.65	12.00	7	-5.20	-43.3%	1.70	1.00	4	2.60	260.0%	1.71

S no.	Name / Description	Approach Road	Approach Direction	Turn	03:30 PM- 04:30 PM										04:30 PM- 05:30 PM									
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					Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH
		Valder Ave	North	R	12.00	13	1.00	8.3%	0.28	1.00	1	0.00	0.0%	0.00	7.00	15	8.20	117.1%	2.46	1.00	1	0.20	20.0%	0.19
		Southee Rd	East	T	166.00	160	-6.20	-3.7%	0.49	4.00	4	0.40	10.0%	0.20	193.00	180	-12.60	-6.5%	0.92	6.00	5	-0.60	-10.0%	0.25
		Southee Rd	East	R	13.00	15	1.80	13.8%	0.48	2.00	2	-0.40	-20.0%	0.30	19.00	23	4.00	21.1%	0.87	3.00	2	-1.00	-33.3%	0.63
13	Southee Rd / Hill Ave	Southee Rd	West	L	3.00	1	-2.20	-73.3%	1.60	0.00	0	0.00	0.0%	0.00	4.00	1	-2.80	-70.0%	1.74	0.00	0	0.00	0.0%	0.00
		Southee Rd	West	T	115.00	102	-12.80	-11.1%	1.23	7.00	8	1.40	20.0%	0.50	95.00	106	11.40	12.0%	1.14	8.00	5	-2.80	-35.0%	1.09
		Hill Ave	North	L	1.00	1	0.20	20.0%	0.19	0.00	0	0.00	0.0%	0.00	3.00	1	-1.80	-60.0%	1.24	0.00	0	0.00	0.0%	0.00
		Hill Ave	North	R	1.00	2	1.40	140.0%	1.07	0.00	0	0.00	0.0%	0.00	2.00	2	-0.40	-20.0%	0.30	1.00	0	-1.00	-100.0%	0.00
		Southee Rd	East	T	182.00	173	-8.60	-4.7%	0.65	6.00	6	-0.20	-3.3%	0.08	213.00	201	-12.20	-5.7%	0.85	8.00	7	-0.60	-7.5%	0.22
		Southee Rd	East	R	0.00	1	1.00	0.0%	1.41	0.00	0	0.00	0.0%	0.00	2.00	2	0.20	10.0%	0.14	0.00	0	0.00	0.0%	0.00
14	Southee Rd / Anderson Ave	Southee Rd	West	L	12.00	10	-2.40	-20.0%	0.73	0.00	0	0.00	0.0%	0.00	10.00	10	-0.20	-2.0%	0.06	0.00	0	0.00	0.0%	0.00
		Southee Rd	West	T	107.00	94	-13.40	-12.5%	1.34	7.00	8	1.40	20.0%	0.50	88.00	98	9.60	10.9%	1.00	8.00	5	-3.00	-37.5%	1.18
		Anderson Ave	North	L	7.00	11	4.40	62.9%	1.45	1.00	1	-0.40	-40.0%	0.45	12.00	10	-2.40	-20.0%	0.73	1.00	1	-0.40	-40.0%	0.45
		Anderson Ave	North	R	5.00	7	2.20	44.0%	0.89	0.00	0	0.00	0.0%	0.00	14.00	11	-3.00	-21.4%	0.85	0.00	0	0.00	0.0%	0.00
		Southee Rd	East	T	179.00	168	-11.00	-6.1%	0.84	6.00	6	-0.20	-3.3%	0.08	199.00	191	-7.60	-3.8%	0.54	7.00	7	0.40	5.7%	0.15
		Southee Rd	East	R	6.00	11	5.00	83.3%	1.71	0.00	0	0.00	0.0%	0.00	22.00	23	1.40	6.4%	0.29	0.00	0	0.00	0.0%	0.00
15	Southee Rd / Londonderry Rd	Southee Rd	West	L	21.00	14	-7.20	-34.3%	1.73	2.00	0	-2.00	-100.0%	0.00	18.00	16	-2.40	-13.3%	0.59	0.00	0	0.00	0.0%	0.00
		Southee Rd	West	R	93.00	90	-2.80	-3.0%	0.29	6.00	9	3.00	50.0%	1.10	84.00	93	8.60	10.2%	0.92	9.00	6	-3.20	-35.6%	1.18
		Londonderry Rd	North	T	299.00	250	-49.40	-16.5%	2.98	11.00	7	-4.00	-36.4%	1.33	285.00	262	-22.80	-8.0%	1.38	5.00	12	6.60	132.0%	2.29
		Londonderry Rd	North	R	39.00	54	14.80	37.9%	2.17	0.00	1	0.80	0.0%	1.26	54.00	75	20.80	38.5%	2.59	0.00	1	1.20	0.0%	1.55
		Londonderry Rd	South	L	148.00	126	-22.00	-14.9%	1.88	6.00	5	-0.80	-13.3%	0.34	174.00	141	-33.40	-19.2%	2.66	7.00	6	-1.00	-14.3%	0.39
		Londonderry Rd	South	T	237.00	210	-26.60	-11.2%	1.78	5.00	8	3.40	68.0%	1.31	218.00	204	-14.40	-6.6%	0.99	6.00	5	-1.20	-20.0%	0.52
16	Londonderry Rd / Vines Dr	Londonderry Rd	North	L	17.00	15	-2.20	-12.9%	0.55	0.00	2	2.00	0.0%	2.00	21.00	17	-4.00	-19.0%	0.92	1.00	2	0.60	60.0%	0.53
		Londonderry Rd	North	T	374.00	325	-48.60	-13.0%	2.60	18.00	14	-4.00	-22.2%	1.00	348.00	338	-10.20	-2.9%	0.55	13.00	16	2.80	21.5%	0.74
		Vines Dr	East	L	61.00	80	19.20	31.5%	2.29	0.00	2	1.80	0.0%	1.90	58.00	91	33.00	56.9%	3.82	0.00	1	0.80	0.0%	1.26
		Vines Dr	East	R	48.00	34	-13.60	-28.3%	2.12	0.00	1	1.40	0.0%	1.67	60.00	30	-30.00	-50.0%	4.47	0.00	1	0.60	0.0%	1.10
		Londonderry Rd	South	T	336.00	302	-33.80	-10.1%	1.89	11.00	12	1.20	10.9%	0.35	330.00	314	-15.80	-4.8%	0.88	13.00	10	-2.80	-21.5%	0.82
		Londonderry Rd	South	R	9.00	7	-1.80	-20.0%	0.63	2.00	2	-0.40	-20.0%	0.30	4.00	6	2.00	50.0%	0.89	0.00	1	1.40	0.0%	1.67
17	Londonderry Rd / The Driftway	The Driftway	West	L	9.00	0	-9.00	-100.0%	0.00	0.00	0	0.00	0.0%	0.00	4.00	0	-3.80	-95.0%	2.62	0.00	0	0.00	0.0%	0.00
		The Driftway	West	T	48.00	35	-13.40	-27.9%	2.09	5.00	3	-2.00	-40.0%	1.00	49.00	40	-8.80	-18.0%	1.32	2.00	5	3.40	170.0%	1.77
		The Driftway	West	R	22.00	13	-9.20	-41.8%	2.21	0.00	0	0.00	0.0%	0.00	23.00	8	-14.60	-63.5%	3.68	0.00	0	0.00	0.0%	0.00
		Londonderry Rd	North	L	11.00	5	-6.40	-58.2%	2.29	0.00	0	0.40	0.0%	0.89	13.00	5	-7.80	-60.0%	2.59	0.00	0	0.00	0.0%	0.00
		Londonderry Rd	North	T	394.00	376	-17.80	-4.5%	0.91	18.00	15	-2.80	-15.6%	0.69	388.00	413	25.00	6.4%	1.25	13.00	16	3.00	23.1%	0.79
		Londonderry Rd	North	R	16.00	19	2.60	16.3%	0.63	0.00	0	0.00	0.0%	0.00	11.00	14	3.40	30.9%	0.95	0.00	0	0.20	0.0%	0.63
		The Driftway	East	L	17.00	12	-4.80	-28.2%	1.26	3.00	1	-1.60	-53.3%	1.08	16.00	15	-0.80	-5.0%	0.20	3.00	1	-2.00	-66.7%	1.41

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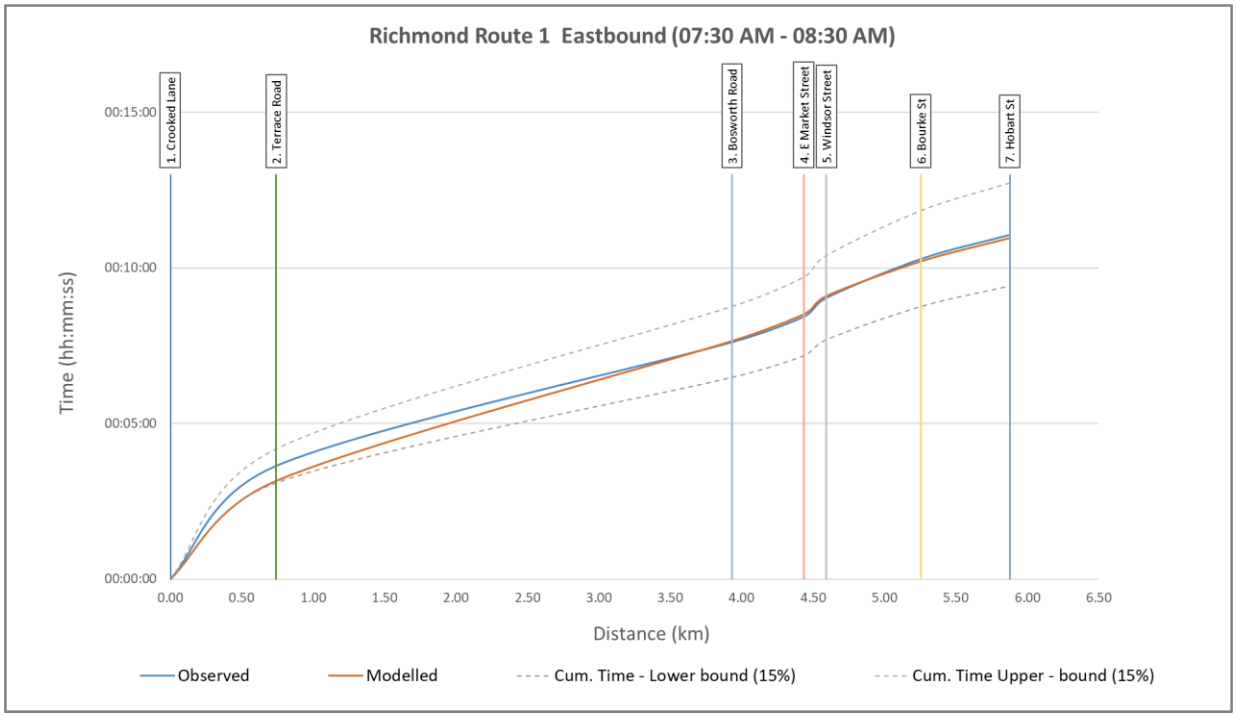
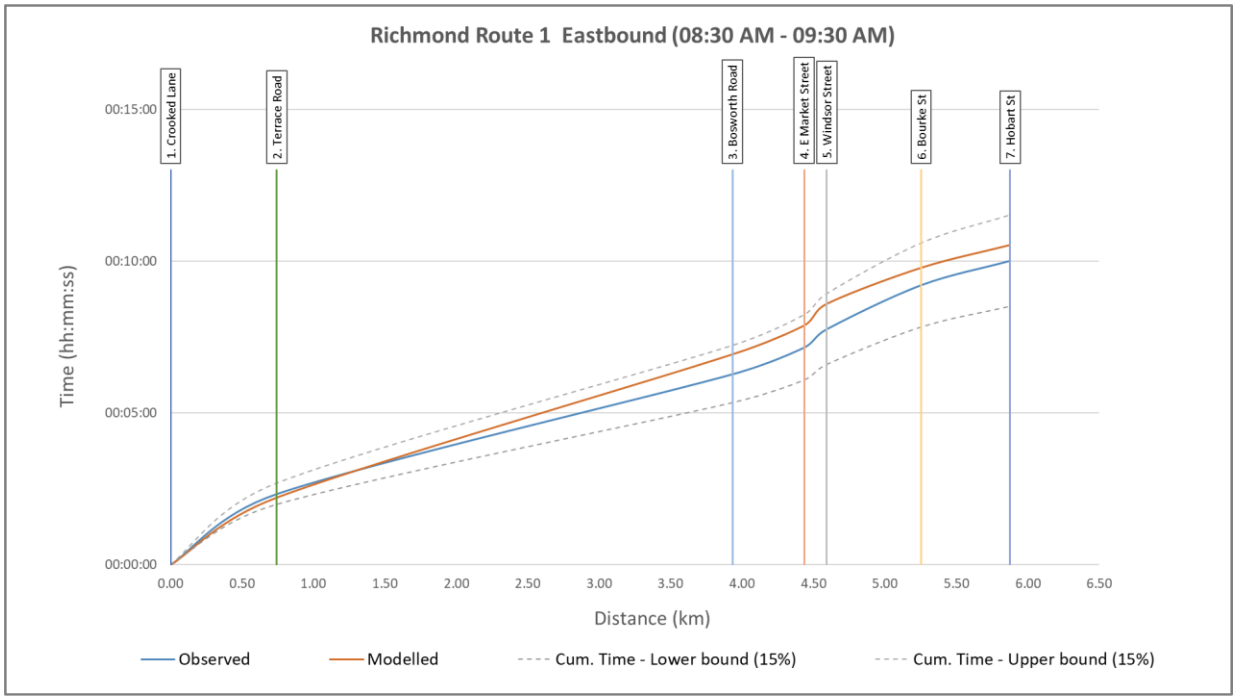
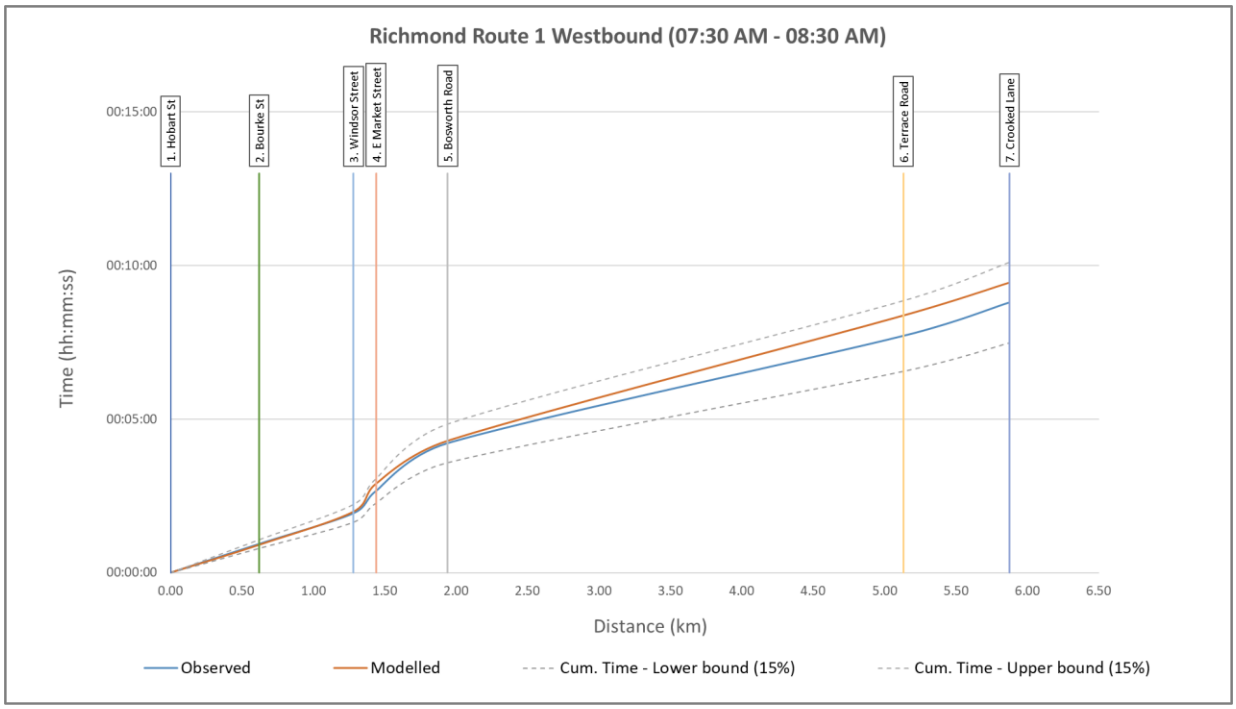
					Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH	Observed Count	Modelled Count	Δ	% Δ	GEH
		The Driftway	East	T	82.00	120	38.20	46.6%	3.80	6.00	14	8.00	133.3%	2.53	105.00	133	28.20	26.9%	2.58	6.00	16	9.60	160.0%	2.92
		The Driftway	East	R	5.00	5	0.20	4.0%	0.09	1.00	1	0.40	40.0%	0.37	14.00	4	-10.00	-71.4%	3.33	0.00	1	1.40	0.0%	1.67
		Londonderry Rd	South	L	76.00	103	27.00	35.5%	2.85	3.00	3	0.40	13.3%	0.22	57.00	72	15.40	27.0%	1.91	4.00	5	1.00	25.0%	0.47
		Londonderry Rd	South	T	323.00	309	-14.00	-4.3%	0.79	12.00	13	0.80	6.7%	0.23	313.00	316	2.80	0.9%	0.16	13.00	10	-3.00	-23.1%	0.88
		Londonderry Rd	South	R	14.00	15	1.40	10.0%	0.37	2.00	0	-1.80	-90.0%	1.72	12.00	15	2.60	21.7%	0.71	0.00	0	0.40	0.0%	0.89
18	Blacktown Rd / The Driftway	Blacktown Rd	West	T	554.00	519	-34.80	-6.3%	1.50	27.00	23	-3.80	-14.1%	0.76	481.00	595	113.80	23.7%	4.91	16.00	24	7.80	48.8%	1.75
		Blacktown Rd	West	R	8.00	0	-8.00	-100.0%	0.00	0.00	0	0.00	0.0%	0.00	11.00	0	-11.00	-100.0%	0.00	0.00	0	0.00	0.0%	0.00
		Blacktown Rd	East	L	145.00	177	31.60	21.8%	2.49	18.00	22	4.00	22.2%	0.89	162.00	171	9.20	5.7%	0.71	13.00	24	11.40	87.7%	2.64
		Blacktown Rd	East	T	557.00	507	-50.40	-9.0%	2.19	44.00	31	-13.40	-30.5%	2.19	523.00	501	-22.20	-4.2%	0.98	32.00	28	-4.20	-13.1%	0.77
		The Driftway	South	L	9.00	0	-9.00	-100.0%	0.00	0.00	0	0.00	0.0%	0.00	6.00	0	-6.00	-100.0%	0.00	1.00	0	-1.00	-100.0%	0.00
		The Driftway	South	R	107.00	87	-20.00	-18.7%	2.03	10.00	16	5.80	58.0%	1.61	86.00	97	11.00	12.8%	1.15	4.00	16	12.00	300.0%	3.79
19	Blacktown Rd / Racecourse Rd	Blacktown Rd	West	L	12.00	20	8.00	66.7%	2.00	3.00	0	-3.00	-100.0%	0.00	6.00	21	15.40	256.7%	4.16	0.00	0	0.20	0.0%	0.63
		Blacktown Rd	West	T	650.00	586	-64.20	-9.9%	2.58	33.00	39	5.80	17.6%	0.97	552.00	668	116.40	21.1%	4.71	20.00	40	19.80	99.0%	3.62
		Racecourse Rd	North	L	188.00	175	-13.20	-7.0%	0.98	22.00	12	-10.20	-46.4%	2.48	160.00	142	-18.00	-11.3%	1.46	16.00	10	-6.00	-37.5%	1.66
		Racecourse Rd	North	R	17.00	17	0.20	1.2%	0.05	2.00	3	1.40	70.0%	0.85	16.00	15	-0.60	-3.8%	0.15	4.00	4	0.20	5.0%	0.10
		Blacktown Rd	East	T	689.00	668	-21.20	-3.1%	0.81	60.00	49	-10.80	-18.0%	1.46	673.00	656	-17.00	-2.5%	0.66	41.00	48	7.00	17.1%	1.05
		Blacktown Rd	East	R	40.00	22	-18.20	-45.5%	3.27	13.00	20	6.80	52.3%	1.68	35.00	25	-10.20	-29.1%	1.87	8.00	21	12.60	157.5%	3.33
20	Bells Line of Rd	Bells Line of Rd	Southbound	Mid block	941.00	889	-52.00	-5.5%	1.72	72.50	57	-15.30	-21.1%	1.90	866.00	881	14.80	1.7%	0.50	53.50	55	1.10	2.1%	0.15
21	Old Kurrajong Rd	Old Kurrajong Rd	Southbound	Mid block	10.00	13	2.60	26.0%	0.77	0.00	0	0.00	0.0%	0.00	9.00	14	4.80	53.3%	1.42	0.50	1	0.10	20.0%	0.13
22	Inalls Ln	Inalls Ln	Southbound	Mid block	125.50	114	-11.90	-9.5%	1.09	5.50	7	1.30	23.6%	0.52	119.50	111	-8.90	-7.4%	0.83	5.00	5	0.00	0.0%	0.00
23	Southee Rd	Southee Rd	Southbound	Mid block	114.00	113	-1.20	-1.1%	0.11	4.50	3	-1.30	-28.9%	0.66	90.00	114	24.40	27.1%	2.41	5.00	2	-2.60	-52.0%	1.35
24	Bells Line of Rd	Bells Line of Rd	Northbound	Mid block	1430.00	1,390	-39.80	-2.8%	1.06	73.00	64	-9.00	-12.3%	1.09	1400.50	1,486	85.30	6.1%	2.25	55.00	69	14.40	26.2%	1.83
25	Old Kurrajong Rd	Old Kurrajong Rd	Northbound	Mid block	47.00	45	-2.40	-5.1%	0.35	1.00	4	3.00	300.0%	1.90	36.00	50	14.00	38.9%	2.13	0.00	1	1.40	0.0%	1.67
26	Inalls Ln	Inalls Ln	Northbound	Mid block	216.50	281	64.70	29.9%	4.10	10.50	10	-0.10	-1.0%	0.03	264.50	333	68.30	25.8%	3.95	12.50	13	0.50	4.0%	0.14
27	Southee Rd	Southee Rd	Northbound	Mid block	174.50	172	-2.70	-1.5%	0.21	7.00	5	-1.60	-22.9%	0.64	205.50	196	-9.90	-4.8%	0.70	6.00	6	0.40	6.7%	0.16

Appendix F Validation results



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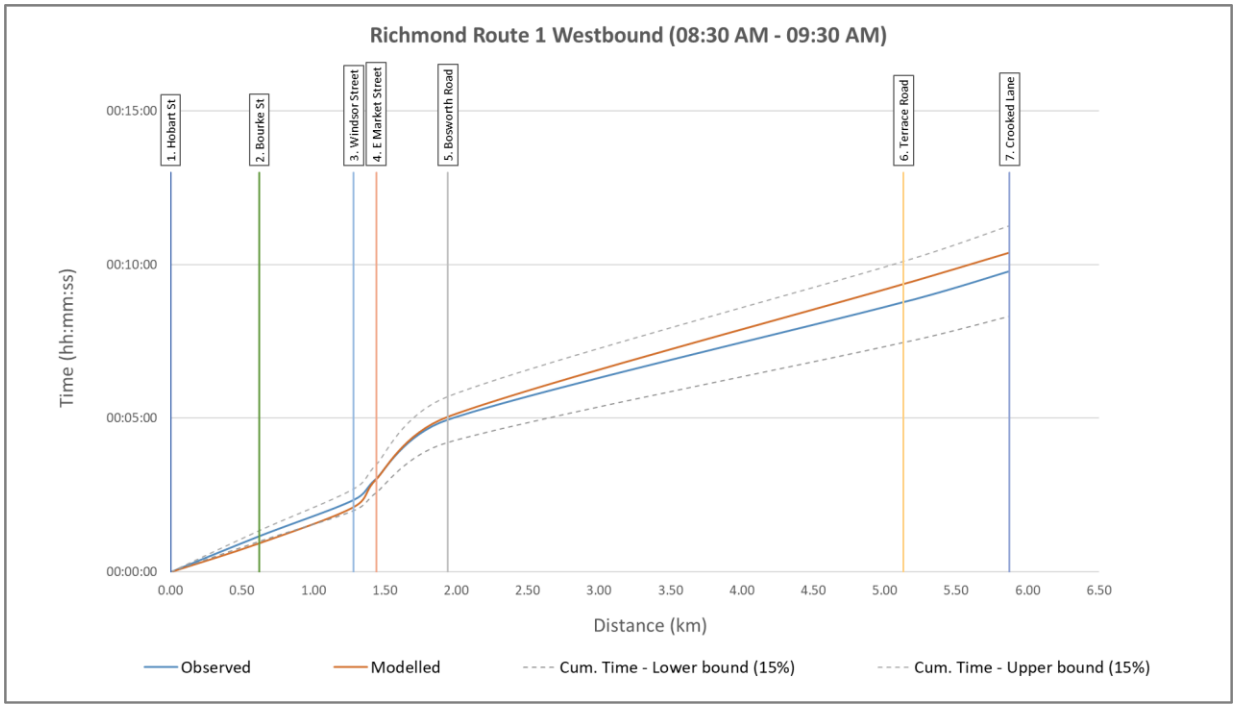
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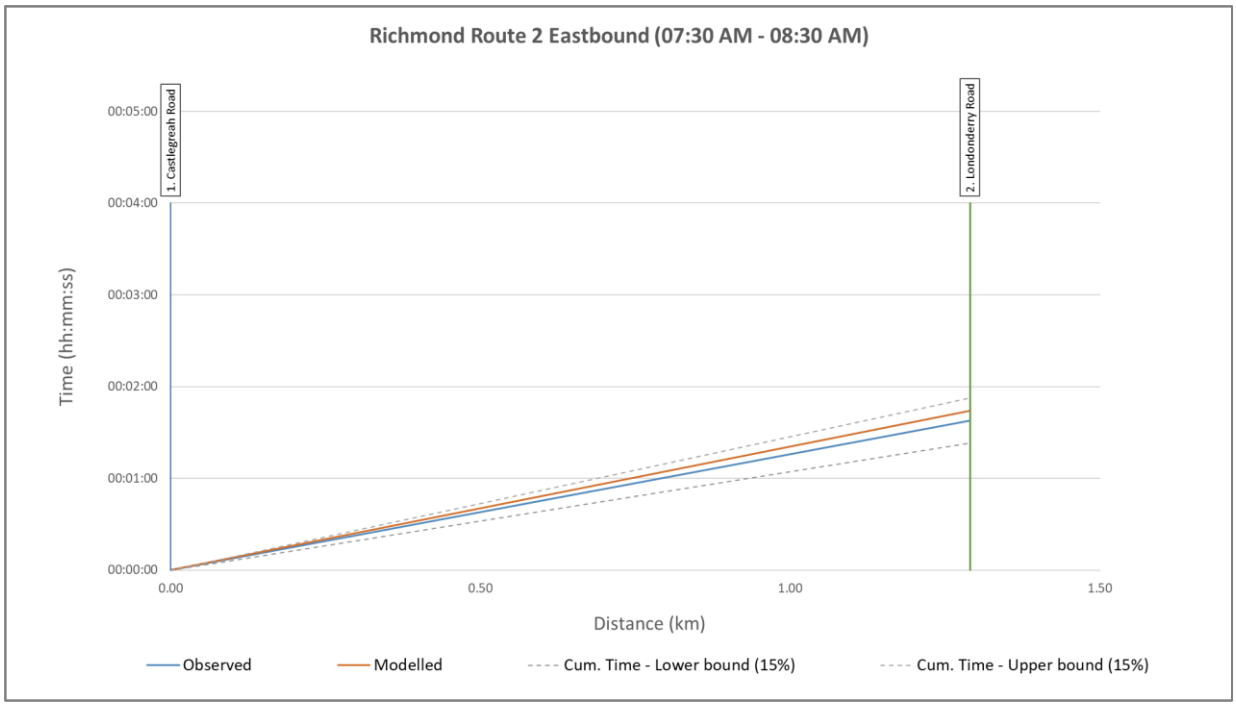
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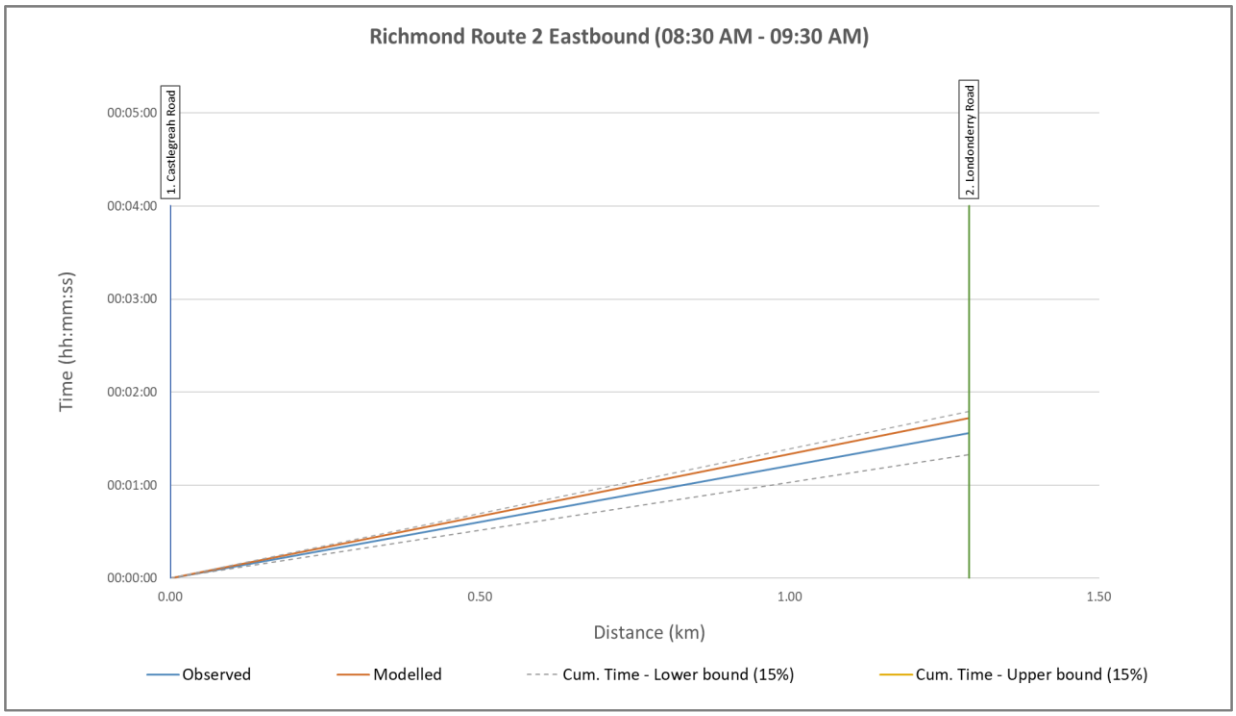
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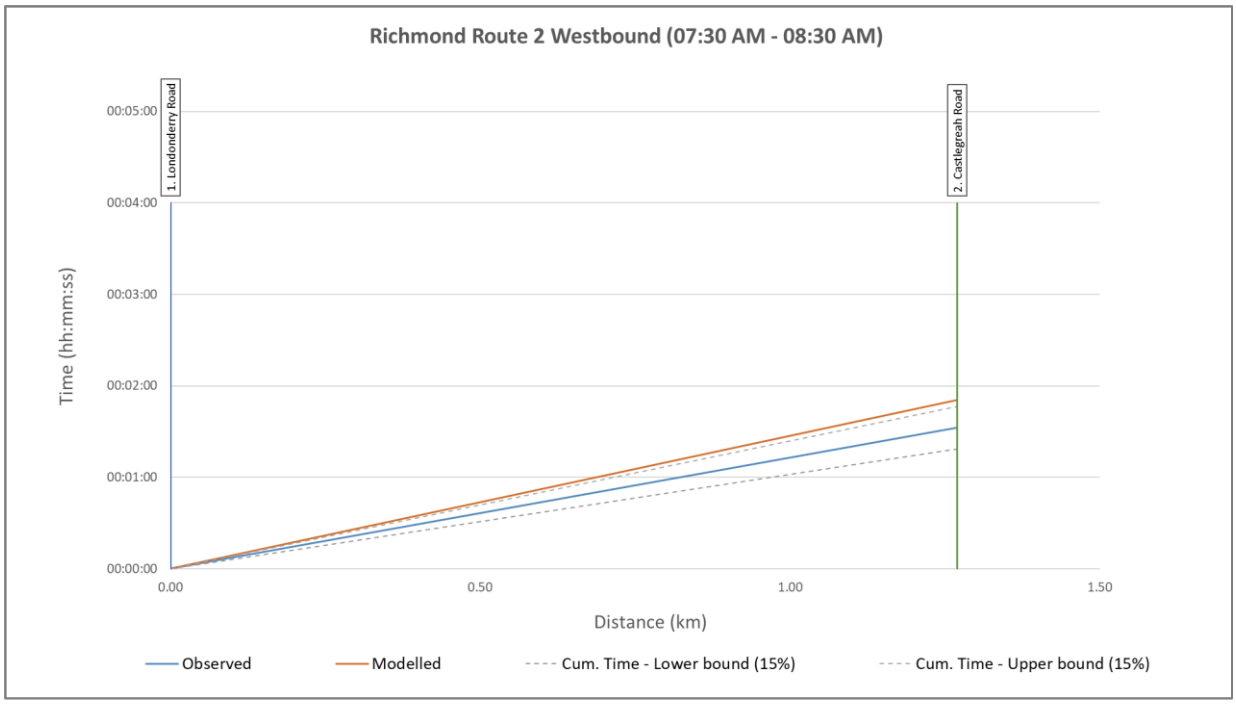
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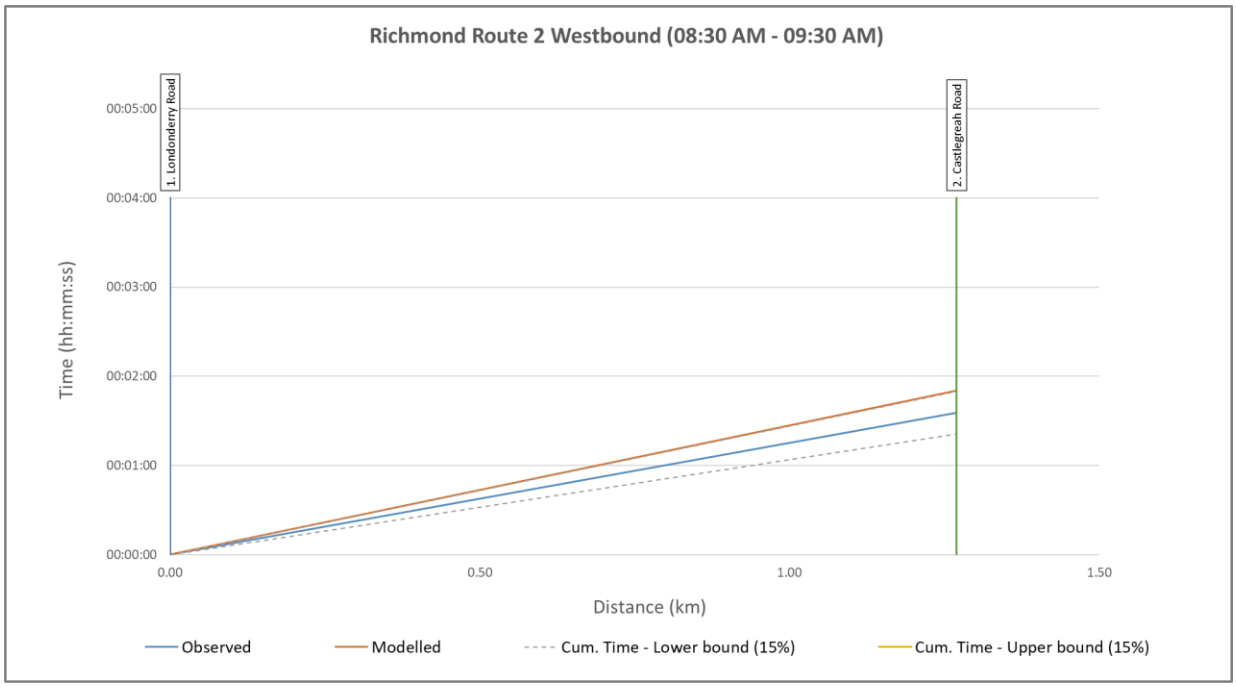
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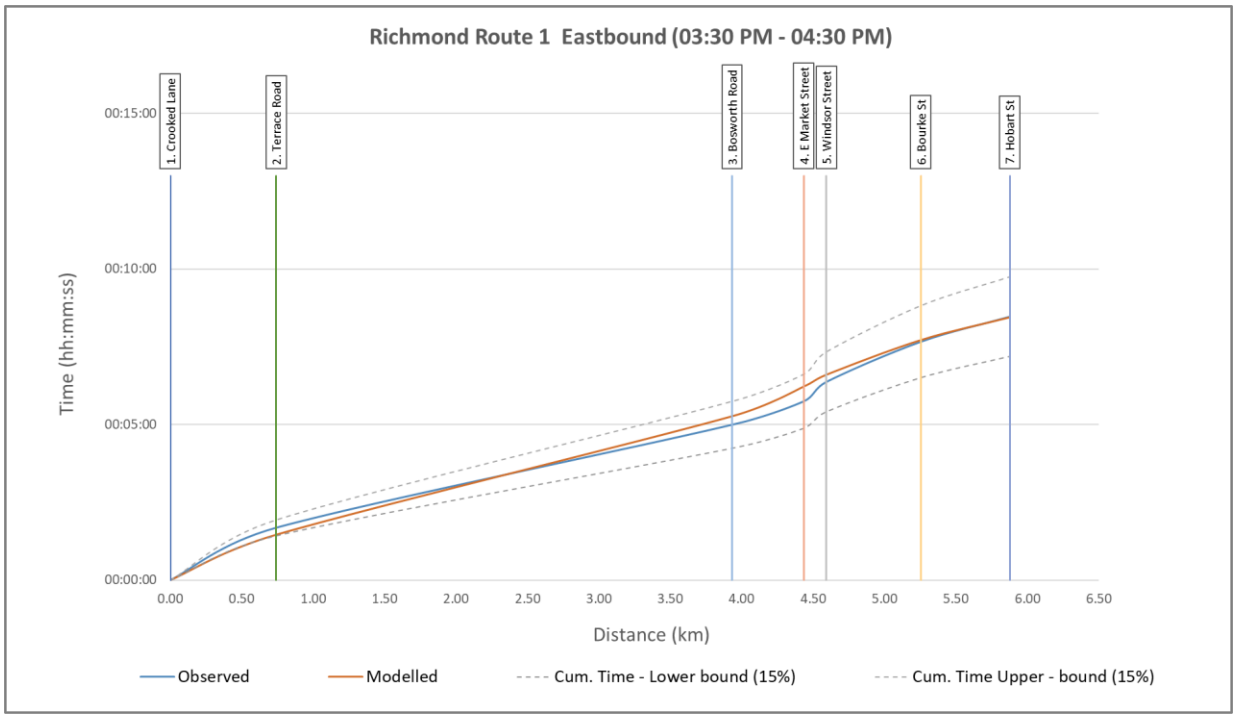
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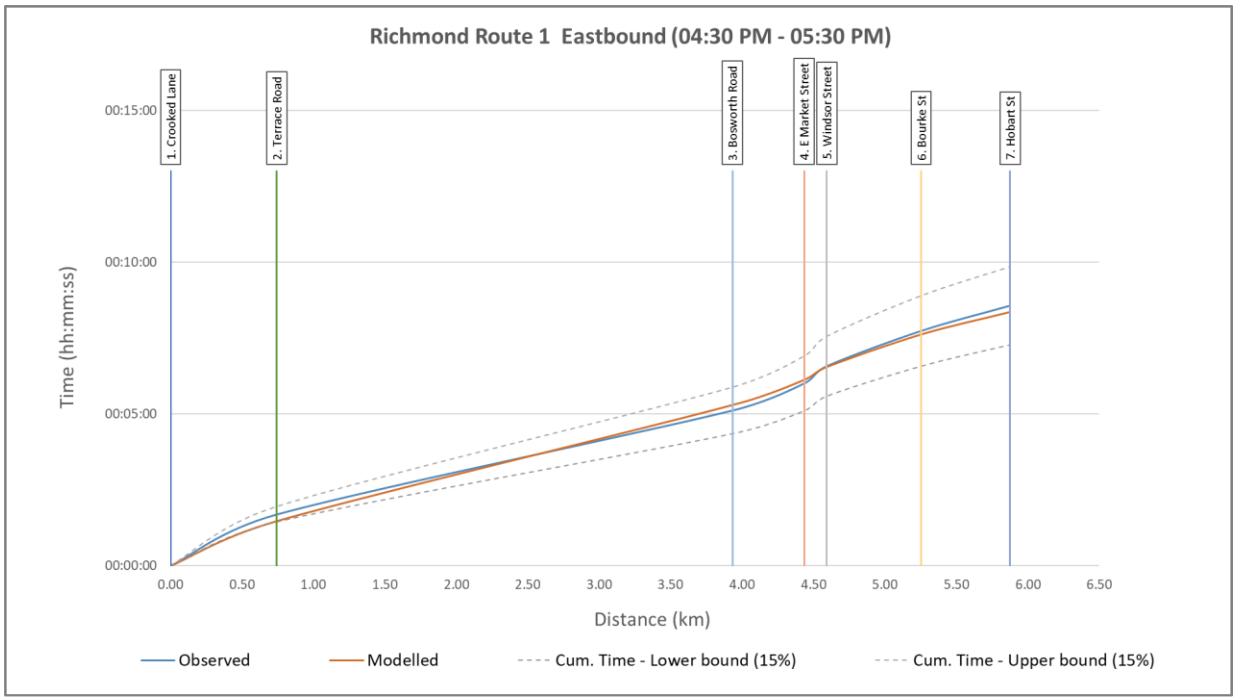
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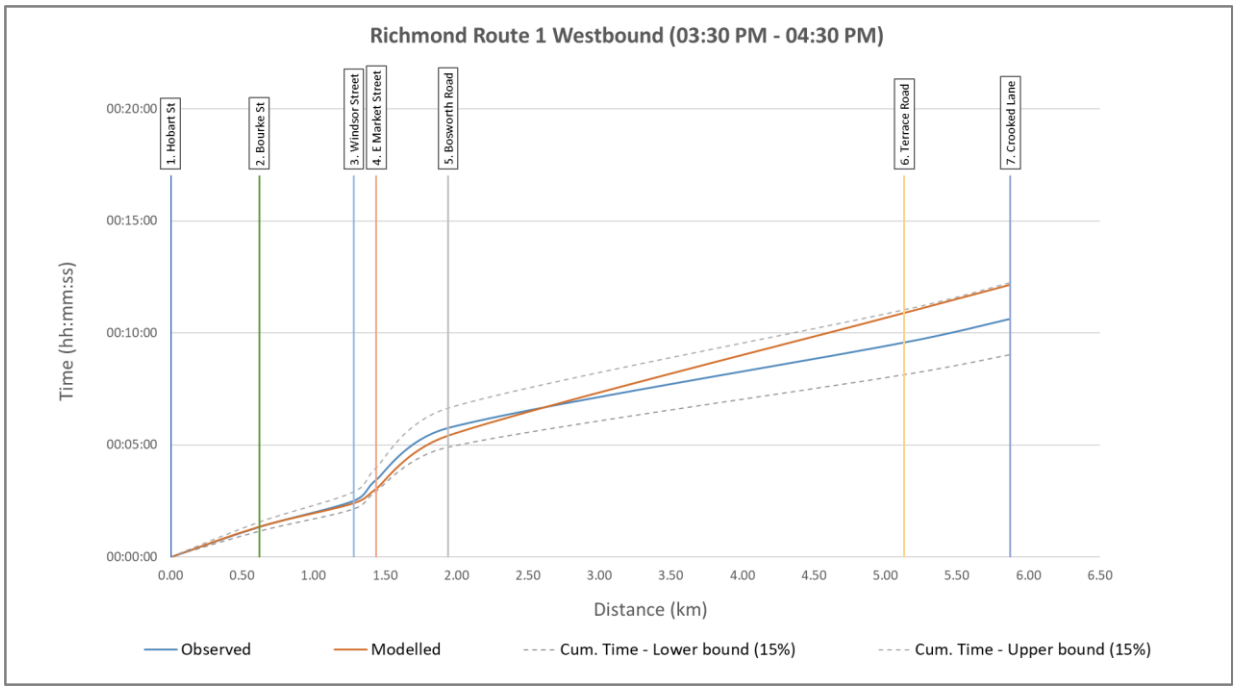
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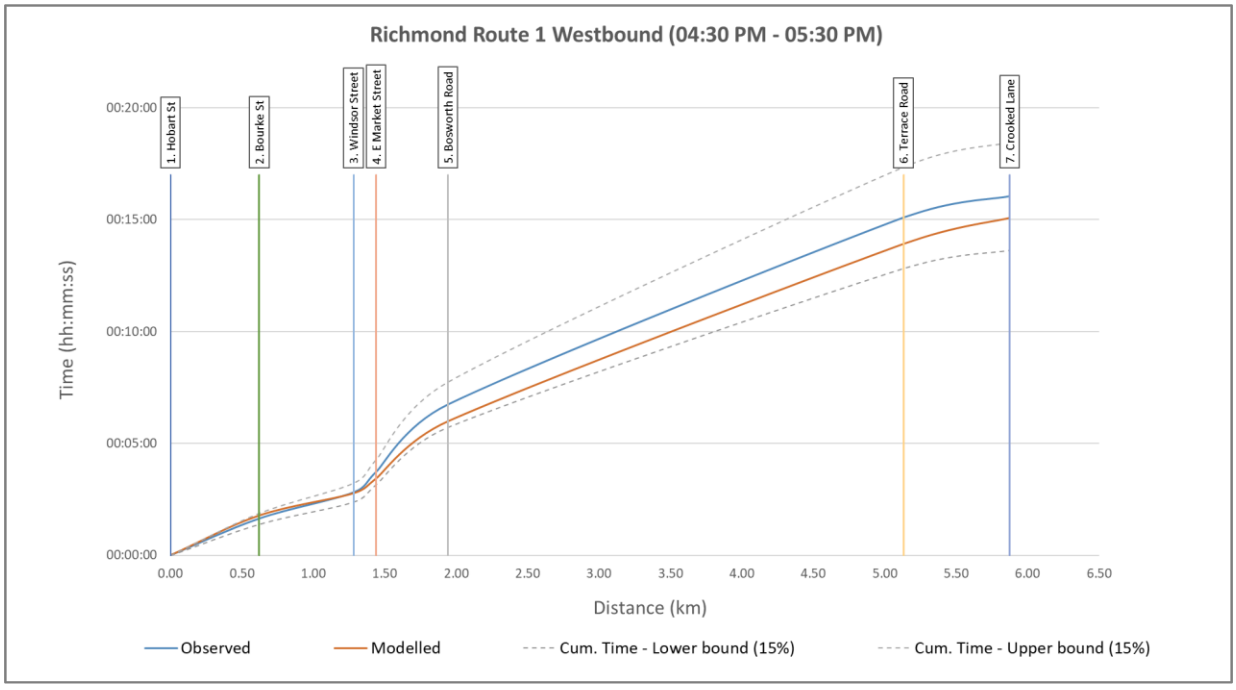
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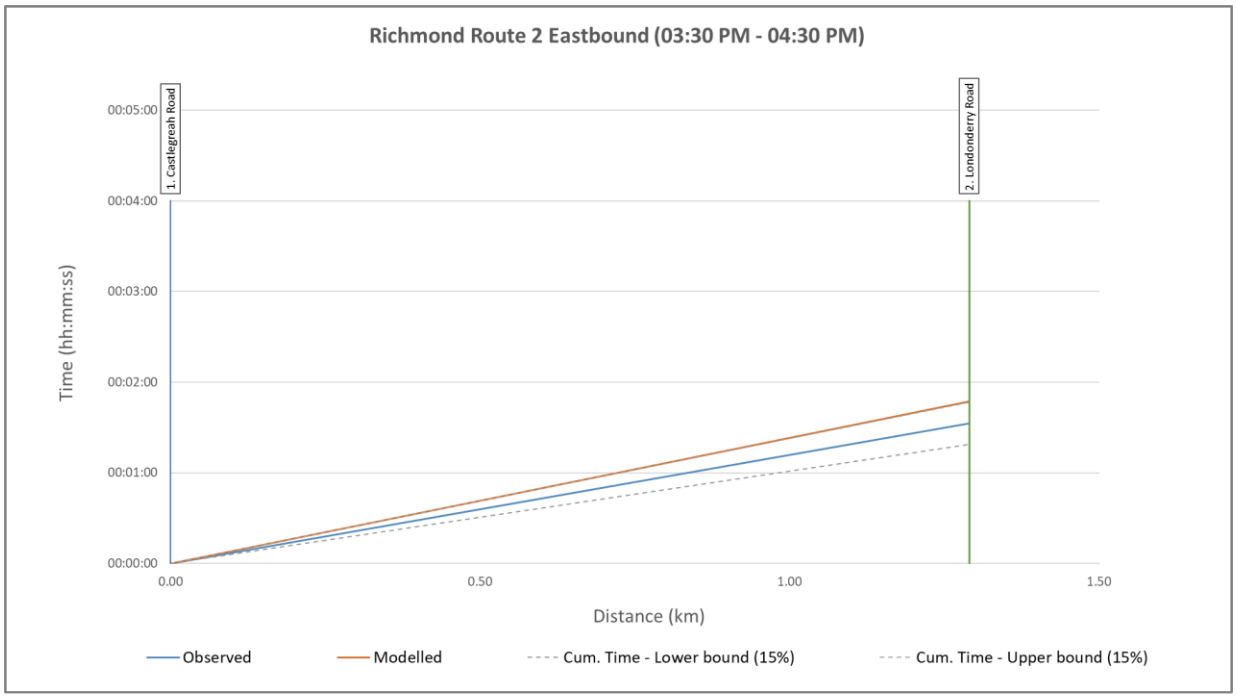
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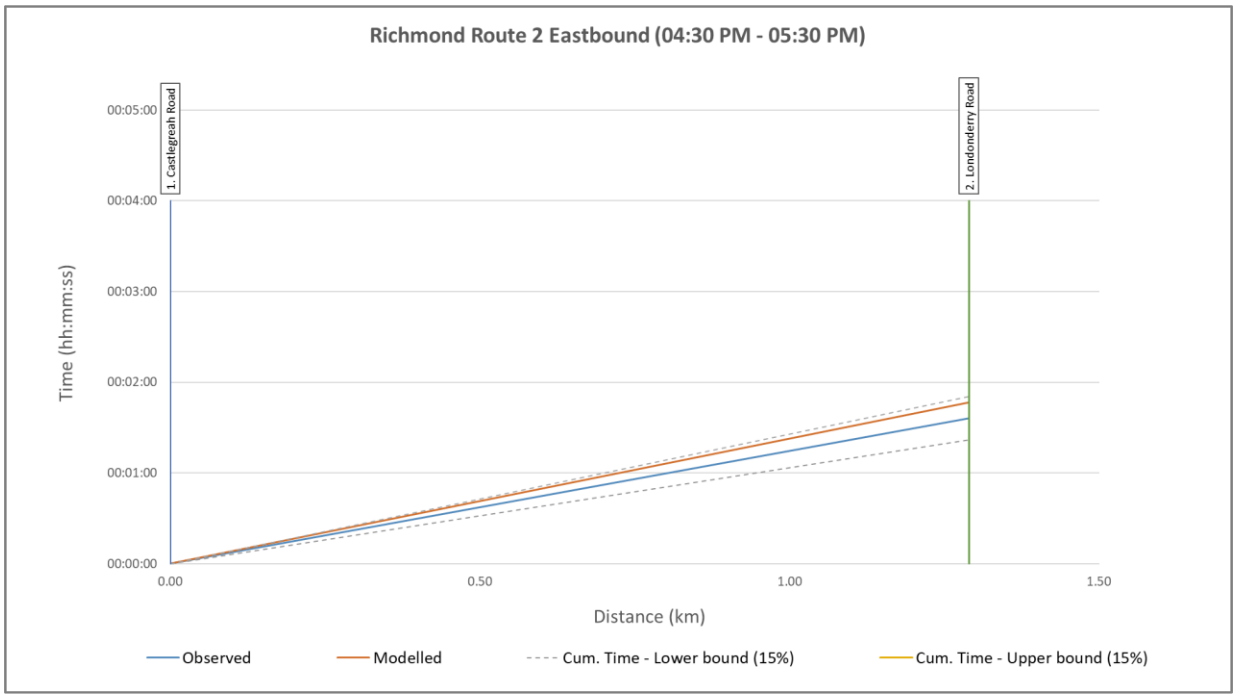
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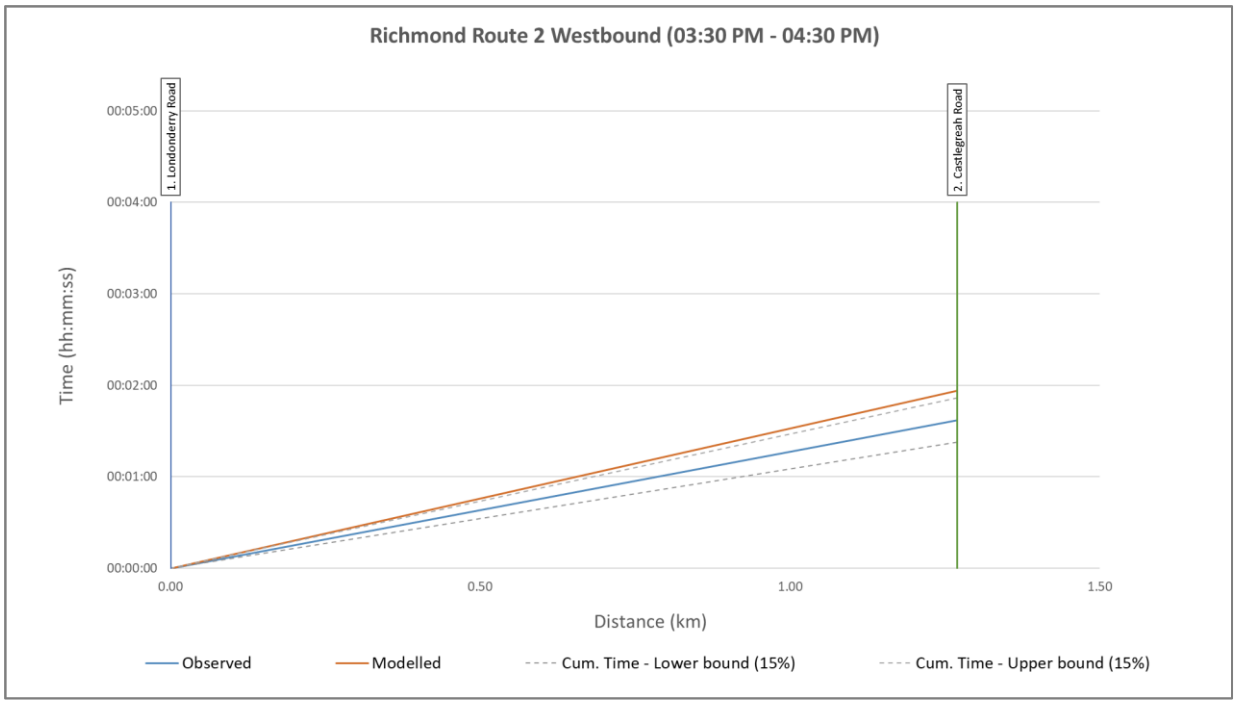
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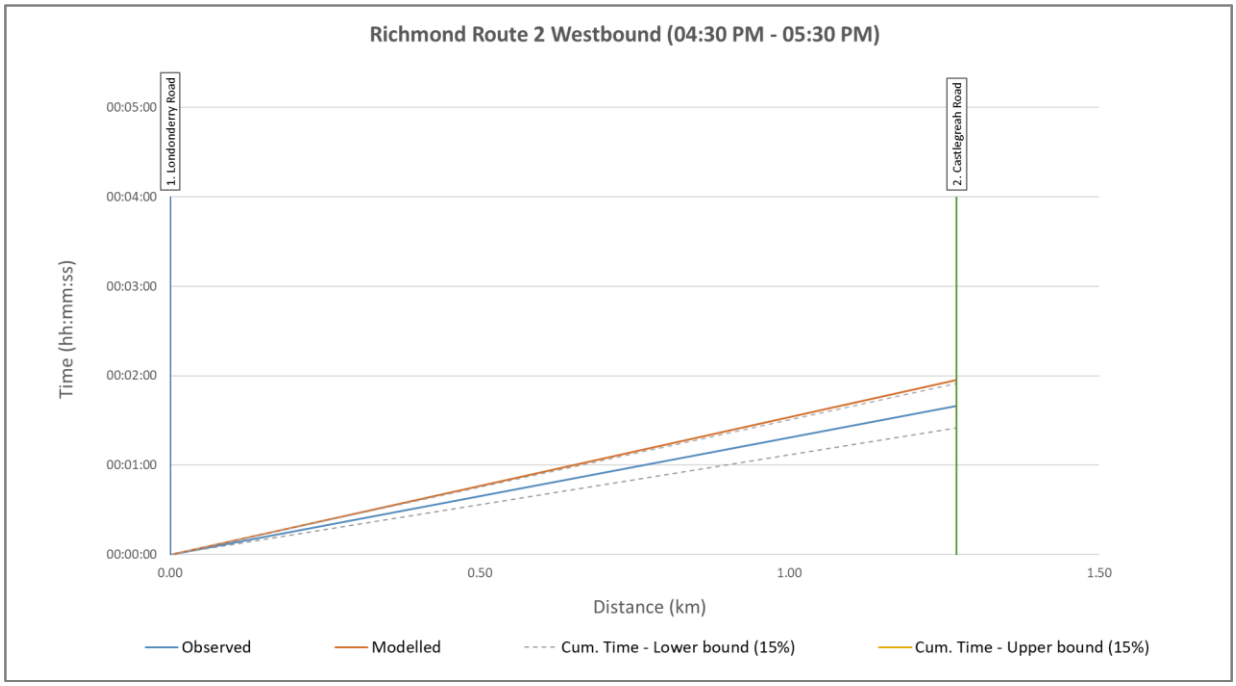
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Appendix B – Future demand development

The calculation of the future years Aimsun demands comprised of two different methods:

- Projection of STMF forecasted demands into Aimsun
- Addition of estimated demand from future developments

Both processes are explained in detail in the sections below.

Relating STFM forecasted demands to Aimsun demands

The growth in STFM forecasts were used to project the Aimsun base year traffic demands to the relevant future years. While the microsimulation model includes a profiled demand extending for an observed peak for both, the morning and evening peak periods, the STFM forecast only spans over a specific two-hour period during the morning and evening, between 7am and 9am and between 4pm and 6pm. The STFM forecasted two-hour peak volumes (AM and PM) therefore required extrapolation across the full simulation period.

To develop the future year demands for Aimsun from STFM, the following process was followed:

1. **Available data:** Matrices from STFM, provided by Transport for years 2021, 2026, 2031, 2036, 2041, 2046 and 2051, were used as the basis for the growth projections. Figure 1-1 presents a timeline of the available STFM years versus the required future Aimsun modelled assessment years for the proposal. The red circles indicate the STFM years while blue circles indicate the required Aimsun model assessment years.

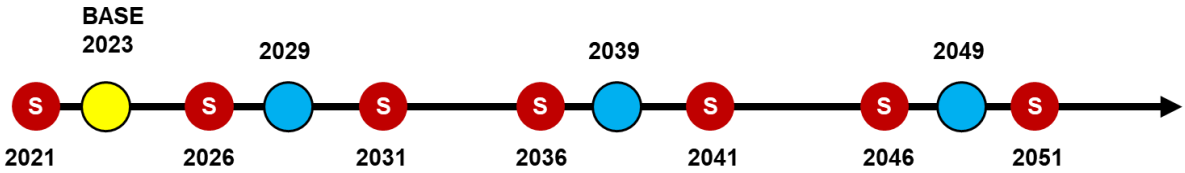


Figure 1 1 Timeline of STFM forecasts, base and Aimsun forecast years

2. **Demand interpolation:** The STFM matrices were interpolated to generate representative demand matrices for the years 2023, 2029 and 2039, to obtain demand matrices that aligned to the Aimsun modelled future years. A linear growth method, between the two consecutive STFM years, was adopted for the interpolation. Table 1-1 presents the supplied STFM forecasted and interpolated total matrix demands for the respective years.

Table 1 1 Interpolated STFM demands

Year	AM Peak (2hr) Traffic Demand	AM Peak linear growth from 2023		PM Peak (2hr) Traffic Demand	PM Peak linear growth from 2023	
		% Change	Vehicles		% Change	Vehicles
2021	10,680			11,366		
2023	10,620			11,316		
2026	10,529			11,241		
2029	10,609	-0.10%	-11	11,336	0.18%	20
2031	10,729			11,479		
2036	10,597			11,298		
2039	10,726	1.00%	106	11,420	0.92%	104
2041	10,919			11,603		
2046	11,167			11,854		
2049	11,255	5.98%	635	11,931	5.43%	615

Year	AM Peak (2hr) Traffic Demand	AM Peak linear growth from 2023		PM Peak (2hr) Traffic Demand	PM Peak linear growth from 2023	
		% Change	Vehicles		% Change	Vehicles
2051	11,386			12,046		

3. **Zone structure:** The STFM zone structure represented broader level zones, which needed to be disaggregated to match the Aimsun model zone structure. The STFM zone structure is presented in Figure 1-2, whereas the assumed relationship between the Aimsun and STFM zone structures are presented in Figure 1-3.

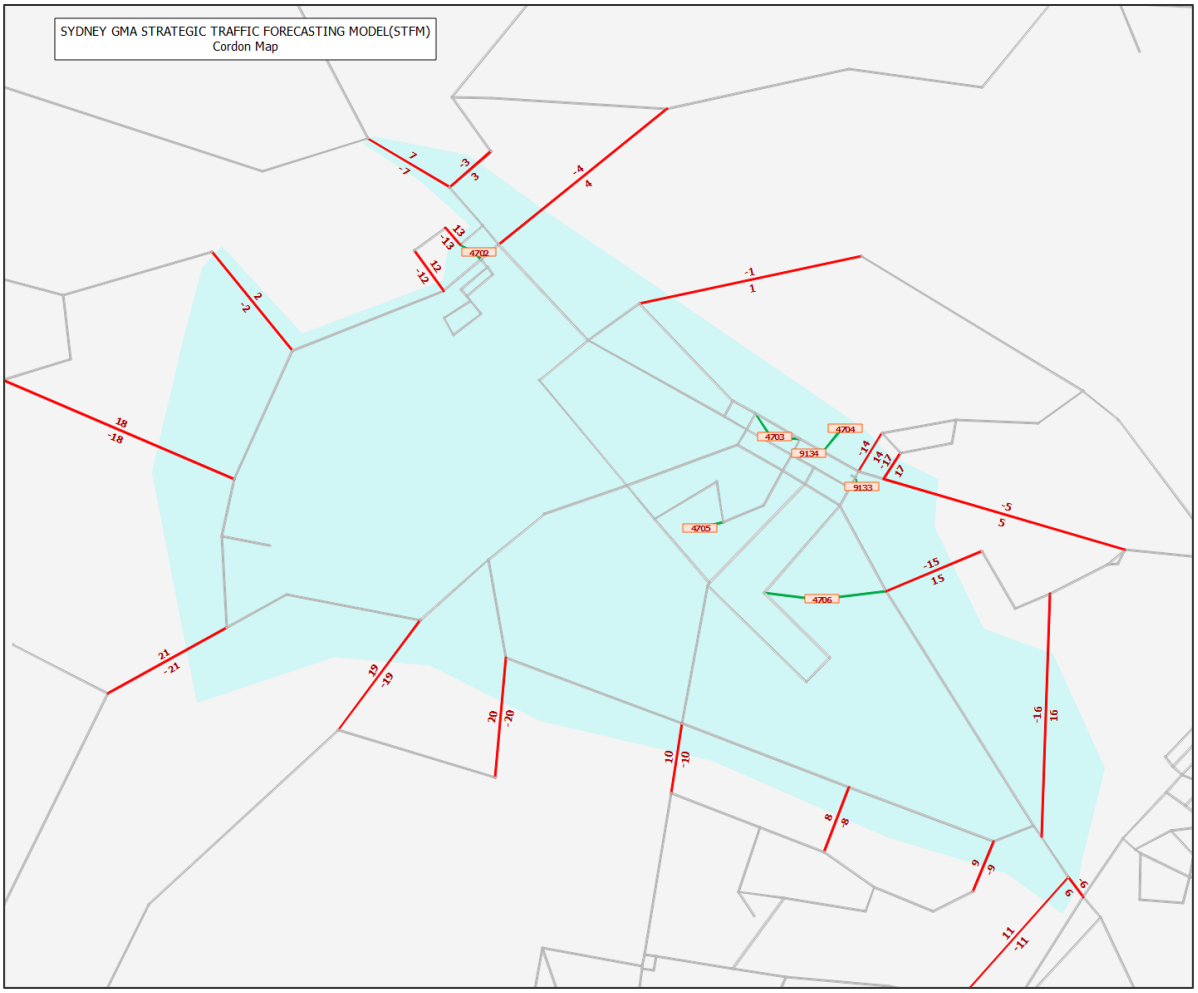


Figure 1 2STFM zone structure

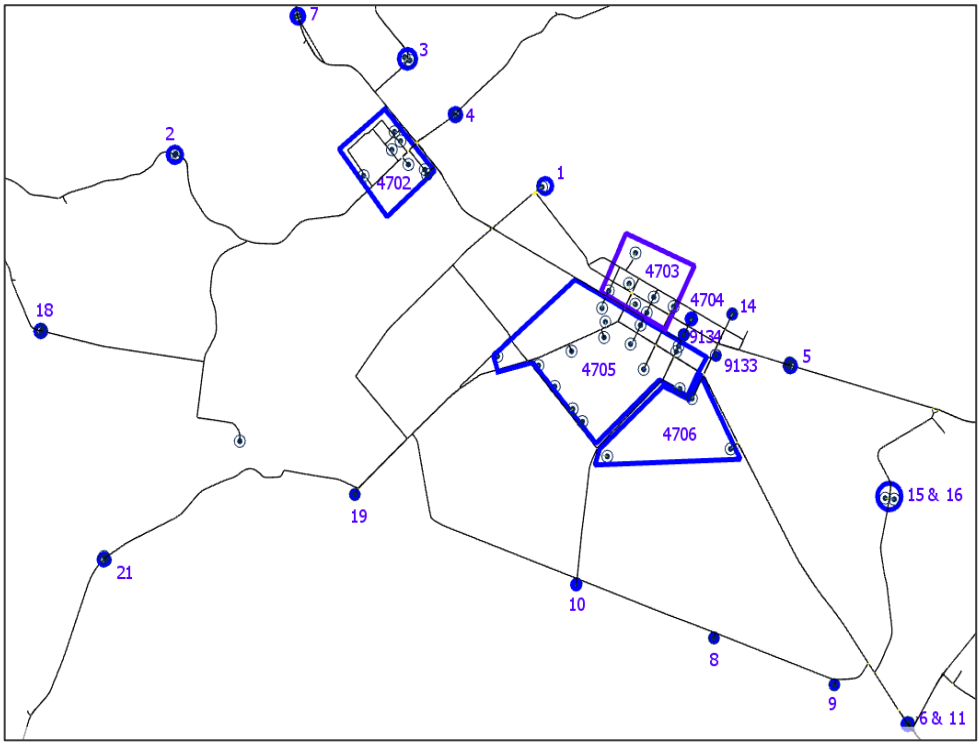


Figure 1 3 Assumed relationship between STFM and Aimsun zone structures

4. **Calculation of OD specific absolute and relative differences:** The matrices from Step 2 were used to calculate the absolute and relative differences between the STFM interpolated future year demands and the 2023 interpolated STFM demand, for each OD pair. Absolute differences represent the growth (or decline) in the absolute number of vehicle trips between the base and future year, whereas the relative difference establishes the percentage of growth (or decline) between the base year and future year.

5. **Zone aggregation and disaggregation:** Considering the broader level that the STFM zones covered, zone disaggregation was required to separate the STFM zones into zones that translated to the Aimsun model. The disaggregation involved calculating the percentage split of an STFM matrix origin and destination zone into its respective Aimsun model zones. As an example, STFM Zone 4706 represents three Aimsun zones, i.e. Aimsun zone 15,16 and 17 (refer to Figure 1-3). The zone totals for these three zones were first added up to represent STFM Zone 4706, following which the percentage split to each zone was calculated. This split was applied to STFM Zone 4706 to split the demand into the three representative Aimsun zones.

   Zone aggregation on the other hand, involved the process of adding up the STFM zones to represent a respective Aimsun Zone.

6. **Future year demand calculation:** The absolute differences calculated in Step 4 were disaggregated /aggregated as described in Step 5, and thereafter added to each OD pair in the 2023 calibrated and validated base Aimsun demand. If the resultant OD demand was negative, the STFM relative growth (or decline) was applied to 2023 Aimsun Demand instead. The resultant of this process was a 2-hour all vehicle peak demand matrix for each of the future year horizons.

7. **Demand classification and profiling:** The provided STFM matrices covered the AM (7–9am) and PM (4–6pm) peak periods. The afore processes (Steps 2 to 6) were separately undertaken for both the AM and PM peak period 2-hour STFM demands.

   The Aimsun model however requires finer demand segments, and vehicle classifications, for traffic assignment. The base year calibrated and validated Aimsun model's vehicle classification and demand profiling were assumed for splitting the 2-hour all vehicle peak period matrix obtained from Step 6 into the finer demand segments, as well as different vehicle classes. This process comprised of:

   a) Vehicle classification: The calibrated and validated base year light and heavy vehicles split were calculated from the 2-hour total modelled demand for the respective peak periods. This percentage split was applied to the 2-hour matrix obtained in Step 6 to yield separate light and heavy vehicle matrices.

b) HV distribution: The calibrated and validated base year 2-hour heavy vehicle matrix was used to calculate the trip percentage for each OD pair against the total demand. This trip percentage was applied to the 2-hour heavy vehicle demand total calculated in Step 7a, to generate a future year two-hour heavy vehicle matrix. It was therefore assumed that the heavy vehicle trip distribution from the base year would remain unchanged in future.

c) The 2-hour future light vehicle matrix was calculated by applying the overall light vehicle demand split percentage calculated in Step 7a to the 2-hour all vehicle peak period matrix.

d) Demand profiling: The 15-minute calibrated and validated base year matrix totals were used to calculate the demand profiles separately for the light and heavy vehicle matrices. These overall profiles were then applied to the matrices calculated in Step 7b, 7c to generate 15-minute profiled matrices for heavy and light vehicles respectively. These 15-minute profiled, and classified, demands were used in Aimsun for the future year traffic demands.

Addition of future development traffic

In addition to the STFM traffic forecasts, traffic generation from several nearby proposed developments were separately estimated and added to the future traffic demands, seeing as these developments were either not included, or only partially included, in the STFM forecasts. The following developments were identified and included in the final expected traffic demand within the proposal area (refer to Figure 1-4):

- Redbank development located along Grose Vale Road
- Vineyard LGA residential development
- Glossodia LGA residential development

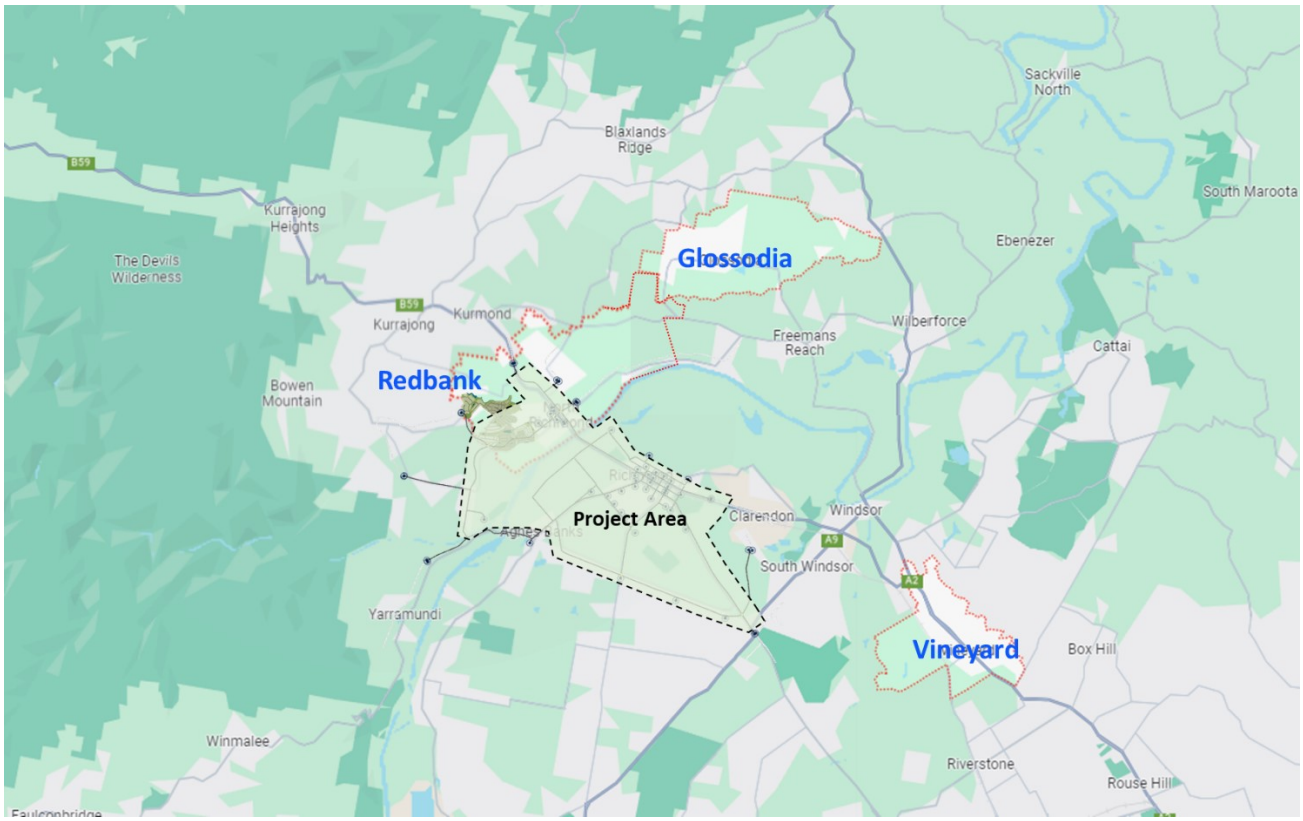


Figure 1 4 Proposed new development locations around Richmond

The individual development projections were provided by Hawkesbury City Council, and entails:

- Redbank – At its current development stage, Redbank currently houses 908 dwellings. By 2029, it is projected to house 1,400 dwellings in total.
- Vineyard – Currently houses 50 dwellings and is forecast to house 2,500 dwellings by 2035.
- Glossodia – Development is expected to commence in 2024 and is expected to house 580 dwellings by 2032.

These projections were used to estimate the individual developments' traffic generation – refer to Table 1-2. The Roads and Maritime services guide to Traffic Generating developments Technical direction TDT 2013/04a for low density residential dwellings was used to translate the development dwellings to actual vehicle numbers. An 80/20 split for Origin/Destination trip generation/attraction was applied to the AM peak, with the inverse assumed for the PM peak.

Table 1 2 Future development traffic generation

Modelled years	No of dwellings	AM peak trips			PM peak trips		
		Total	Generate	Attract	Total	Generate	Attract
REDBANK							
2021	908	645	516	129	708	142	567
2029	1,400	994	795	199	1,092	218	874
2039	1,400	994	795	199	1,092	218	874
VINEYARD							
2021	150	107	14	3	117	4	15
2029	1,300	923	119	30	1,014	33	131
2039	2,500	1,775	229	57	1,950	63	251
GLOSSODIA							
2021	0	0	0	0	0	0	0
2029	250	178	89	22	195	98	25
2039	580	412	208	52	452	228	57
TOTAL							
2021	**1,058**	**751**	**529**	**132**	**825**	**145**	**582**
2029	**2,950**	**2,095**	**1,004**	**251**	**2,301**	**349**	**1,029**
2039	**4,480**	**3,181**	**1,231**	**308**	**3,494**	**509**	**1,182**

The development traffic was assigned to the respective Aimsun zones as indicated in Figure 1-5.

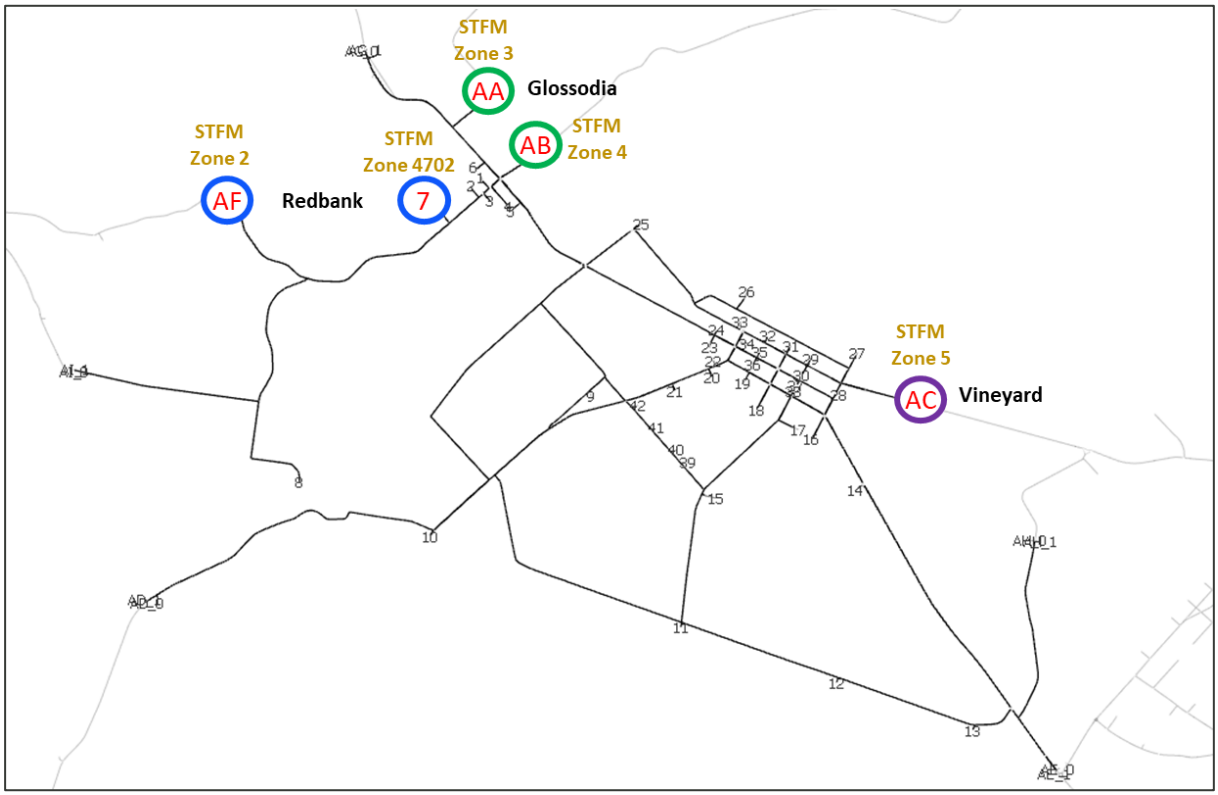


Figure 1 5 Aimsun zone allocations for additional development traffic

As seen on Figure 1-5, for both the Redbank and Glossodia developments it was assumed that the developments would access the study area via two separate zones. To allow for the distribution of the respective developments' traffic to the applicable zones, the zone distributions shown in Table 1-3 was assumed.

Table 1 3 Development traffic zone distribution

Development	STFM Zone	Aimsun Zone	Zone Distribution
Redbank zone	4702	7	0.5
		AF	0.5
Vineyard zone	5	AC	1
Glossodia zone	3	AA	0.7
	4	AB	0.3

To allow for the distribution of the development traffic to and from the proposal area zones, it was assumed that the distributions would follow similar distribution patterns as the STFM zones, or the calibrated Aimsun zones, where applicable.

It is noted that the ABS 'workplace of work' dataset was also considered whilst distributing the development traffic. Based on this, the following assumptions were made:

- Redbank development is located directly in the study area and it was therefore assumed that 100 per cent of drivers will need to travel through the study area. The distribution pattern of the traffic from Redbank was therefore based on the STFM traffic distribution.
- Vineyard is located outside the study area. It was therefore assumed based on ABS data that only 46 per cent of the development's generated trips would remain in the Hawkesbury LGA. These trips from Vineyard LGA could travel along three main roads, one of which is Windsor Street that traverses the proposal area. It was therefore assumed that of the 46 per cent of Vineyard's traffic, only a third (1/3) will interact with the study area and will travel along Windsor Street.
- Glossodia is located outside the study area, however considering the development location, most traffic going east, south, or west should interact with the study area. It was therefore assumed that 90 per cent of the development's traffic will travel to/from these areas and of this, 70 per cent would interact with the North Richmond area.

It was assumed that all these development's generated traffic would be light vehicles, given the residential nature of the developments. The development traffic demand was added as a separate set of matrices to the overall traffic demand derived from STFM. The development traffic demand was profiled as per the light vehicle traffic profile to generate the 15 minutes travel matrices.

Table 1-4 presents the resulting 2-hour traffic demand totals used for the traffic modelling, as well as the resulting growth in traffic for each scenario year with respect to the base year.

Table 1-4 Overall Traffic Demand Comparison between the model scenario years

Scenario Year	AM (2-hour Demand)				PM (2-hour Demand)			
	STFM Growth	Additional Development Traffic Demand	Total	% Growth with respect to Base Year	PM Peak 2hr Traffic Demand	Dev Traffic Demand	Total	% Growth with respect to Base Year
2023	12,749		12,749		14,990		14,990	
2029	12,856	1,246	14,102	11%	15,131	1,364	16,495	10%
2039	13,285	1,530	14,814	16%	15,443	1,683	17,126	14%

Appendix C – Detailed intersection performance

AM Peak – LOS results

Time Period: 7.30–8.30am

ID	Intersection	Approach	Movement	2023 AM Base			2029 AM Without proposal			2029 AM With proposal (Stage 2A)			2039 AM Without proposal			2039 AM With proposal (Stage 2B)		
				Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS
1	Bells Line of Road / Grose Vale Road / Terrace Road	West	L	50	144	F	53	56	D	54	58	E	47	77	F	49	41	C
		West	T	724	146	F	639	61	E	640	64	E	676	83	F	692	44	D
		West	R	74	191	F	100	104	F	98	111	F	96	132	F	97	69	E
		North	L	199	44	D	195	40	C	195	39	C	219	40	C	219	40	C
		North	T	45	51	D	76	60	E	76	60	E	87	54	D	87	57	E
		North	R	42	36	C	45	34	C	45	33	C	47	36	C	48	32	C
		East	L	266	16	B	261	15	B	268	13	A	256	16	B	275	13	A
		East	T	319	33	C	388	36	C	397	36	C	425	35	C	434	42	C
		East	R	121	75	F	112	60	E	114	62	E	123	68	E	127	73	F
		South	L	22	104	F	49	83	F	49	68	E	44	179	F	47	89	F
		South	T	16	118	F	39	102	F	50	72	F	43	207	F	56	88	F
		South	R	457	153	F	558	94	F	632	50	D	513	181	F	743	53	D
2	Kurrajong Road / Old Kurrajong Road / Bells Line Of Road (Base / Do Nothing) Kurrajong Road / Richmond bypass / Bells Line Of Road (With proposal)	West	L	86	13	A	133	13	A	-	0	-	127	13	A	-	0	-
		West	T	1,120	13	A	1,163	12	A	1,251	8	A	1,199	13	A	1,335	12	A
		West	R	336	21	B	246	23	B	297	31	C	242	26	B	398	26	B
		North	L	23	68	E	21	83	F	-	0	-	25	102	F	-	0	-
		North	T	3	58	E	7	85	F	-	0	-	5	103	F	-	0	-
		North	R	4	84	F	12	105	F	-	0	-	15	163	F	-	0	-
		East	L	0	0	-	0	0	-	-	0	-	0	0	-	0	0	-
		East	T	532	13	A	569	12	A	435	30	C	580	13	A	395	37	C
		East	R	4	40	C	3	53	D	-	0	-	3	46	D	-	0	-
		South	L	215	4	A	229	8	A	395	20	B	255	19	B	495	16	B
		South	T	12	88	F	20	115	F	-	0	-	21	126	F	-	0	-
		South	R	2	79	F	4	86	F	4	52	D	3	76	F	11	44	D
3	March Street / Bosworth Street	West	L	86	16	B	113	17	B	205	16	B	135	18	B	202	16	B
		West	T	529	18	B	616	20	B	629	20	B	592	21	B	684	20	B
		West	R	445	51	D	380	42	C	336	24	B	416	48	D	320	24	B
		North	L	18	29	C	1	0	-	2	18	B	0	0	-	2	24	B
		North	T	104	30	C	55	28	B	96	26	B	73	26	B	158	29	C
		North	R	27	30	C	16	38	C	21	41	C	19	37	C	28	37	C
		East	L	55	55	D	67	68	E	96	58	E	76	90	F	107	52	D
		East	T	329	48	D	362	58	E	321	49	D	378	76	F	303	47	D
		South	L	193	45	D	233	52	D	117	55	D	231	67	E	93	48	D
		South	T	187	54	D	251	56	D	334	65	E	265	74	F	275	56	D
		South	R	72	58	E	50	60	E	50	69	E	55	81	F	46	66	E
4	Castlereagh Road / Inalls Lane / Southee Road (Base / Do Nothing) Richmond bypass / Castlereagh Road (With proposal)	West	L	25	13	A	26	12	A	30	21	B	27	14	A	46	20	B
		West	T	82	14	A	40	14	A	109	22	B	46	17	B	224	20	B
		West	R	8	14	A	-	0	-	175	23	B	1	0	-	142	18	B
		North	L	32	2	A	13	2	A	28	6	A	16	2	A	100	8	A
		North	T	151	2	A	179	2	A	136	7	A	206	3	A	151	9	A
		North	R	15	7	A	15	7	A	58	7	A	18	11	A	69	11	A
		East	L	7	11	A	14	9	A	19	13	A	15	11	A	27	11	A
		East	T	80	12	A	66	13	A	238	14	A	85	16	B	327	12	A

ID	Intersection	Approach	Movement	2023 AM Base			2029 AM Without proposal			2029 AM With proposal (Stage 2A)			2039 AM Without proposal			2039 AM With proposal (Stage 2B)		
				Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS
		East	R	46	9	A	40	9	A	45	14	A	49	10	A	136	11	A
		South	L	2	6	A	15	5	A	90	19	B	7	7	A	91	15	B
		South	T	285	4	A	362	4	A	428	20	B	379	4	A	339	16	B
		South	R	20	5	A	8	6	A	11	19	B	11	7	A	54	18	B
5	Richmond bypass / Valder Avenue (Local road connection)	West	L	7	2	A	12	2	A	12	2	A	10	2	A	20	6	A
		West	T	124	1	A	45	1	A	133	1	A	62	1	A	357	3	A
		North	L	8	1	A	9	1	A	10	1	A	12	2	A	30	4	A
		North	R	21	2	A	20	2	A	20	3	A	20	3	A	38	7	A
		East	T	107	1	A	90	1	A	287	2	A	120	1	A	460	5	A
		East	R	15	7	A	14	2	A	14	3	A	14	2	A	31	11	A
6	Richmond bypass / Londonderry Road	West	L	15	5	A	6	4	A	8	7	A	9	4	A	27	8	A
		West	T	-	0	-	-	0	-	-	0	-	-	0	-	77	12	A
		West	R	122	7	A	53	5	A	137	9	A	66	5	A	278	18	B
		North	L	-	0	-	-	0	-	-	0	-	-	0	-	12	59	E
		North	T	177	5	A	134	3	A	159	5	A	130	3	A	82	59	E
		North	R	26	6	A	19	6	A	46	10	A	20	8	A	32	57	E
		East	L	-	0	-	-	0	-	-	0	-	-	0	-	18	5	A
		East	T	-	0	-	-	0	-	-	0	-	-	0	-	18	62	E
		East	R	-	0	-	-	0	-	-	0	-	-	0	-	10	50	D
		South	L	105	6	A	95	6	A	268	8	A	120	7	A	443	5	A
		South	T	205	5	A	215	5	A	200	7	A	207	6	A	144	34	C
		South	R	-	0	-	-	0	-	-	0	-	-	0	-	55	38	C
7	Castlereagh Road / The Driftway	North	L	50	9	A	121	10	A	21	10	A	123	11	A	0	0	-
		North	T	238	4	A	248	5	A	309	4	A	243	8	A	318	3	A
		East	L	52	11	A	196	21	B	130	15	B	213	27	B	115	14	A
		East	R	1	27	B	1	51	D	1	50	D	1	42	C	1	33	C
		South	T	433	4	A	474	12	A	562	6	A	479	13	A	517	4	A
		South	R	102	8	A	218	19	B	216	10	A	213	20	B	185	8	A

AM Peak – LOS results

Time Period: 8.30–9.30am

ID	Intersection	Approach	Movement	2023 AM Base			2029 AM Without proposal			2029 AM With proposal (Stage 2A)			2039 AM Without proposal			2039 AM With proposal (Stage 2B)		
				Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS
1	Bells Line of Road / Grose Vale Road / Terrace Road	West	L	50	89	F	53	58	E	53	55	D	49	96	F	48	33	C
		West	T	495	101	F	595	63	E	597	60	E	640	101	F	631	42	C
		West	R	68	149	F	88	97	F	87	91	F	83	140	F	84	70	F
		North	L	191	40	C	186	41	C	186	39	C	207	44	D	207	42	C
		North	T	81	50	D	66	54	D	65	53	D	71	53	D	71	52	D
		North	R	46	41	C	41	35	C	41	35	C	48	37	C	49	37	C
		East	L	301	17	B	260	15	B	256	14	A	282	14	A	291	14	A
		East	T	405	34	C	444	35	C	442	40	C	476	38	C	473	42	C
		East	R	140	92	F	126	71	F	126	67	E	140	82	F	136	75	F
		South	L	21	162	F	49	106	F	45	79	F	49	277	F	50	106	F
		South	T	13	184	F	42	128	F	50	87	F	45	305	F	58	94	F
		South	R	482	205	F	550	113	F	596	47	D	592	304	F	744	63	E
2	Kurrajong Road / Old Kurrajong Road / Bells Line Of Road (Base / Do Nothing) Kurrajong Road / Richmond bypass / Bells Line Of Road (With proposal)	West	L	99	13	A	143	15	B	-	0	-	123	18	B	-	0	-
		West	T	1,078	13	A	1,153	15	B	1,201	8	A	1,263	16	B	1,261	9	A
		West	R	245	23	B	249	29	C	278	30	C	261	32	C	420	26	B
		North	L	19	46	D	15	65	E	-	0	-	16	183	F	-	0	-
		North	T	4	124	F	8	72	F	-	0	-	4	236	F	-	0	-
		North	R	7	86	F	12	128	F	-	0	-	15	227	F	-	0	-
		East	L	0	0	-	-	0	-	0	0	-	0	0	-	0	0	-
		East	T	634	14	A	610	11	A	421	30	C	637	17	B	389	36	C
		East	R	5	42	C	2	40	C	-	0	-	6	58	E	-	0	-
		South	L	230	5	A	217	13	A	410	20	B	267	7	A	524	16	B
		South	T	14	71	F	20	120	F	-	0	-	12	152	F	-	0	-
		South	R	2	48	D	4	79	F	9	56	D	2	170	F	7	41	C
3	March Street / Bosworth Street	West	L	101	18	B	111	17	B	217	16	B	133	21	B	205	18	B
		West	T	568	22	B	645	19	B	621	20	B	685	25	B	753	22	B
		West	R	403	70	F	387	40	C	296	24	B	396	63	E	279	21	B
		North	L	3	30	C	1	22	B	2	25	B	4	31	C	1	43	D
		North	T	71	25	B	52	26	B	135	28	B	96	26	B	131	28	B
		North	R	54	34	C	14	39	C	19	39	C	15	38	C	31	39	C
		East	L	60	102	F	58	79	F	104	53	D	74	95	F	101	56	D
		East	T	396	97	F	388	68	E	319	47	D	426	90	F	307	46	D
		South	L	226	58	E	220	45	D	97	52	D	223	51	D	75	45	D
		South	T	239	64	E	256	50	D	345	56	D	280	57	E	286	49	D
		South	R	61	66	E	53	50	D	36	57	E	56	61	E	41	54	D
4	Castlereagh Road / Inalls Lane / Southee Road (Base / Do Nothing) Richmond bypass / Castlereagh Road (With proposal)	West	L	19	12	A	17	14	A	21	21	B	21	12	A	51	21	B
		West	T	74	15	B	51	16	B	123	21	B	60	16	B	233	19	B
		West	R	6	16	B	1	0	-	153	23	B	3	21	B	152	18	B
		North	L	29	3	A	12	3	A	38	6	A	15	2	A	77	9	A
		North	T	126	2	A	183	3	A	143	7	A	185	2	A	138	10	A
		North	R	19	6	A	18	10	A	69	8	A	17	9	A	75	10	A
		East	L	18	11	A	13	11	A	18	13	A	17	14	A	21	11	A
		East	T	82	12	A	81	14	A	239	13	A	103	16	B	356	12	A

ID	Intersection	Approach	Movement	2023 AM Base			2029 AM Without proposal			2029 AM With proposal (Stage 2A)			2039 AM Without proposal			2039 AM With proposal (Stage 2B)		
				Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS
		East	R	37	8	A	41	10	A	37	12	A	51	11	A	114	11	A
		South	L	2	6	A	23	6	A	89	20	B	1	3	A	83	16	B
		South	T	300	4	A	370	4	A	428	22	B	392	4	A	335	17	B
		South	R	14	4	A	13	6	A	19	23	B	13	6	A	65	17	B
5	Richmond bypass / Valder Avenue (Local road connection)	West	L	11	2	A	11	2	A	11	2	A	11	2	A	21	6	A
		West	T	106	1	A	67	1	A	172	1	A	79	1	A	355	3	A
		North	L	10	1	A	11	1	A	15	2	A	5	1	A	17	4	A
		North	R	15	1	A	21	2	A	16	3	A	17	2	A	33	8	A
		East	T	109	1	A	107	1	A	282	2	A	150	1	A	458	5	A
		East	R	11	6	A	13	2	A	12	4	A	12	2	A	30	10	A
6	Richmond bypass / Londonderry Road	West	L	15	4	A	8	5	A	19	6	A	7	5	A	29	7	A
		West	T	-	0	-	-	0	-	-	0	-	-	0	-	71	12	A
		West	R	105	6	A	74	4	A	174	8	A	83	5	A	276	17	B
		North	L	-	0	-	-	0	-	-	0	-	-	0	-	13	58	E
		North	T	155	4	A	122	3	A	144	5	A	122	4	A	97	57	E
		North	R	36	6	A	24	6	A	43	12	A	30	8	A	36	77	F
		East	L	-	0	-	-	0	-	-	0	-	-	0	-	14	4	A
		East	T	-	0	-	-	0	-	-	0	-	-	0	-	15	55	D
		East	R	-	0	-	-	0	-	-	0	-	-	0	-	9	55	D
		South	L	89	6	A	102	6	A	250	8	A	136	5	A	435	5	A
		South	T	223	6	A	204	5	A	198	7	A	178	5	A	129	36	C
		South	R	-	0	-	-	0	-	-	0	-	-	0	-	43	37	C
7	Castlereagh Road / The Driftway	North	L	33	9	A	116	9	A	3	14	A	110	19	B	2	12	A
		North	T	214	3	A	241	5	A	315	3	A	267	12	A	317	3	A
		East	L	67	11	A	165	19	B	123	15	B	190	47	D	109	16	B
		East	R	-	0	-	-	0	-	-	0	-	-	0	-	0	0	-
		South	T	383	3	A	467	13	A	543	5	A	479	15	B	493	4	A
		South	R	124	7	A	233	19	B	229	7	A	232	19	B	190	8	A

PM Peak – LOS results

Time Period: 3.30–4.30pm

ID	Intersection	Approach	Movement	2023 PM Base			2029 PM Without proposal			2029 PM With proposal (Stage 2A)			2039 PM Without proposal			2039 PM With proposal (Stage 2B)		
				Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS
1	Bells Line of Road / Grose Vale Road / Terrace Road	West	L	29	35	C	27	37	C	27	37	C	33	38	C	33	30	C
		West	T	460	42	C	395	42	C	395	42	C	398	42	C	394	37	C
		West	R	111	59	E	186	69	E	186	71	F	200	74	F	205	66	E
		North	L	137	31	C	156	29	C	156	29	C	156	27	B	156	27	B
		North	T	123	47	D	136	50	D	136	50	D	142	52	D	142	52	D
		North	R	75	49	D	84	51	D	84	51	D	86	48	D	86	48	D
		East	L	507	26	B	587	27	B	619	32	C	576	28	B	675	37	C
		East	T	610	40	C	571	40	C	578	45	D	573	41	C	601	43	D
		East	R	221	60	E	225	62	E	229	63	E	230	61	E	235	74	F
		South	L	7	48	D	40	54	D	43	55	D	40	54	D	41	56	D
		South	T	30	69	E	46	76	F	60	64	E	47	72	F	59	62	E
		South	R	274	63	E	241	63	E	291	50	D	261	68	E	320	54	D
2	Kurrajong Road / Old Kurrajong Road / Bells Line Of Road (Base / Do Nothing) Kurrajong Road / Richmond bypass / Bells Line Of Road (With proposal)	West	L	21	13	A	20	8	A	-	0	-	24	9	A	-	0	-
		West	T	715	11	A	713	7	A	717	6	A	754	8	A	656	6	A
		West	R	193	55	D	111	20	B	130	32	C	116	22	B	244	36	C
		North	L	9	22	B	1	17	B	-	0	-	2	108	F	-	0	-
		North	T	15	44	D	20	39	C	-	0	-	13	131	F	-	0	-
		North	R	1	173	F	1	152	F	-	0	-	1	262	F	-	0	-
		East	L	-	0	-	-	0	-	-	0	-	-	0	-	0	0	-
		East	T	938	71	F	936	51	D	879	32	C	958	58	E	864	29	C
		East	R	4	105	F	3	45	D	-	0	-	4	52	D	-	0	-
		South	L	550	8	A	597	7	A	703	29	C	570	8	A	807	42	C
		South	T	0	0	-	0	68	E	-	0	-	3	75	F	-	0	-
		South	R	-	0	-	-	0	-	0	0	-	-	0	-	4	89	F
3	March Street / Bosworth Street	West	L	80	15	B	83	9	A	66	12	A	28	11	A	79	14	A
		West	T	345	14	A	428	13	A	460	14	A	482	12	A	451	12	A
		West	R	286	62	E	281	57	E	266	50	D	312	69	E	216	40	C
		North	L	14	26	B	4	22	B	4	30	C	10	28	B	5	34	C
		North	T	146	32	C	84	25	B	108	25	B	98	26	B	97	25	B
		North	R	205	47	D	52	32	C	51	33	C	41	29	C	50	32	C
		East	L	39	80	F	49	54	D	49	50	D	60	52	D	56	52	D
		East	T	540	84	F	589	51	D	572	50	D	576	49	D	569	45	D
		South	L	232	51	D	301	57	E	232	55	D	358	63	E	230	46	D
		South	T	157	58	E	136	53	D	161	62	E	115	58	E	158	53	D
		South	R	68	61	E	91	59	E	91	67	E	98	59	E	115	61	E
4	Castlereagh Road / Inalls Lane / Southee Road (Base / Do Nothing) Richmond bypass / Castlereagh Road (With proposal)	West	L	19	9	A	27	10	A	29	10	A	24	10	A	33	12	A
		West	T	29	14	A	13	17	B	53	10	A	17	17	B	147	14	A
		West	R	-	0	-	-	0	-	37	10	A	-	0	-	55	13	A
		North	L	33	3	A	21	2	A	53	4	A	23	2	A	71	6	A
		North	T	321	5	A	318	5	A	292	5	A	326	6	A	291	8	A
		North	R	92	12	A	95	11	A	105	5	A	108	12	A	120	9	A
		East	L	18	17	B	37	17	B	48	16	B	35	17	B	67	19	B
		East	T	132	18	B	118	19	B	385	16	B	118	17	B	499	17	B

ID	Intersection	Approach	Movement	2023 PM Base			2029 PM Without proposal			2029 PM With proposal (Stage 2A)			2039 PM Without proposal			2039 PM With proposal (Stage 2B)		
				Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS
		East	R	34	10	A	56	11	A	54	15	B	53	12	A	154	17	B
		South	L	11	5	A	3	7	A	205	44	D	2	5	A	196	24	B
		South	T	270	3	A	292	3	A	276	47	D	292	3	A	293	24	B
		South	R	9	6	A	9	8	A	6	44	D	7	7	A	20	23	B
5	Richmond bypass / Valder Avenue (Local road connection)	West	L	14	2	A	17	2	A	16	2	A	16	2	A	39	5	A
		West	T	48	1	A	17	1	A	85	2	A	22	1	A	197	2	A
		North	L	10	1	A	14	1	A	14	2	A	21	1	A	31	3	A
		North	R	14	2	A	13	3	A	13	6	A	10	2	A	29	8	A
		East	T	169	1	A	200	1	A	481	3	A	199	2	A	707	6	A
		East	R	19	6	A	17	2	A	18	3	A	24	3	A	46	11	A
6	Richmond bypass / Londonderry Road	West	L	15	5	A	14	5	A	11	6	A	18	4	A	37	7	A
		West	T	-	0	-	-	0	-	-	0	-	-	0	-	7	24	B
		West	R	48	9	A	19	8	A	91	10	A	27	8	A	183	31	C
		North	L	-	0	-	-	0	-	-	0	-	-	0	-	9	20	B
		North	T	266	6	A	239	7	A	234	9	A	237	7	A	220	17	B
		North	R	54	9	A	51	9	A	82	15	B	53	9	A	93	33	C
		East	L	-	0	-	-	0	-	-	0	-	-	0	-	74	4	A
		East	T	-	0	-	-	0	-	-	0	-	-	0	-	36	43	D
		East	R	-	0	-	-	0	-	-	0	-	-	0	-	2	55	D
		South	L	113	6	A	146	5	A	400	7	A	158	5	A	628	5	A
		South	T	223	6	A	185	5	A	181	7	A	185	5	A	95	23	B
		South	R	-	0	-	-	0	-	-	0	-	-	0	-	21	22	B
7	Castlereagh Road / The Driftway	North	L	41	10	A	65	12	A	0	0	-	61	13	A	0	0	-
		North	T	366	5	A	341	8	A	377	4	A	352	8	A	407	4	A
		East	L	231	21	B	438	45	D	236	21	B	455	68	E	192	20	B
		East	R	13	28	B	1	43	D	5	27	B	1	62	E	16	31	C
		South	T	409	3	A	432	5	A	514	3	A	404	7	A	524	3	A
		South	R	51	10	A	131	12	A	140	7	A	149	14	A	144	8	A

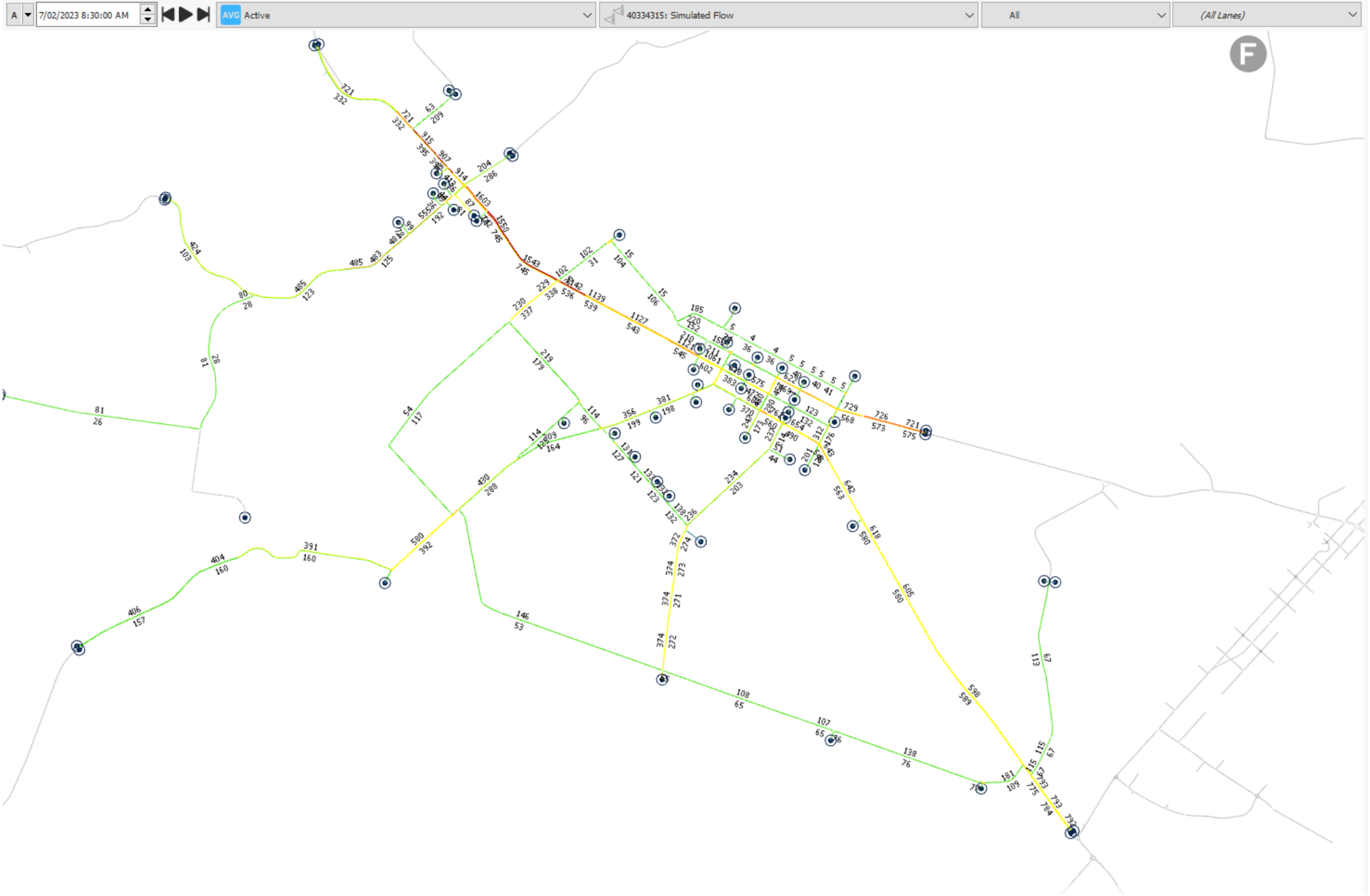
PM Peak – LOS results

Time Period: 4.30–5.30pm

ID	Intersection	Approach	Movement	2023 PM Base			2029 PM Without proposal			2029 PM With proposal (Stage 2A)			2039 PM Without proposal			2039 PM With proposal (Stage 2B)		
				Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS
1	Bells Line of Road / Grose Vale Road / Terrace Road	West	L	31	39	C	30	42	C	30	42	C	32	41	C	32	31	C
		West	T	406	42	C	392	43	D	392	43	D	377	45	D	371	39	C
		West	R	99	55	D	182	67	E	182	66	E	208	79	F	212	63	E
		North	L	150	27	B	153	29	C	153	29	C	163	28	B	163	28	B
		North	T	138	50	D	130	48	D	130	48	D	141	54	D	141	54	D
		North	R	70	46	D	78	42	C	78	42	C	77	45	D	77	45	D
		East	L	555	27	B	616	28	B	681	33	C	620	29	C	735	39	C
		East	T	635	46	D	657	45	D	680	55	D	660	48	D	673	48	D
		East	R	235	68	E	231	60	E	238	64	E	221	61	E	232	77	F
		South	L	10	41	C	38	56	D	38	52	D	46	60	E	40	60	E
		South	T	31	68	E	49	73	F	64	70	F	59	87	F	67	71	F
		South	R	297	51	D	254	58	E	309	48	D	275	58	E	325	49	D
2	Kurrajong Road / Old Kurrajong Road / Bells Line Of Road (Base / Do Nothing) Kurrajong Road / Richmond bypass / Bells Line Of Road (With proposal)	West	L	10	14	A	18	10	A	-	0	-	25	8	A	-	0	-
		West	T	739	9	A	751	8	A	741	6	A	775	8	A	683	6	A
		West	R	193	30	C	109	21	B	137	34	C	122	25	B	220	37	C
		North	L	1	47	D	2	11	A	-	0	-	10	28	B	-	0	-
		North	T	6	46	D	17	111	F	-	0	-	26	51	D	-	0	-
		North	R	3	121	F	3	290	F	-	0	-	5	98	F	-	0	-
		East	L	0	0	-	-	0	-	1	0	-	-	0	-	0	0	-
		East	T	863	177	F	948	143	F	947	33	C	935	221	F	892	30	C
		East	R	3	170	F	2	177	F	-	0	-	3	272	F	-	0	-
		South	L	692	31	C	674	9	A	771	31	C	690	16	B	867	46	D
		South	T	1	0	-	3	69	E	-	0	-	10	84	F	-	0	-
		South	R	-	0	-	-	0	-	-	0	-	-	0	-	4	74	F
3	March Street / Bosworth Street	West	L	85	17	B	78	11	A	70	15	B	33	11	A	64	13	A
		West	T	371	16	B	471	15	B	471	15	B	539	13	A	502	15	B
		West	R	294	67	E	282	96	F	270	66	E	290	77	F	214	44	D
		North	L	18	26	B	3	26	B	7	21	B	4	37	C	4	38	C
		North	T	181	26	B	82	22	B	100	22	B	91	26	B	96	25	B
		North	R	123	31	C	44	26	B	40	25	B	39	26	B	47	27	B
		East	L	40	90	F	39	92	F	38	77	F	46	84	F	43	71	F
		East	T	486	90	F	611	91	F	606	72	F	598	86	F	602	70	F
		South	L	217	41	C	294	52	D	247	41	C	260	47	D	209	38	C
		South	T	175	50	D	128	52	D	133	47	D	114	50	D	134	47	D
		South	R	80	57	E	98	52	D	90	51	D	101	53	D	118	52	D
4	Castlereagh Road / Inalls Lane / Southee Road (Base / Do Nothing) Richmond bypass / Castlereagh Road (With proposal)	West	L	18	10	A	27	10	A	33	11	A	24	11	A	28	13	A
		West	T	32	18	B	21	18	B	56	11	A	15	21	B	143	15	B
		West	R	-	0	-	0	0	-	40	9	A	-	0	-	60	14	A
		North	L	49	4	A	22	3	A	45	5	A	19	5	A	64	7	A
		North	T	329	10	A	325	8	A	312	6	A	352	14	A	318	8	A
		North	R	165	15	B	130	16	B	119	6	A	142	22	B	116	8	A
		East	L	22	19	B	33	20	B	38	18	B	33	25	B	64	20	B
		East	T	132	19	B	162	20	B	414	18	B	195	26	B	510	18	B

ID	Intersection	Approach	Movement	2023 PM Base			2029 PM Without proposal			2029 PM With proposal (Stage 2A)			2039 PM Without proposal			2039 PM With proposal (Stage 2B)		
				Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS	Volume	Delay	LOS
		East	R	47	11	A	62	12	A	48	19	B	53	14	A	166	17	B
		South	L	10	5	A	4	5	A	218	49	D	2	6	A	213	23	B
		South	T	279	4	A	288	3	A	306	53	D	306	3	A	311	25	B
		South	R	7	8	A	11	7	A	9	56	D	10	7	A	26	25	B
5	Richmond bypass / Valder Avenue (Local road connection)	West	L	15	2	A	15	2	A	15	3	A	16	2	A	40	5	A
		West	T	67	1	A	31	1	A	89	2	A	21	1	A	195	3	A
		North	L	10	1	A	15	1	A	14	1	A	13	2	A	25	4	A
		North	R	17	2	A	9	4	A	9	7	A	13	5	A	31	9	A
		East	T	186	2	A	249	2	A	500	3	A	269	2	A	709	6	A
		East	R	27	4	A	18	3	A	19	4	A	23	3	A	45	10	A
6	Richmond bypass / Londonderry Road	West	L	15	6	A	16	5	A	13	7	A	14	6	A	34	6	A
		West	T	-	0	-	-	0	-	-	0	-	-	0	-	5	23	B
		West	R	65	10	A	23	7	A	84	11	A	22	11	A	181	30	C
		North	L	-	0	-	-	0	-	-	0	-	-	0	-	10	18	B
		North	T	285	6	A	259	7	A	262	9	A	264	8	A	244	18	B
		North	R	64	10	A	59	10	A	72	16	B	62	11	A	94	35	C
		East	L	-	0	-	-	0	-	-	0	-	-	0	-	79	4	A
		East	T	-	0	-	-	0	-	-	0	-	-	0	-	37	46	D
		East	R	-	0	-	-	0	-	-	0	-	-	0	-	3	70	F
		South	L	138	4	A	194	4	A	421	6	A	216	4	A	622	6	A
		South	T	208	3	A	181	4	A	190	6	A	194	5	A	92	23	B
		South	R	-	0	-	-	0	-	-	0	-	-	0	-	16	20	B
7	Castlereagh Road / The Driftway	North	L	25	9	A	57	11	A	0	0	-	65	12	A	1	0	-
		North	T	391	6	A	356	7	A	393	4	A	390	8	A	443	4	A
		East	L	246	23	B	452	40	C	241	19	B	461	64	E	197	20	B
		East	R	8	25	B	1	38	C	1	36	C	2	54	D	9	30	C
		South	T	378	2	A	398	6	A	517	4	A	368	7	A	550	4	A
		South	R	54	8	A	147	12	A	148	8	A	146	12	A	146	9	A

2023 AM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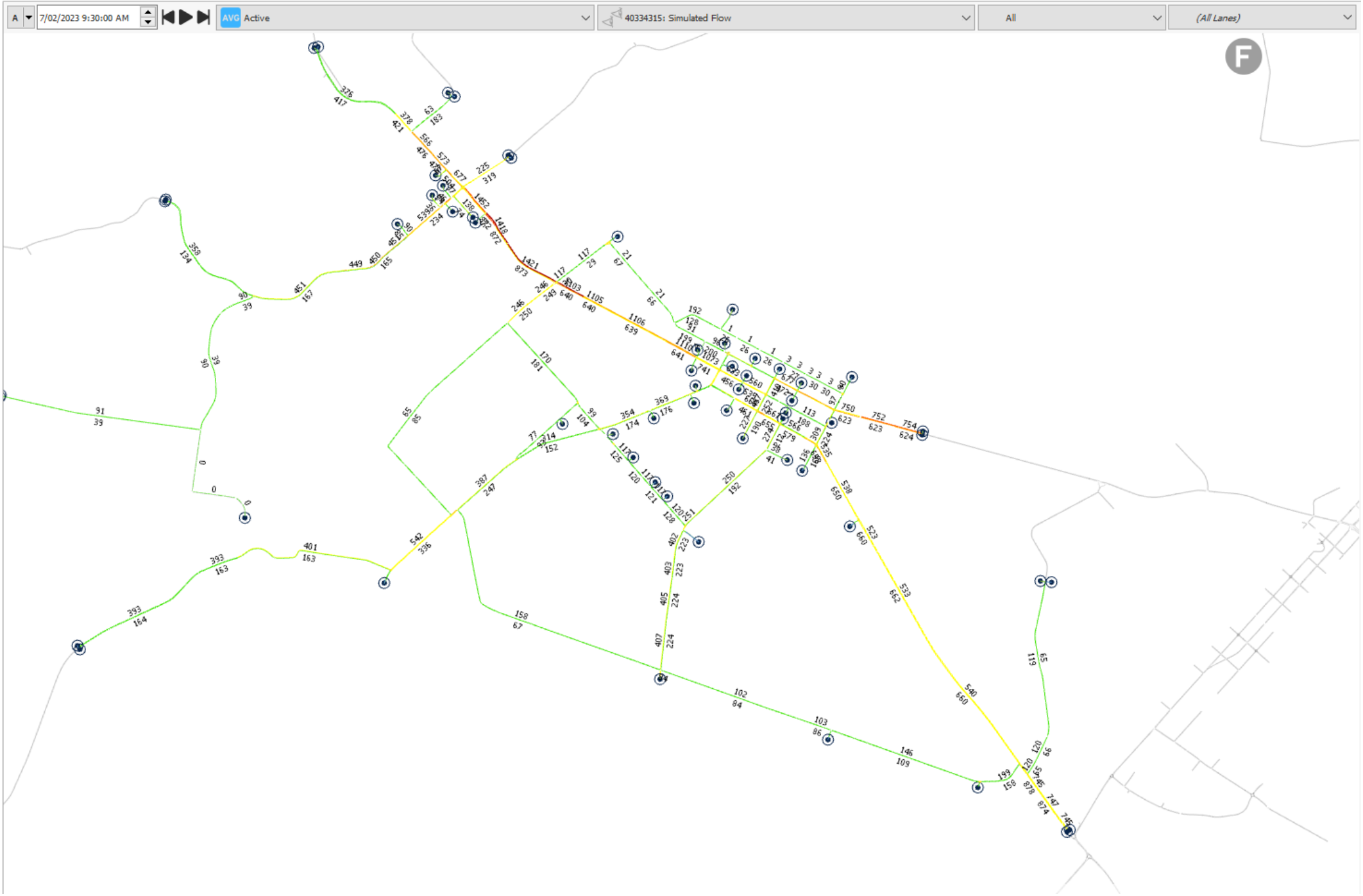
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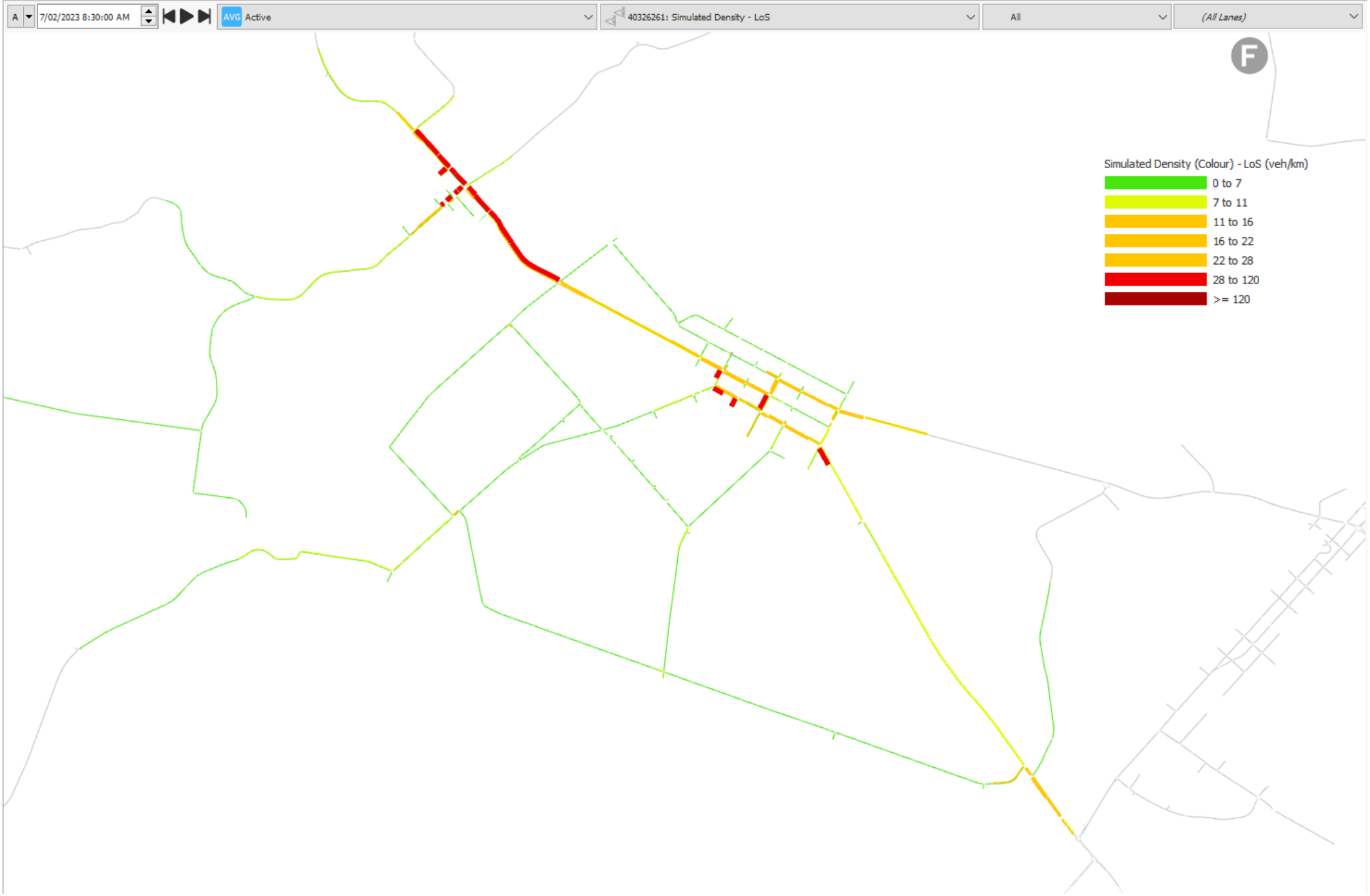
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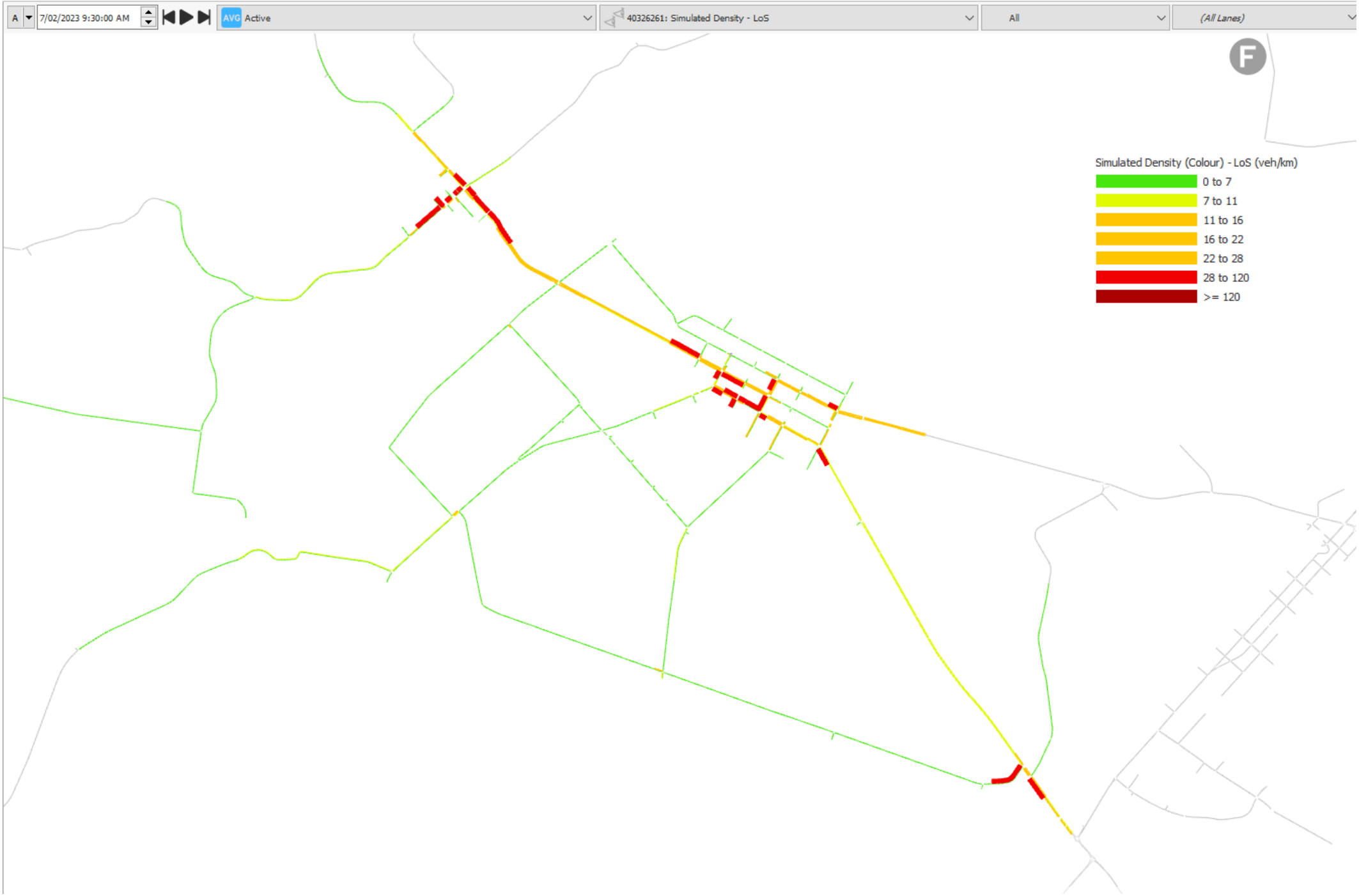
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120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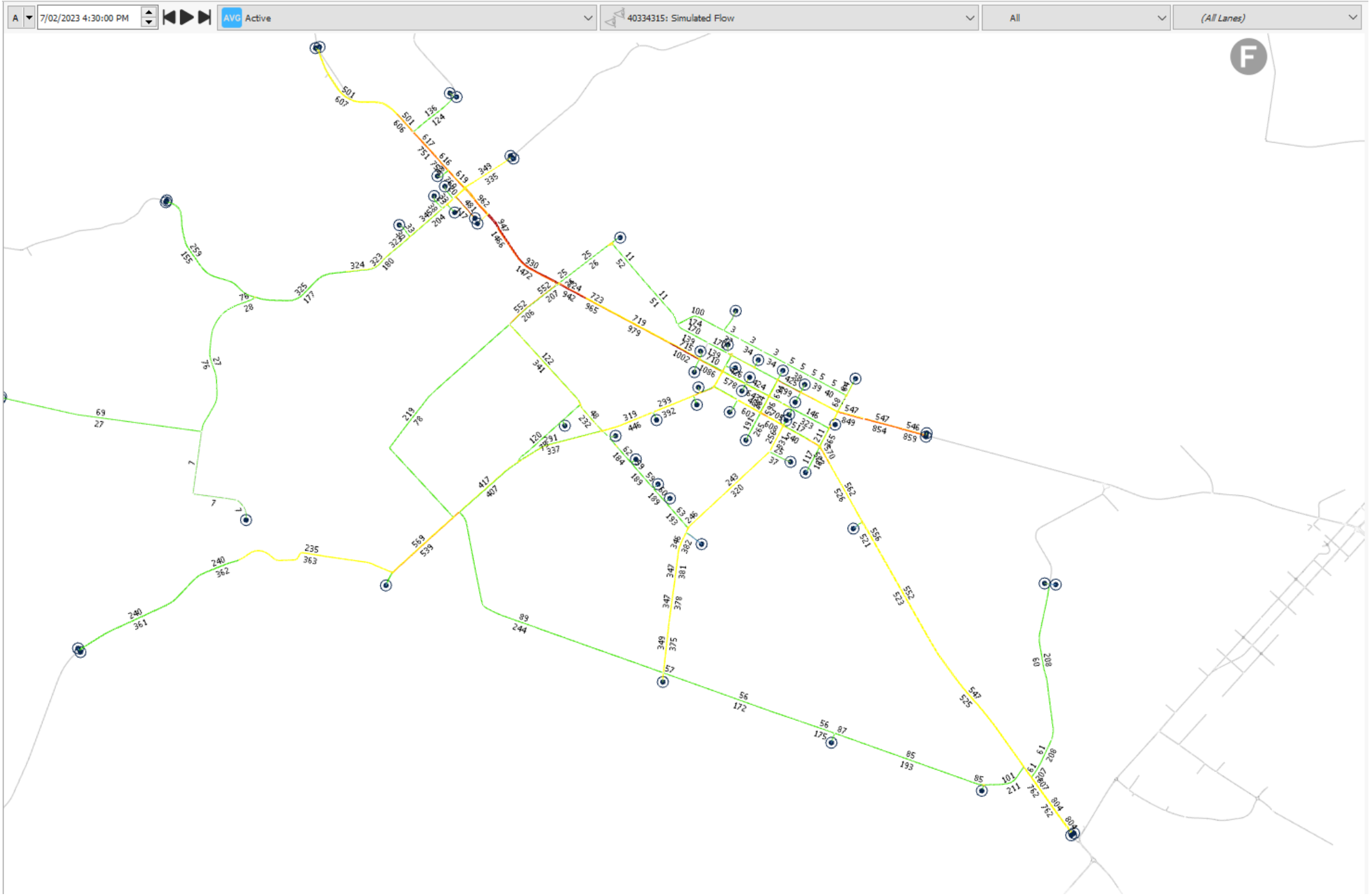
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120

2023 PM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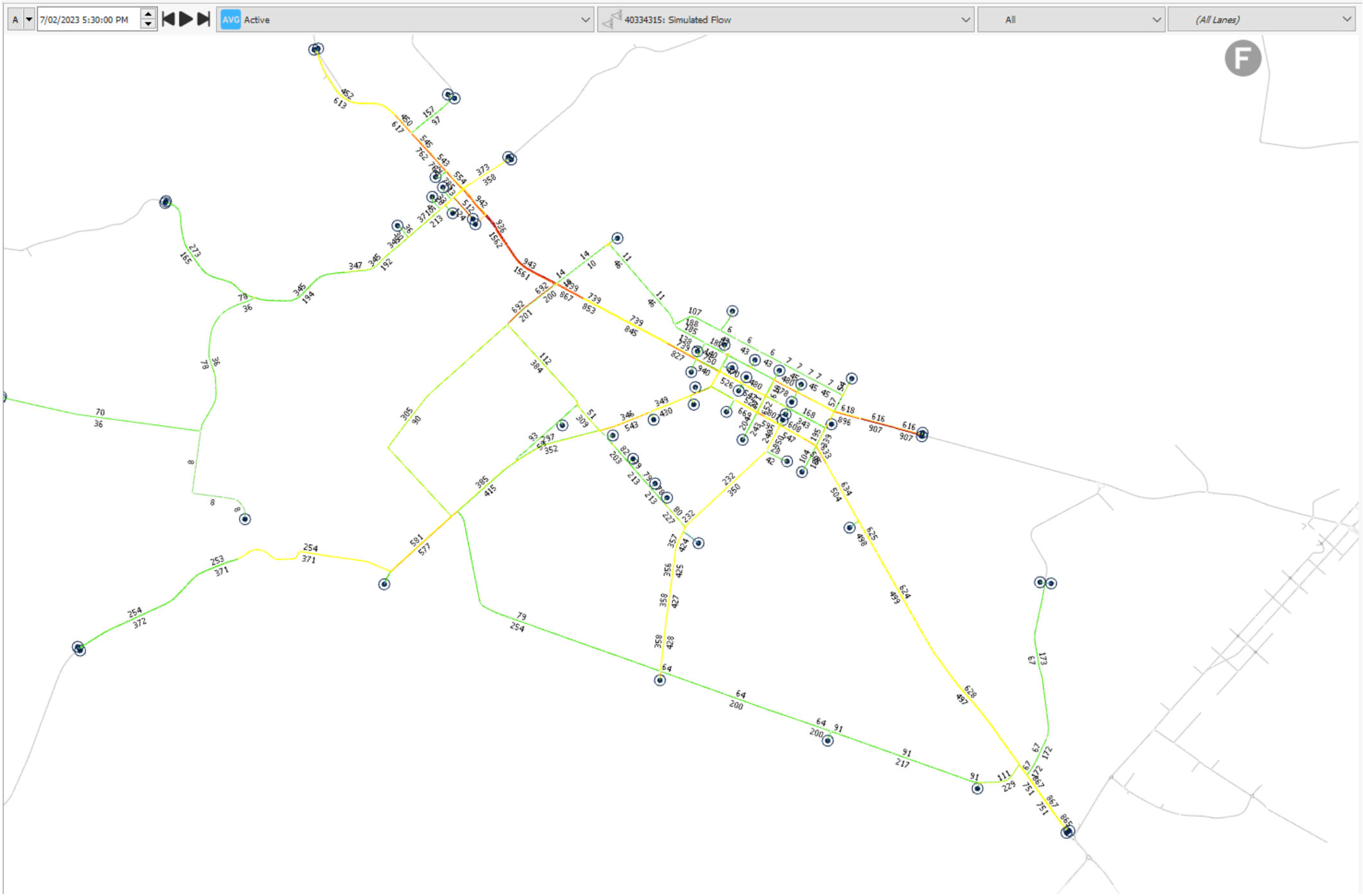
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(All Lanes)
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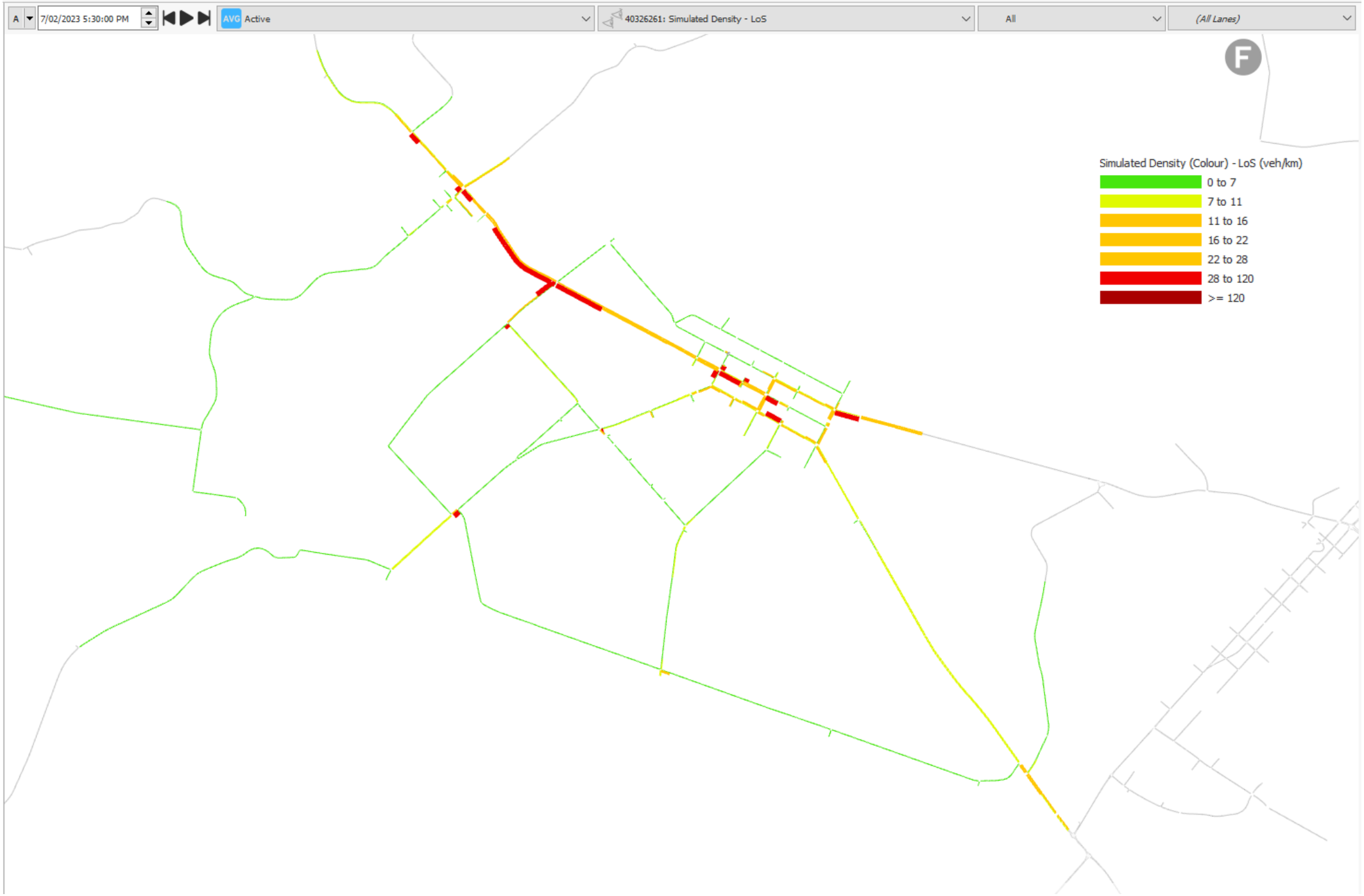
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120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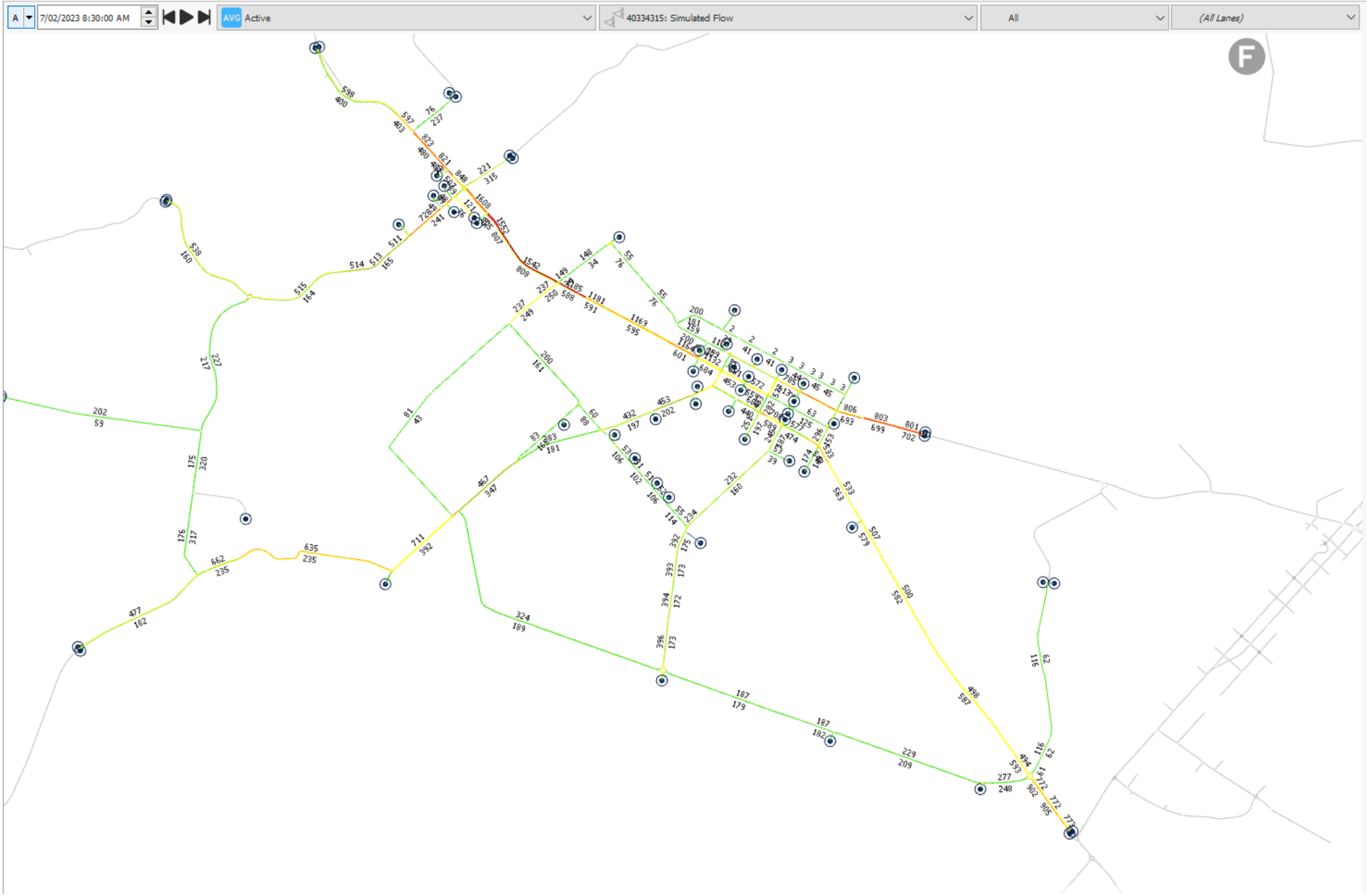
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120

2029 AM DM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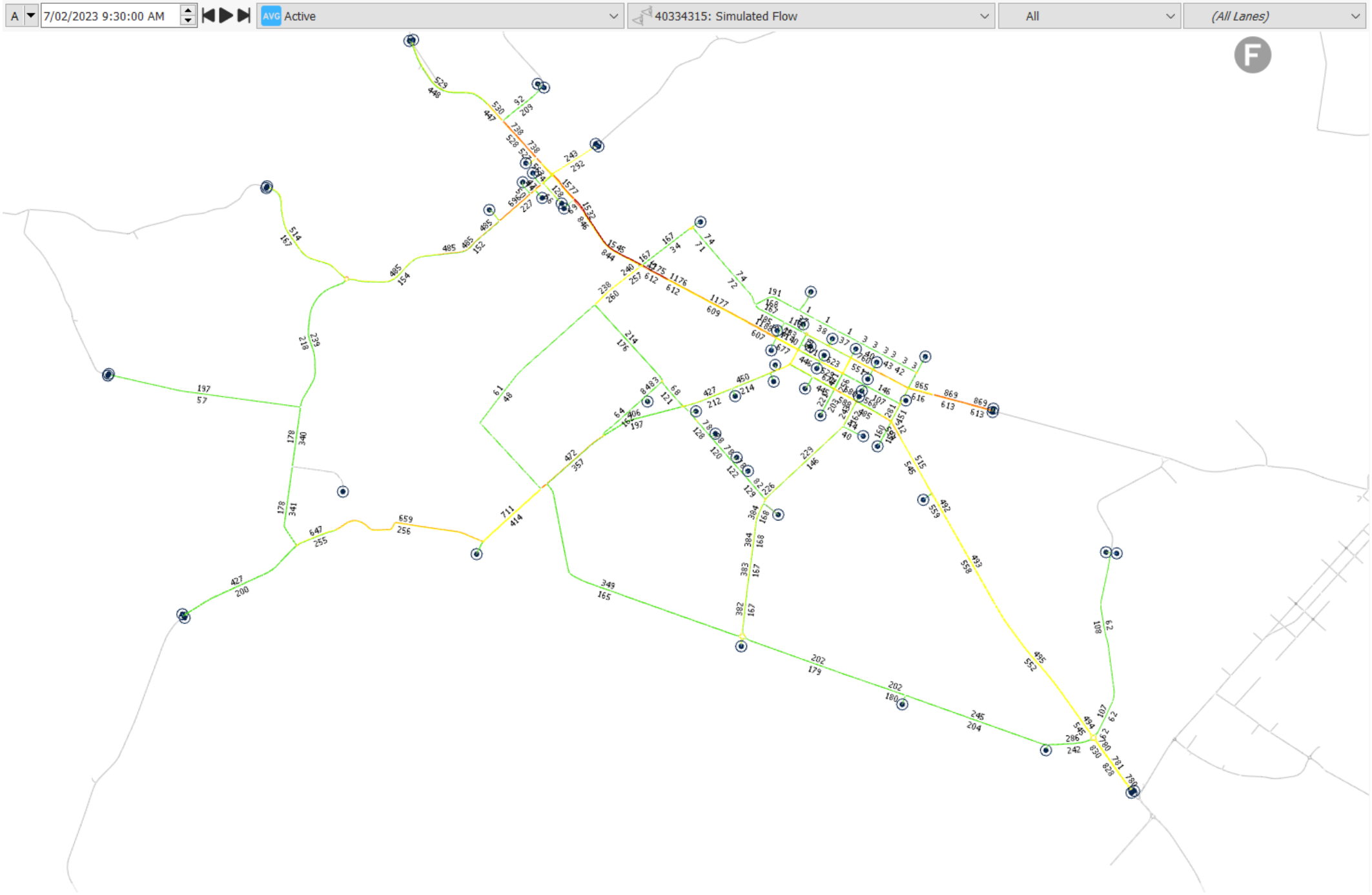
All
(All Lanes)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All
(All Lanes)
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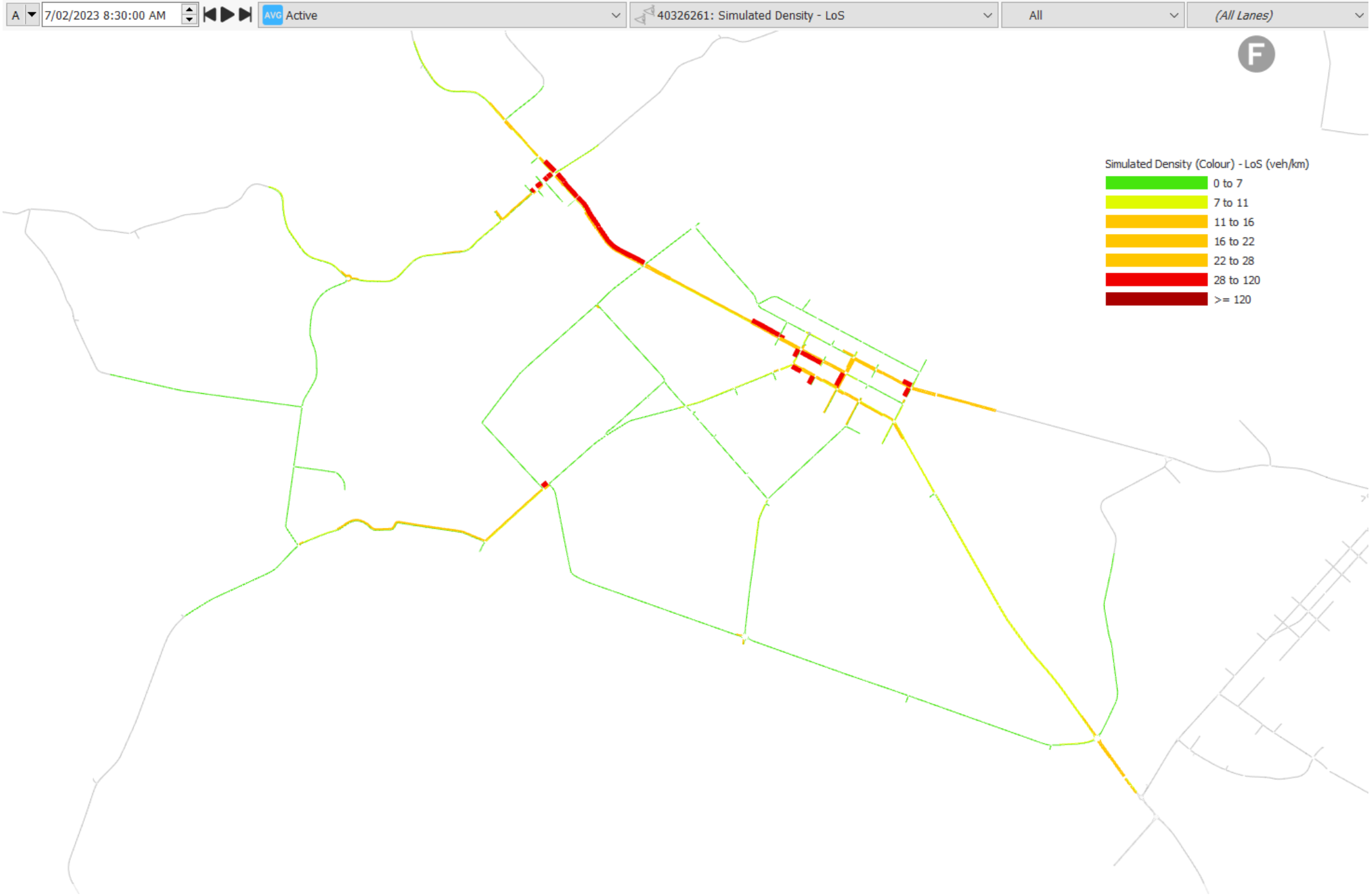
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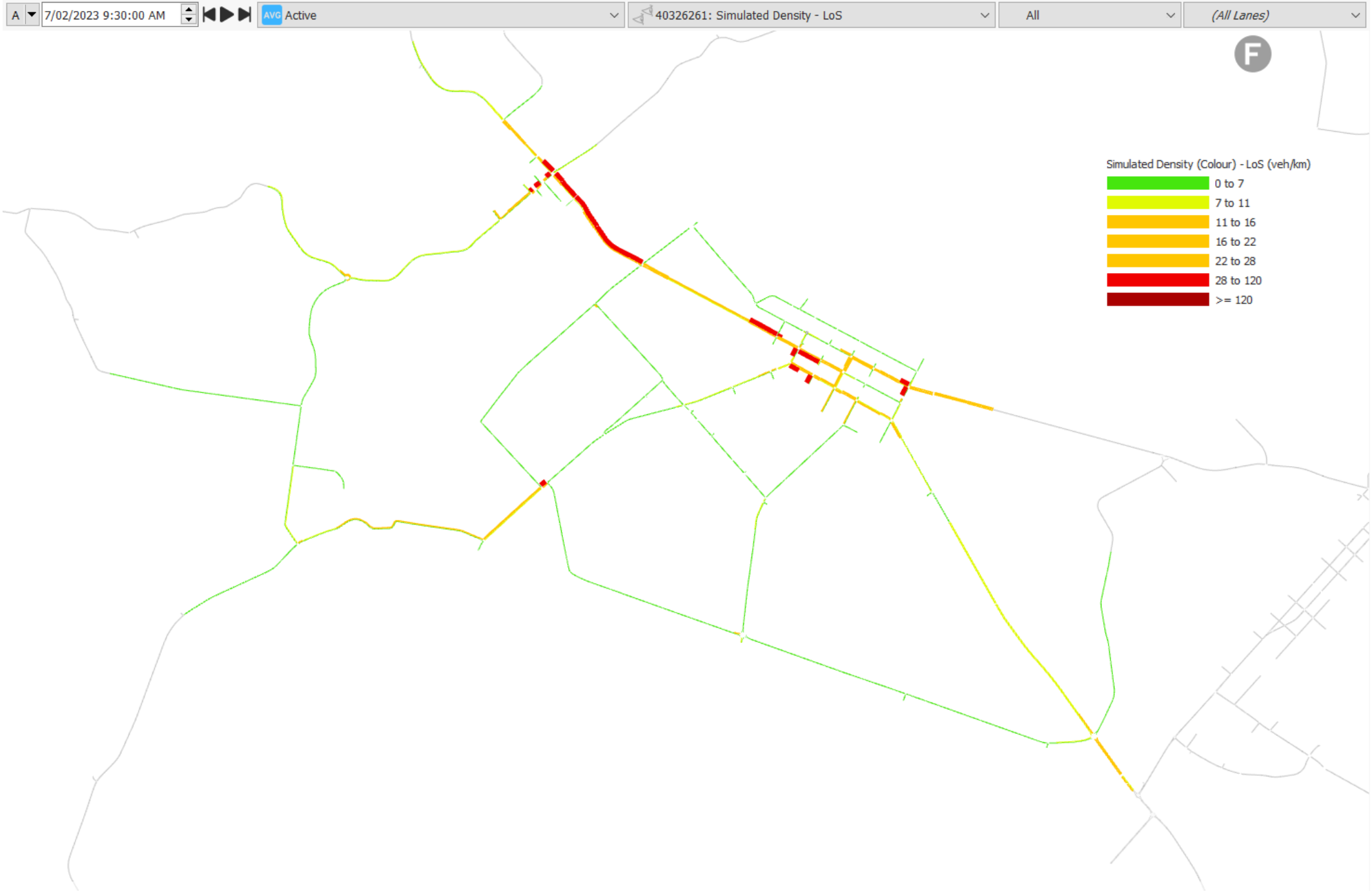
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120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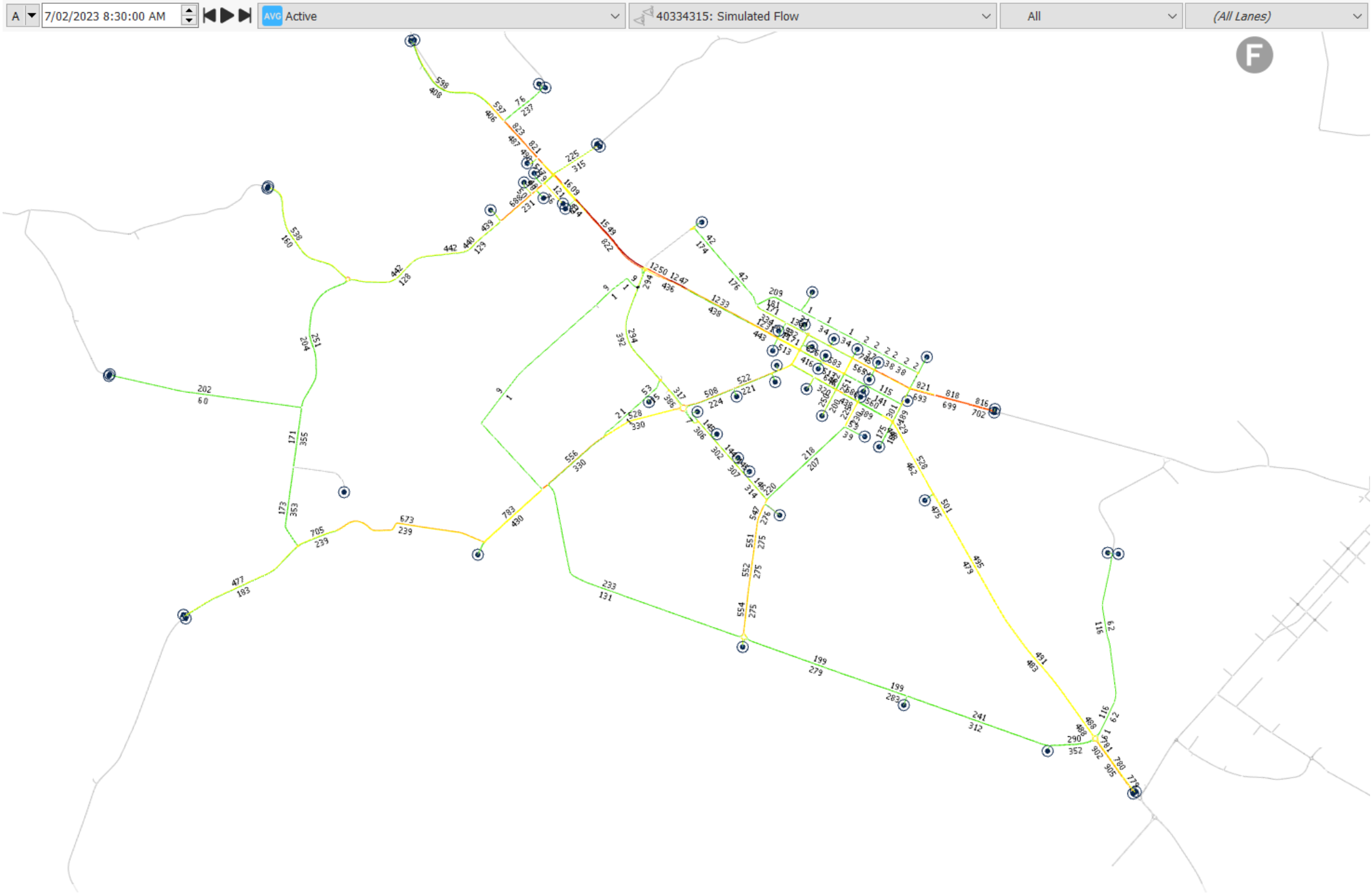
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120

2029 AM PC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(All Lanes)
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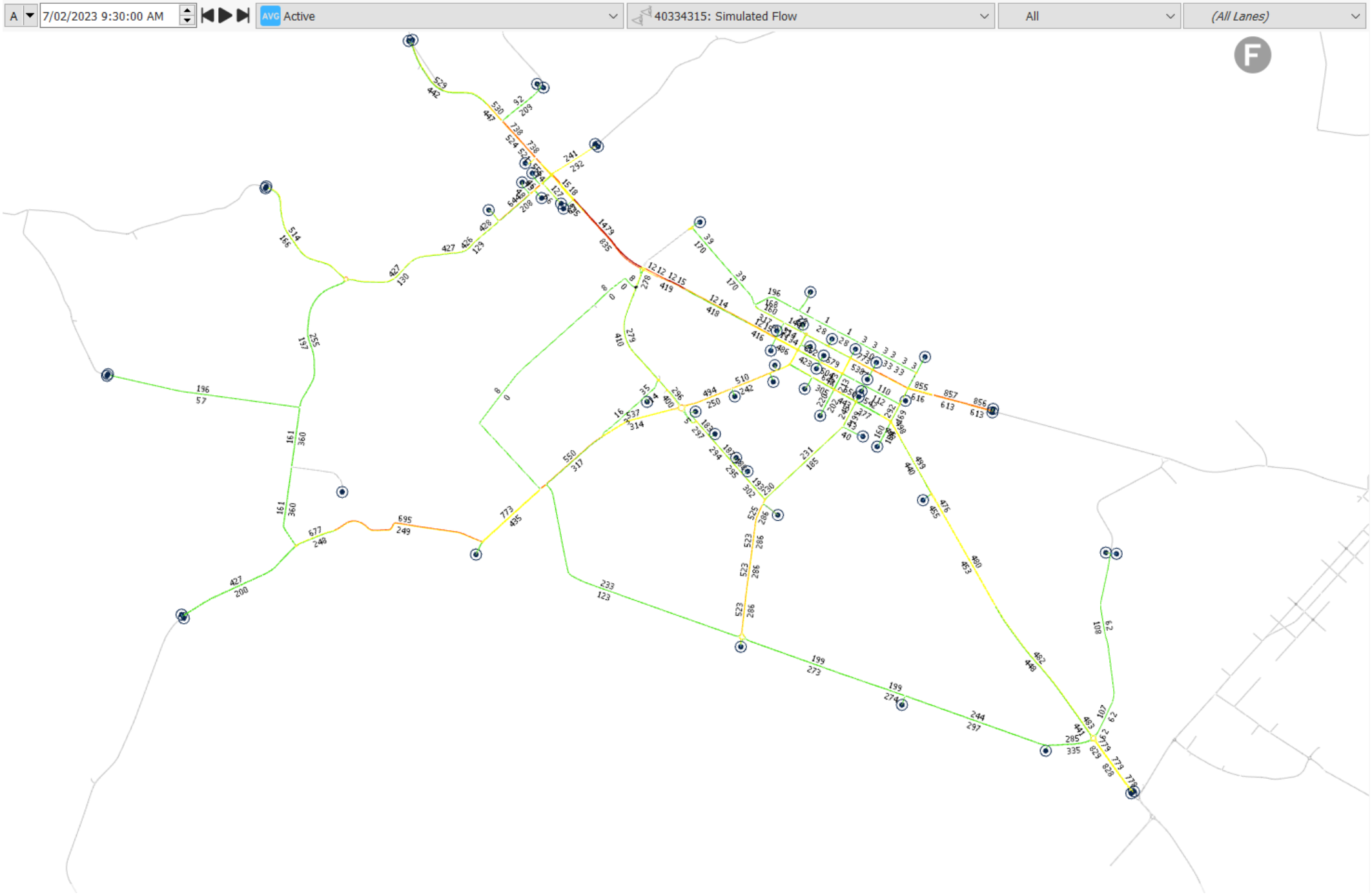
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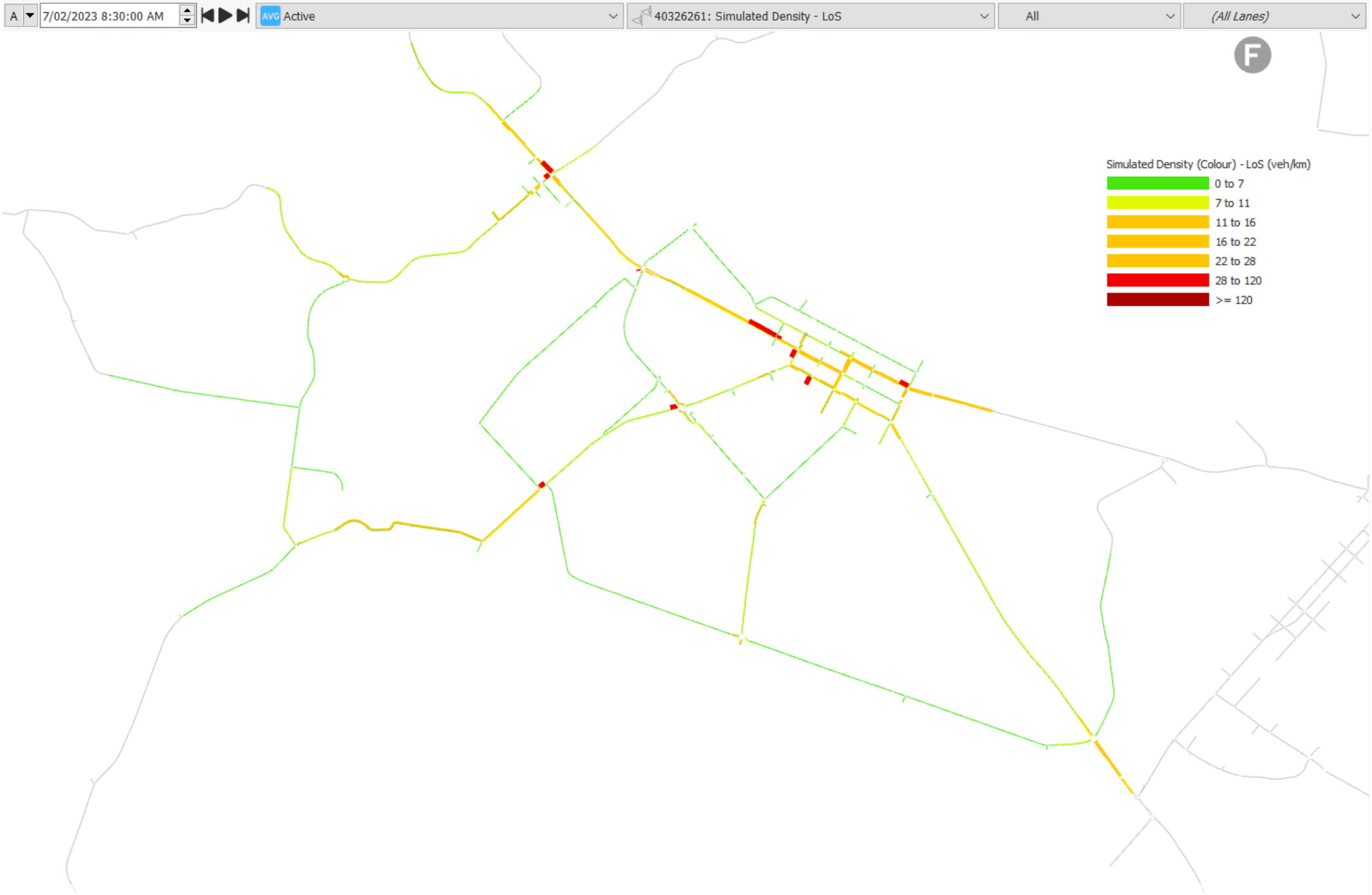
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(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
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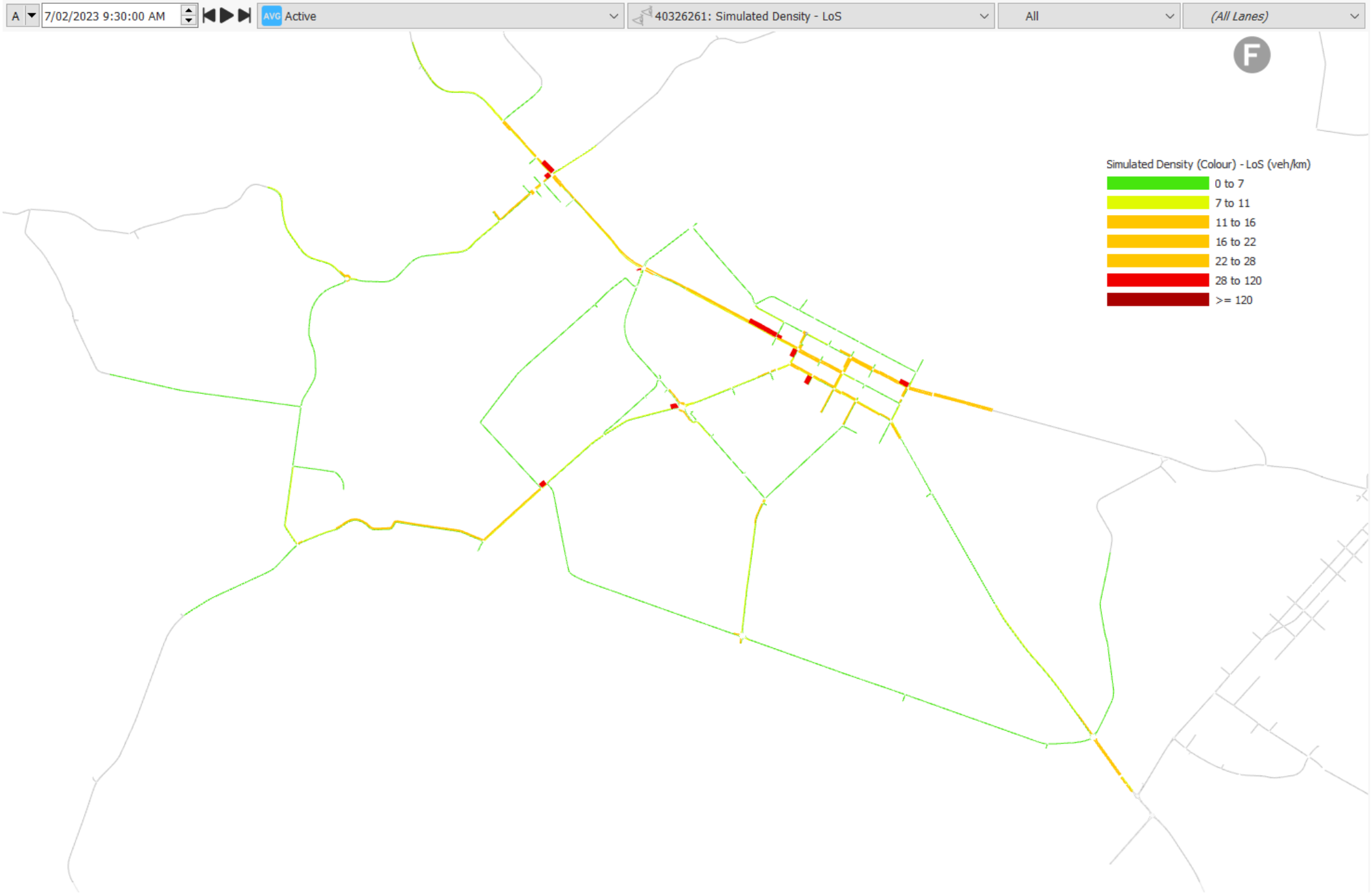
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120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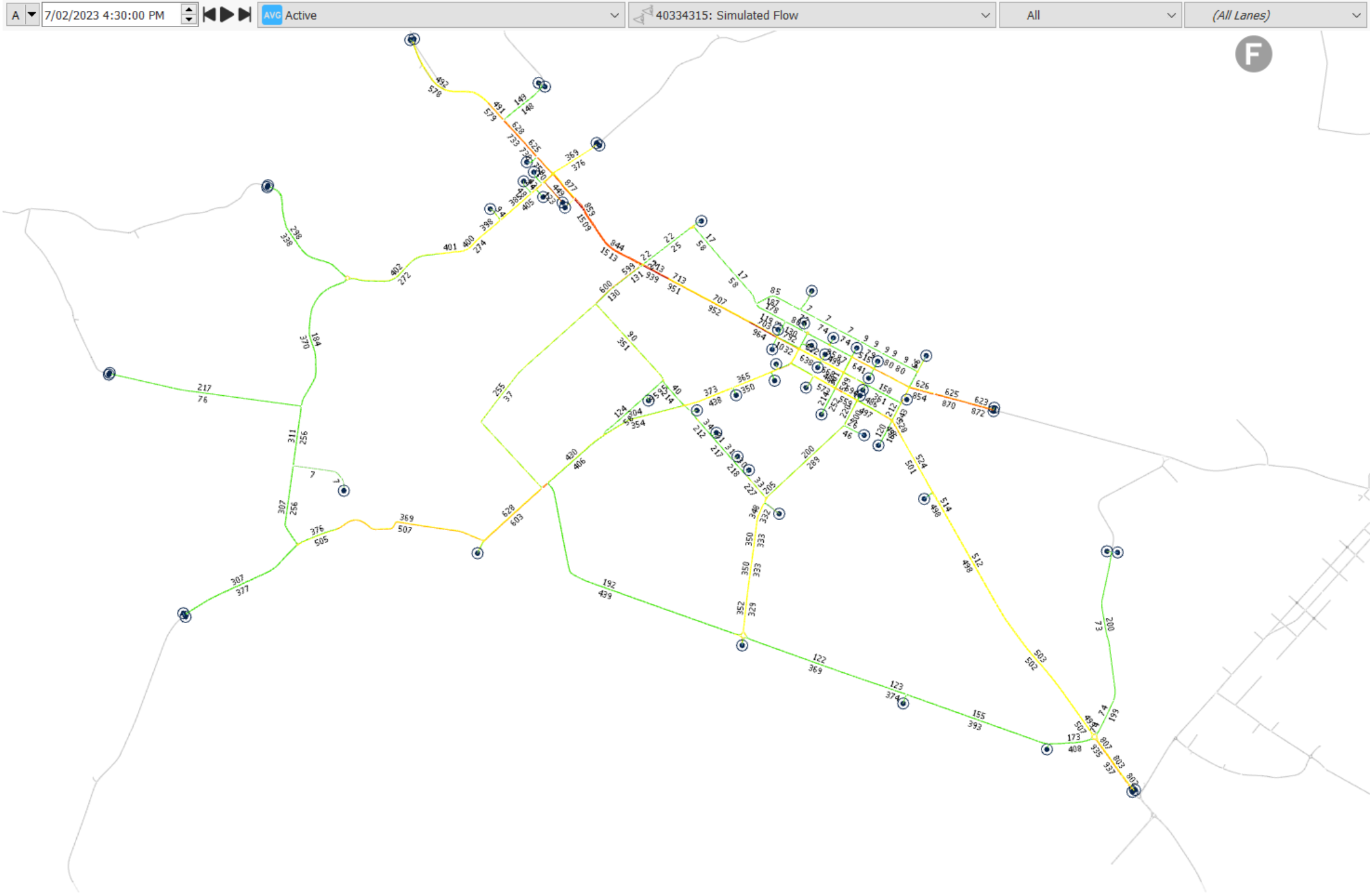
AVG Active
40326261: Simulated Density - LoS
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120

2029 PM DM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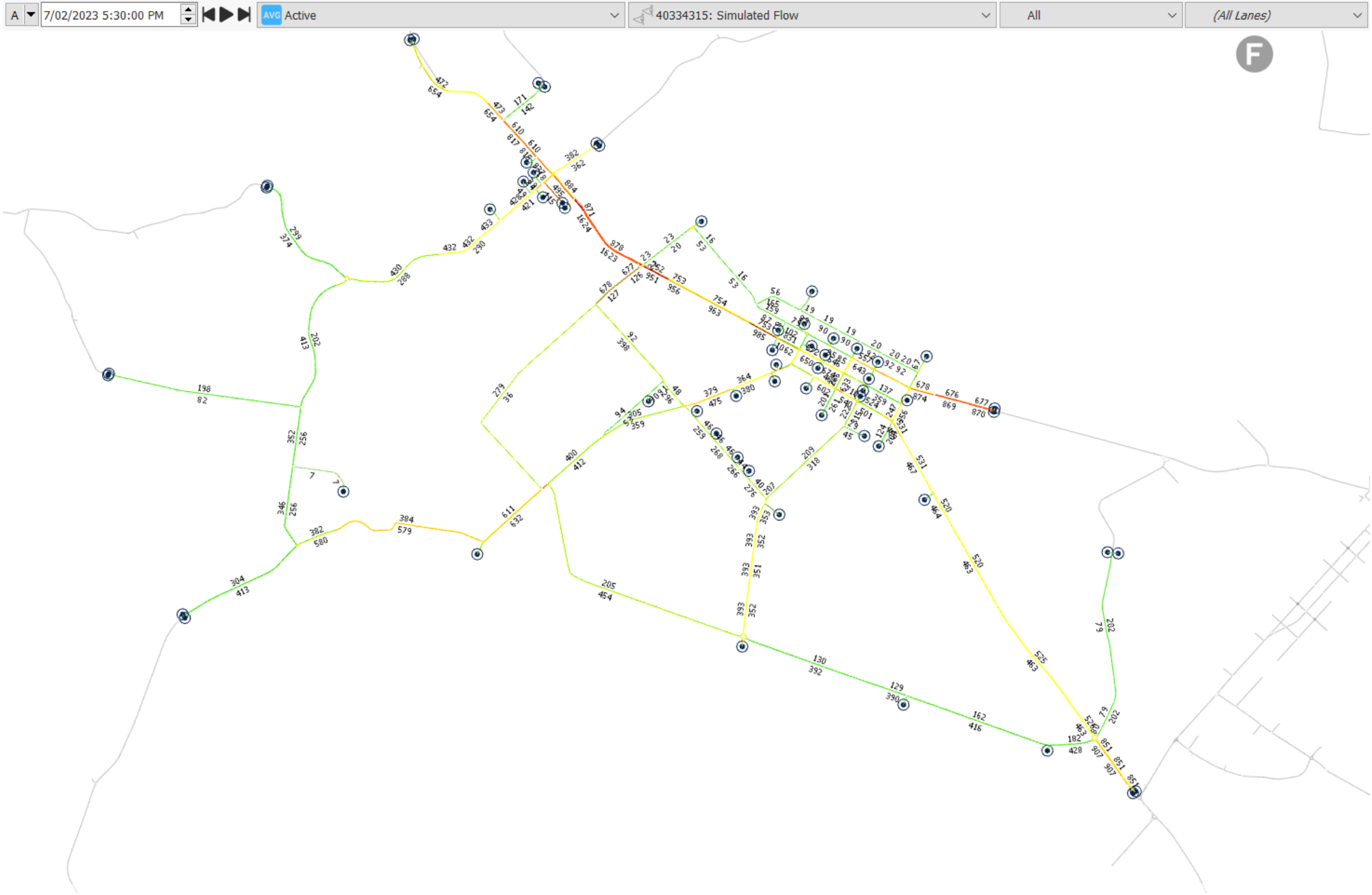
40334315: Simulated Flow
All
(All Lanes)
F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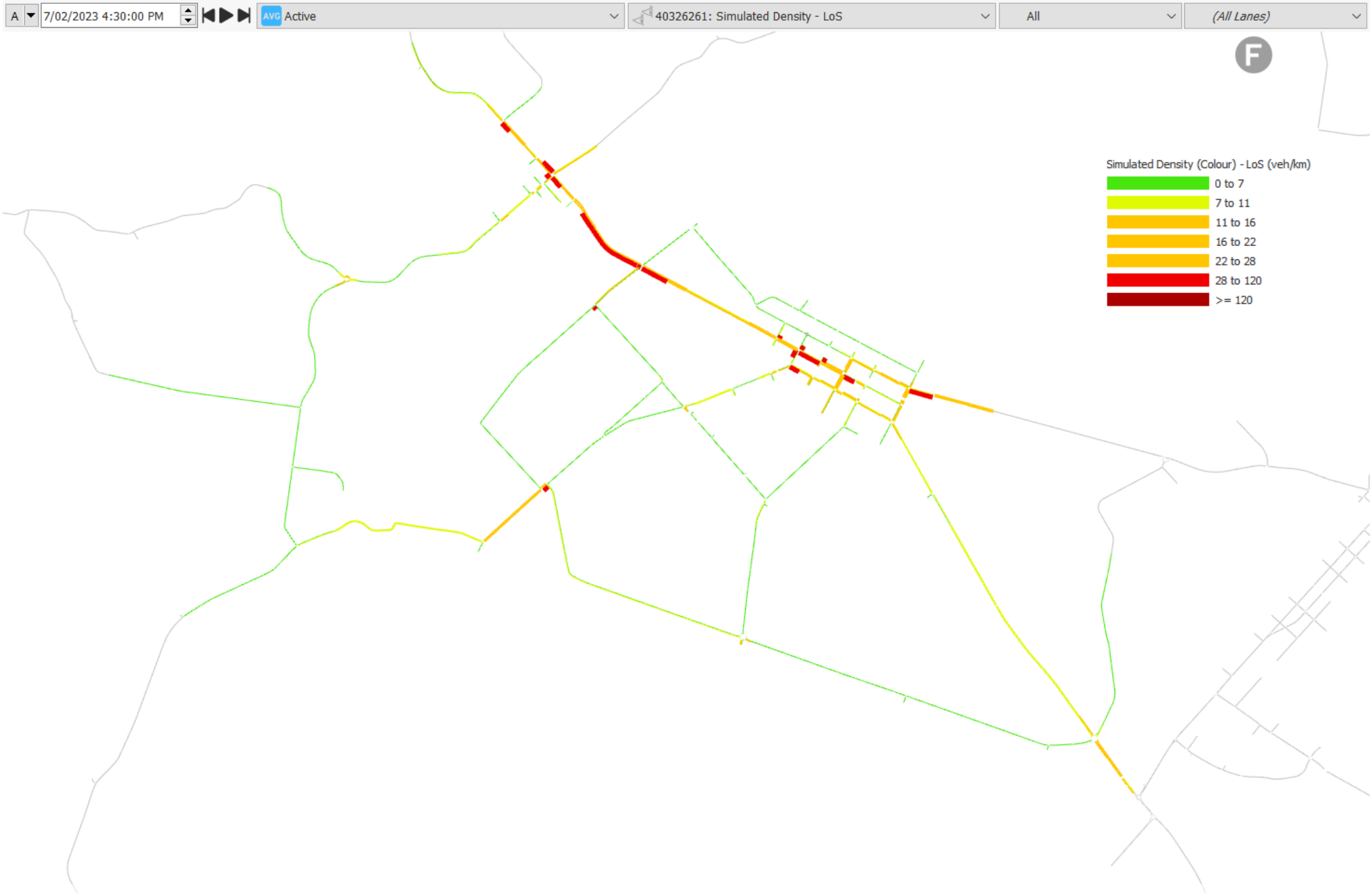
AVG Active
40334315: Simulated Flow
All
(All Lanes)
F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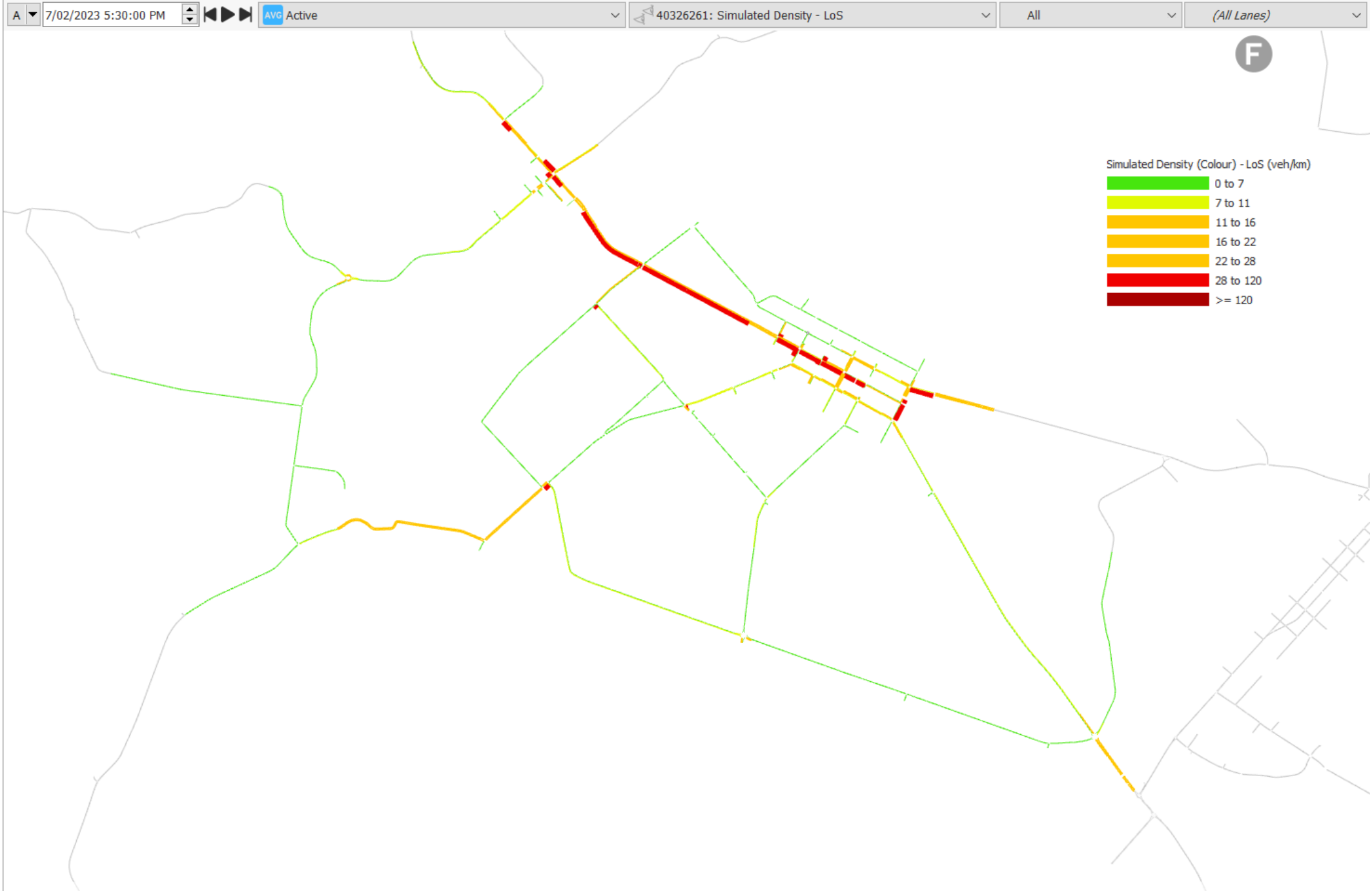
AVG Active
40326261: Simulated Density - LoS
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120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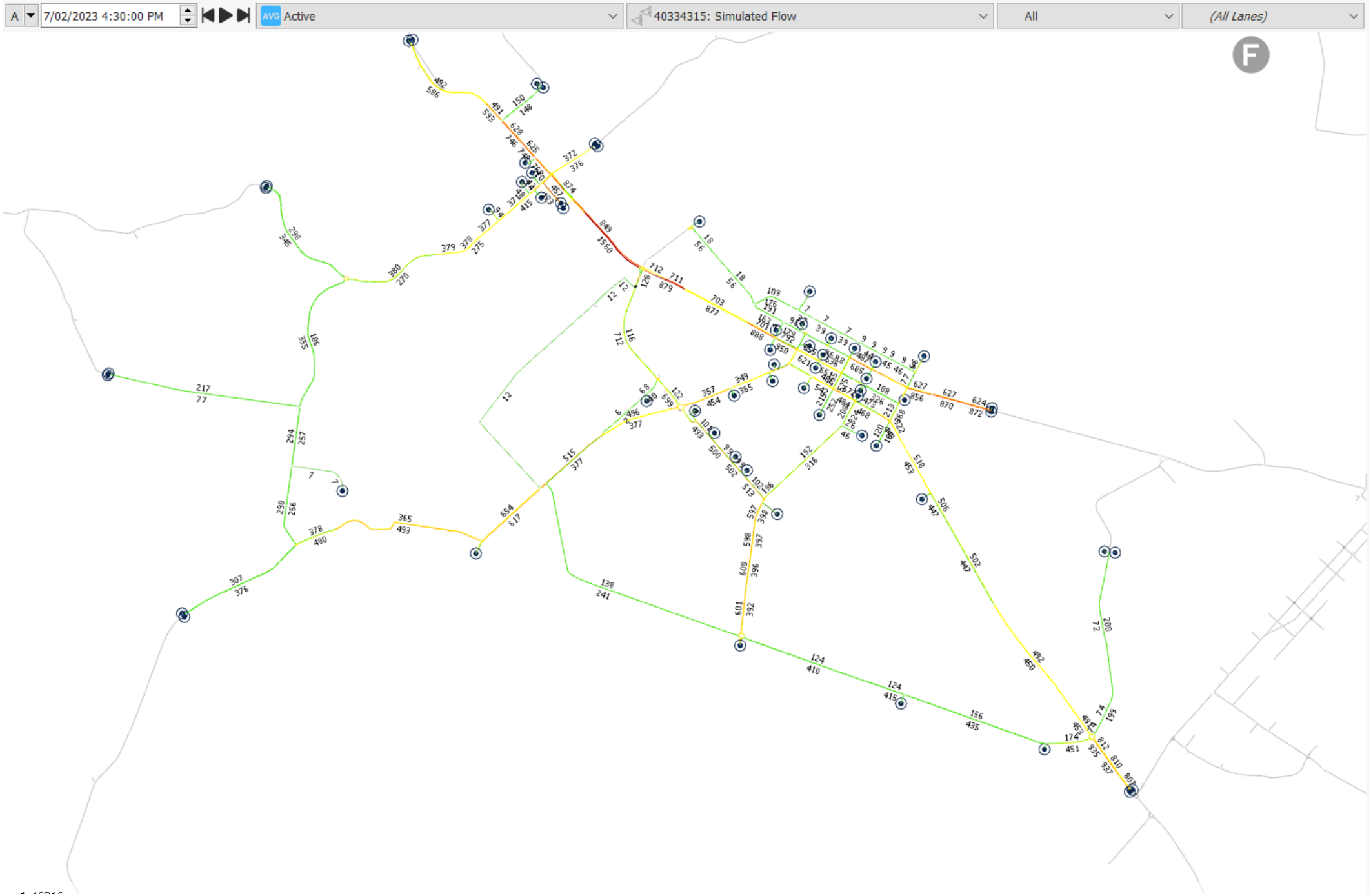
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120

2029 PM PC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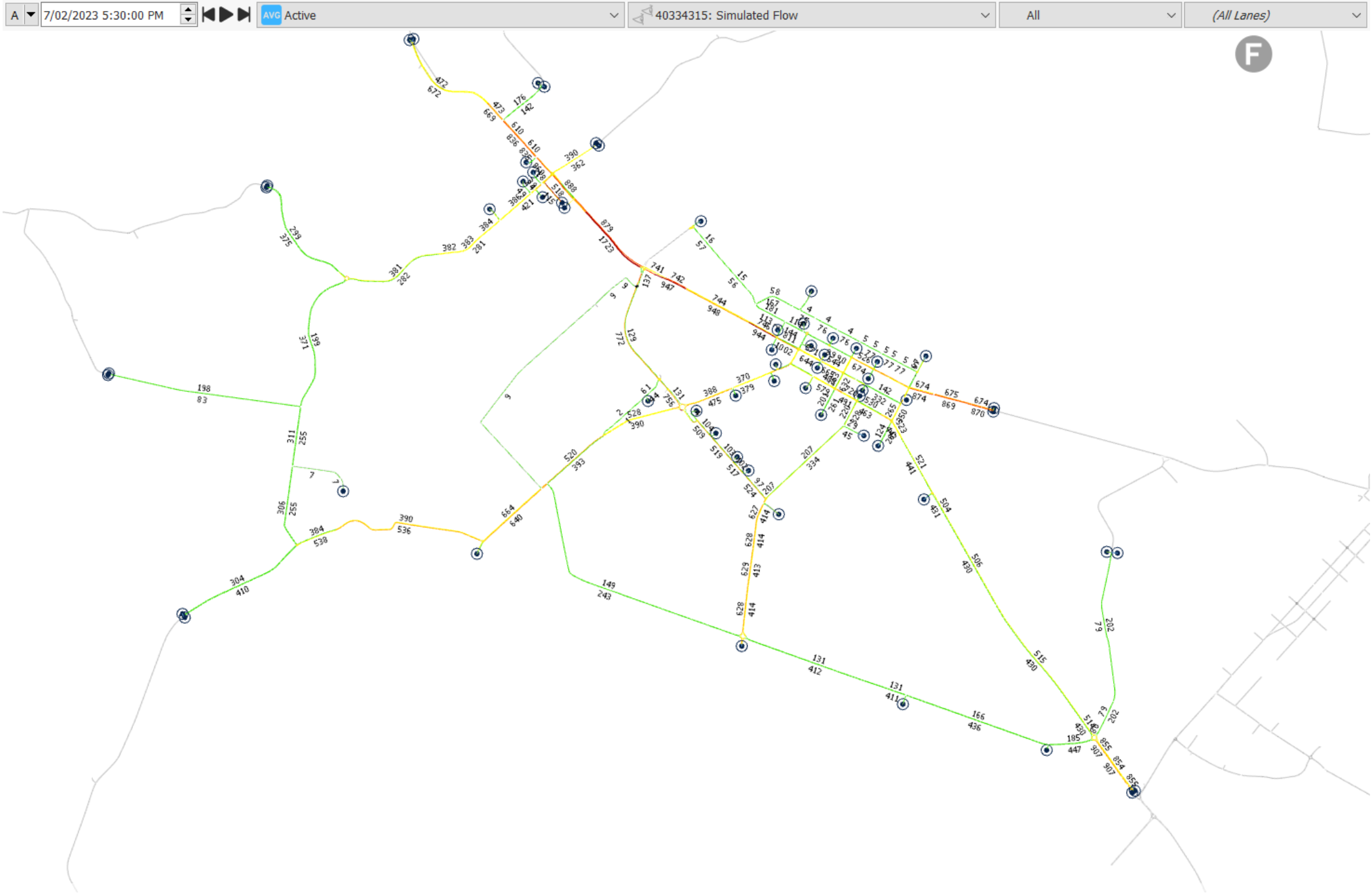
All
(All Lanes)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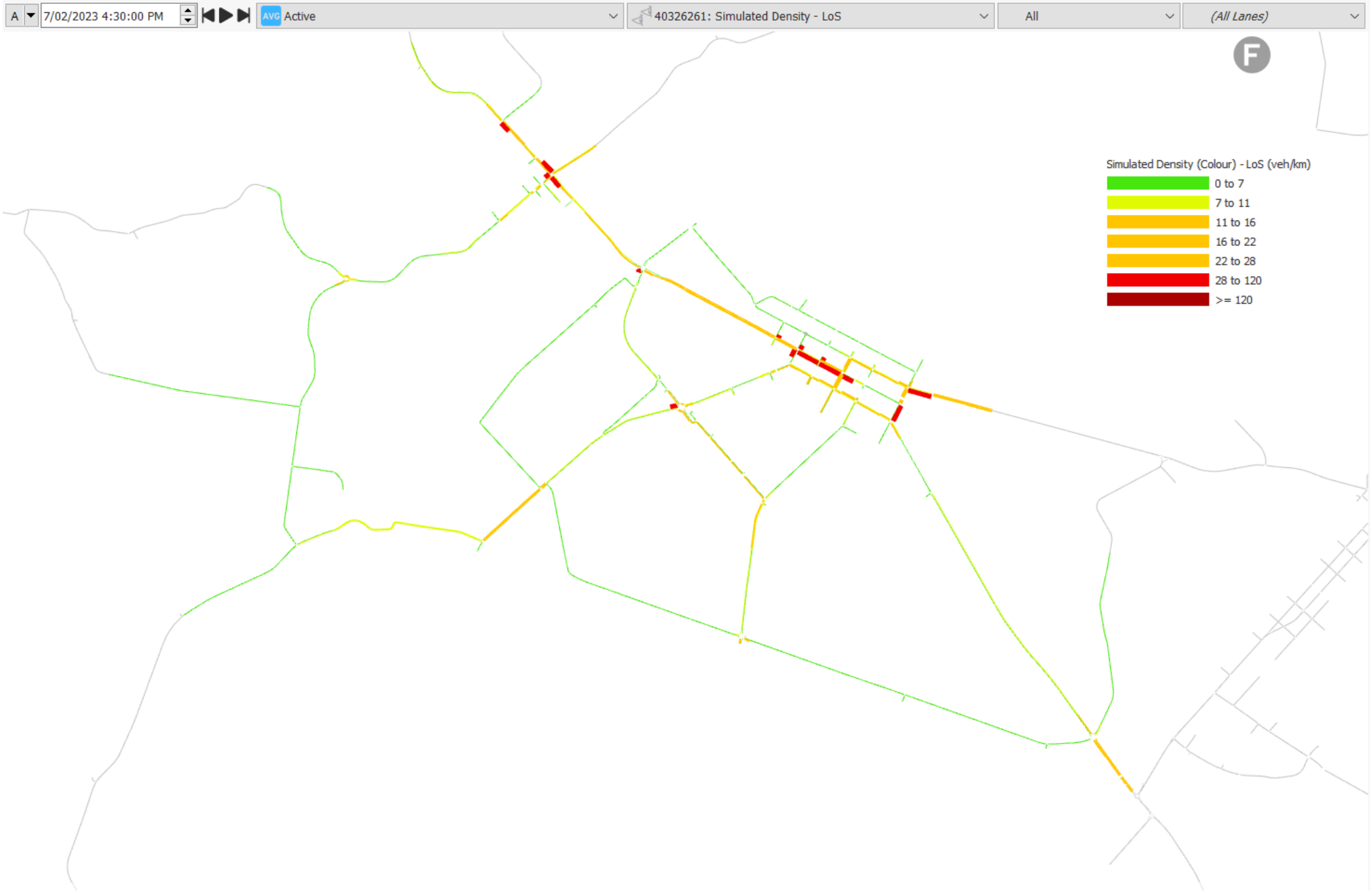
AVG Active
40334315: Simulated Flow
All
(All Lanes)
F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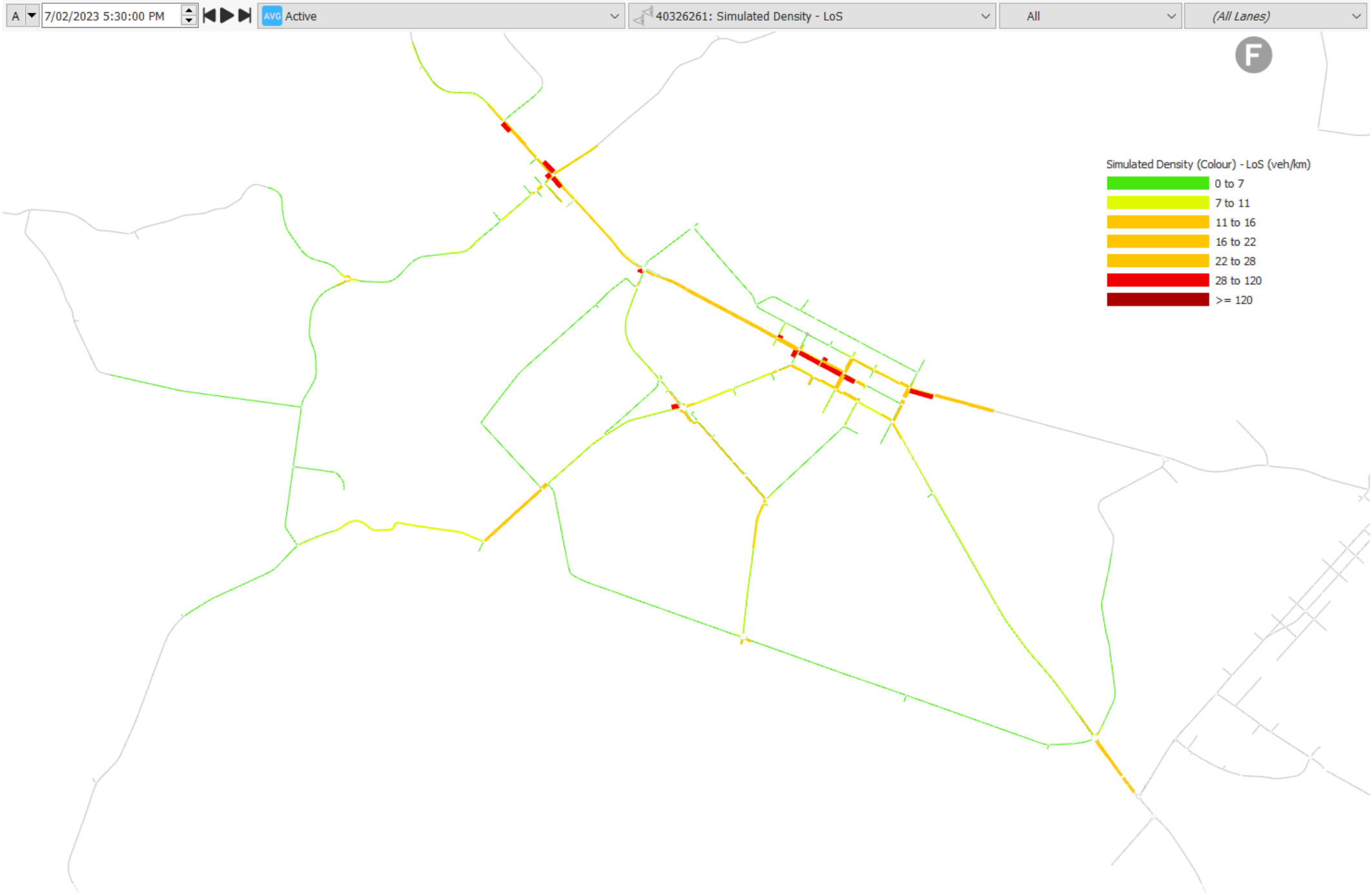
AVG Active
40326261: Simulated Density - LoS
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120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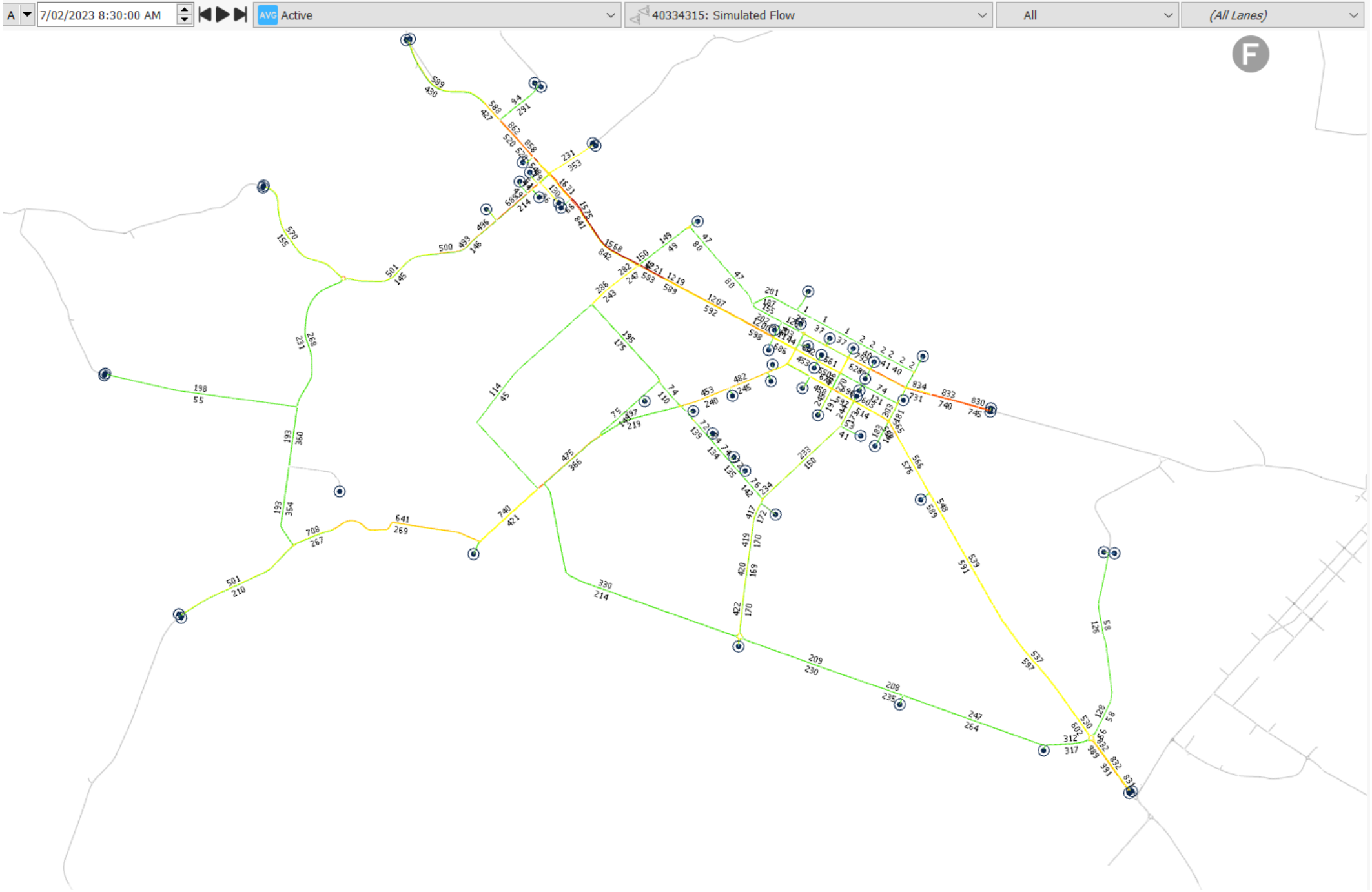
40326261: Simulated Density - LoS
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120

2039 AM DM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AVG Active
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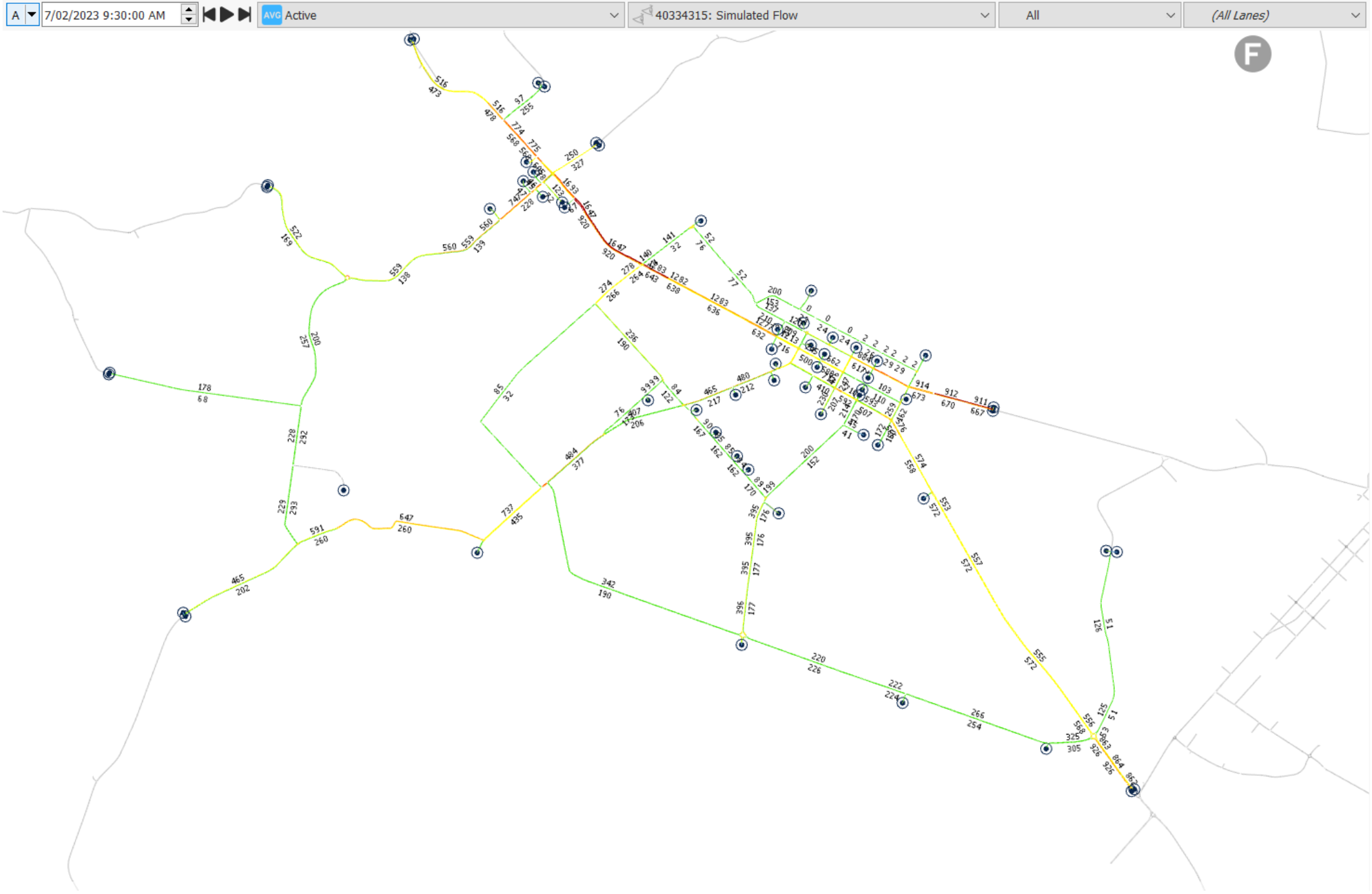
All
(All Lanes)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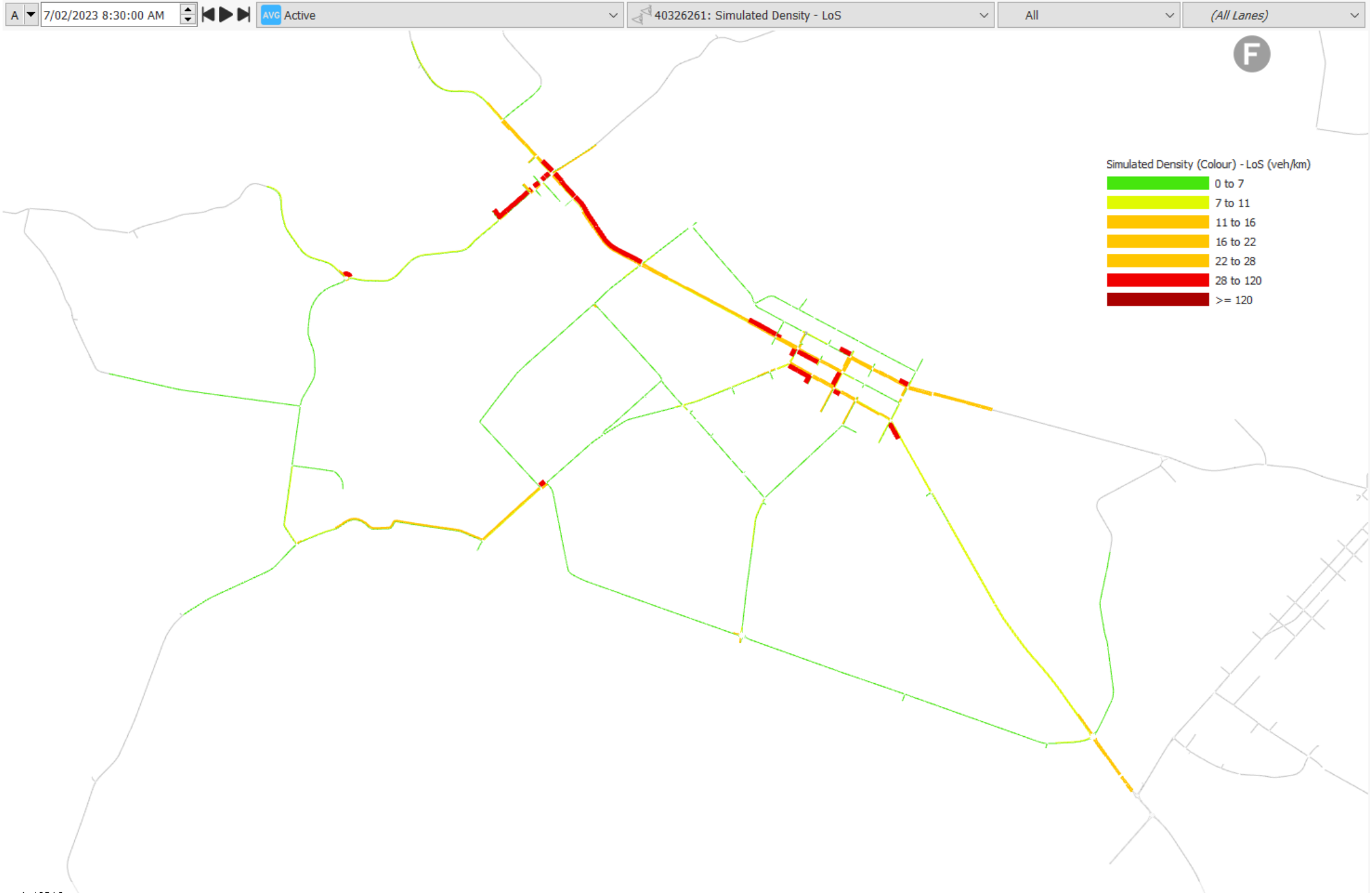
AVG Active
40334315: Simulated Flow
All
(All Lanes)
F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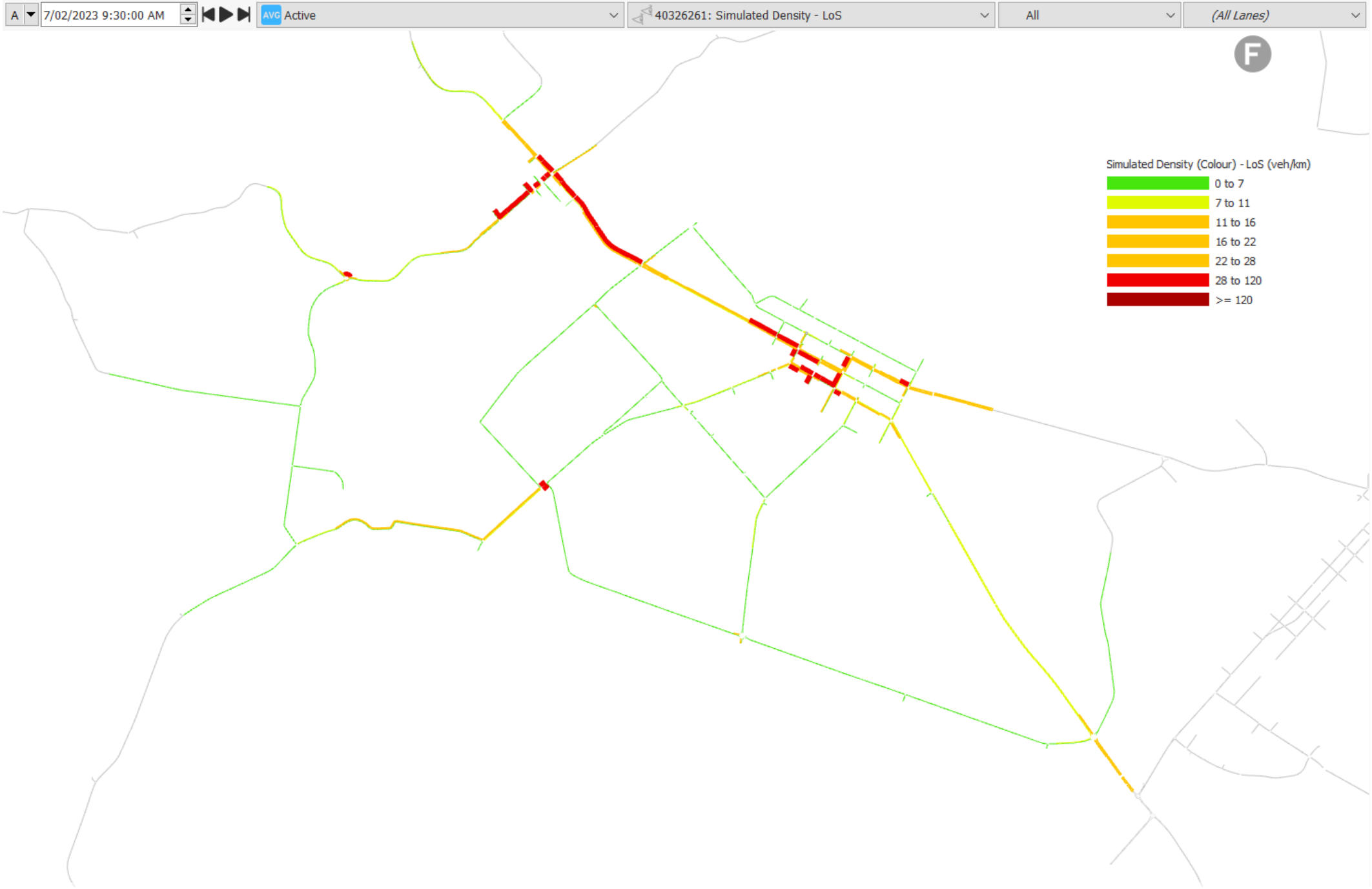
40326261: Simulated Density - LoS
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120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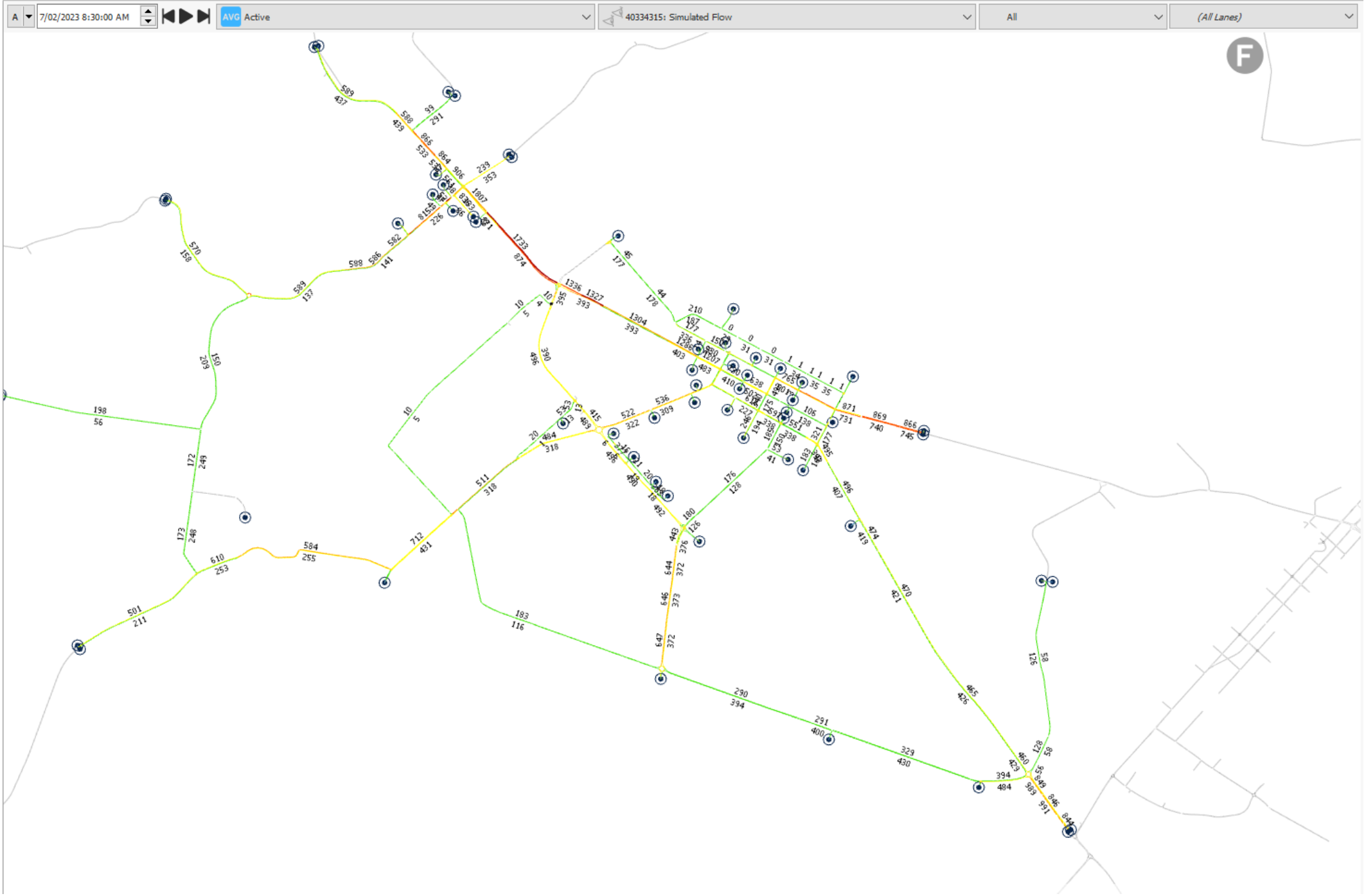
AVG Active
40326261: Simulated Density - LoS
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120

2039 AM PC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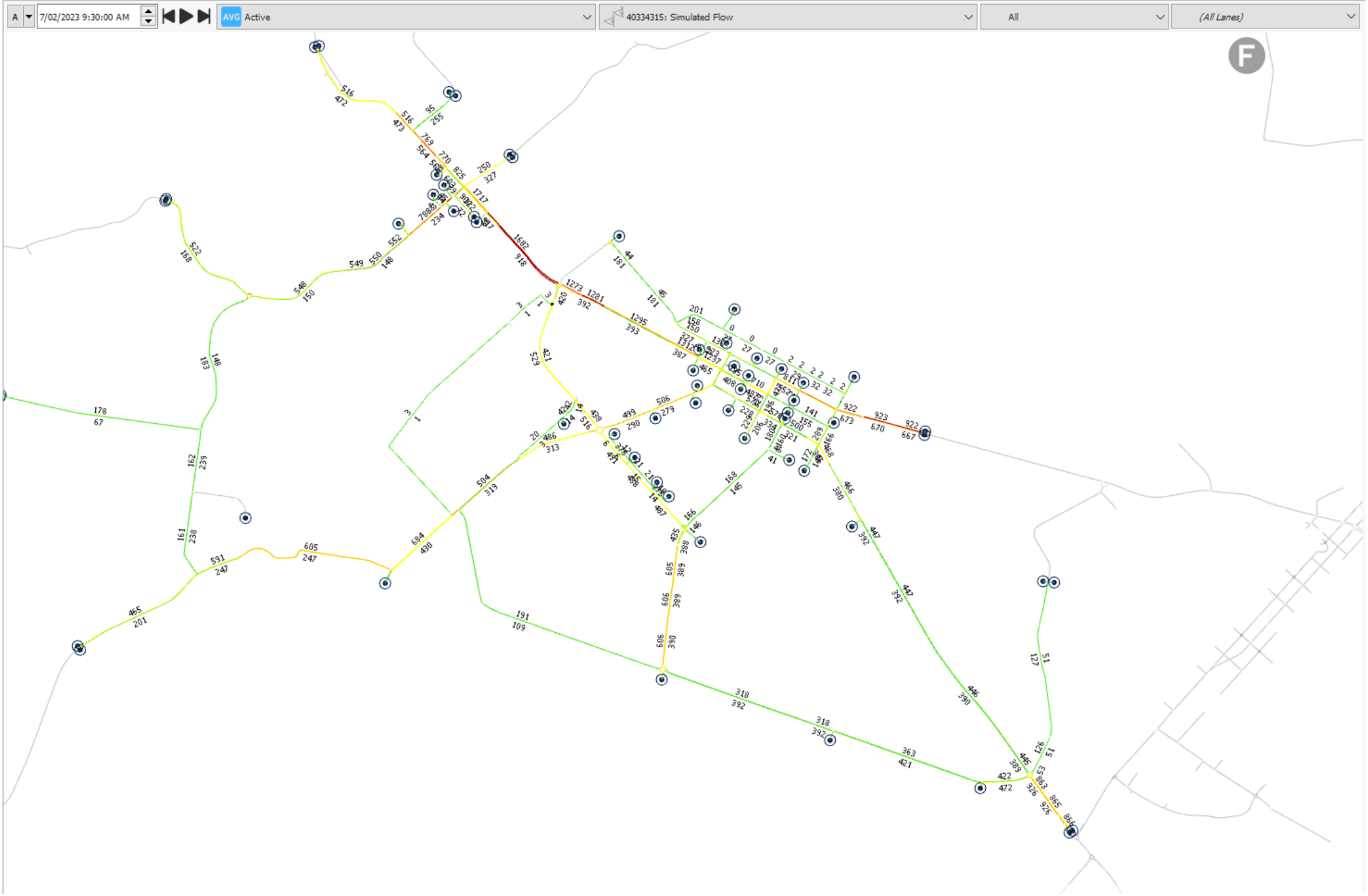
40334315: Simulated Flow
All
(All Lanes)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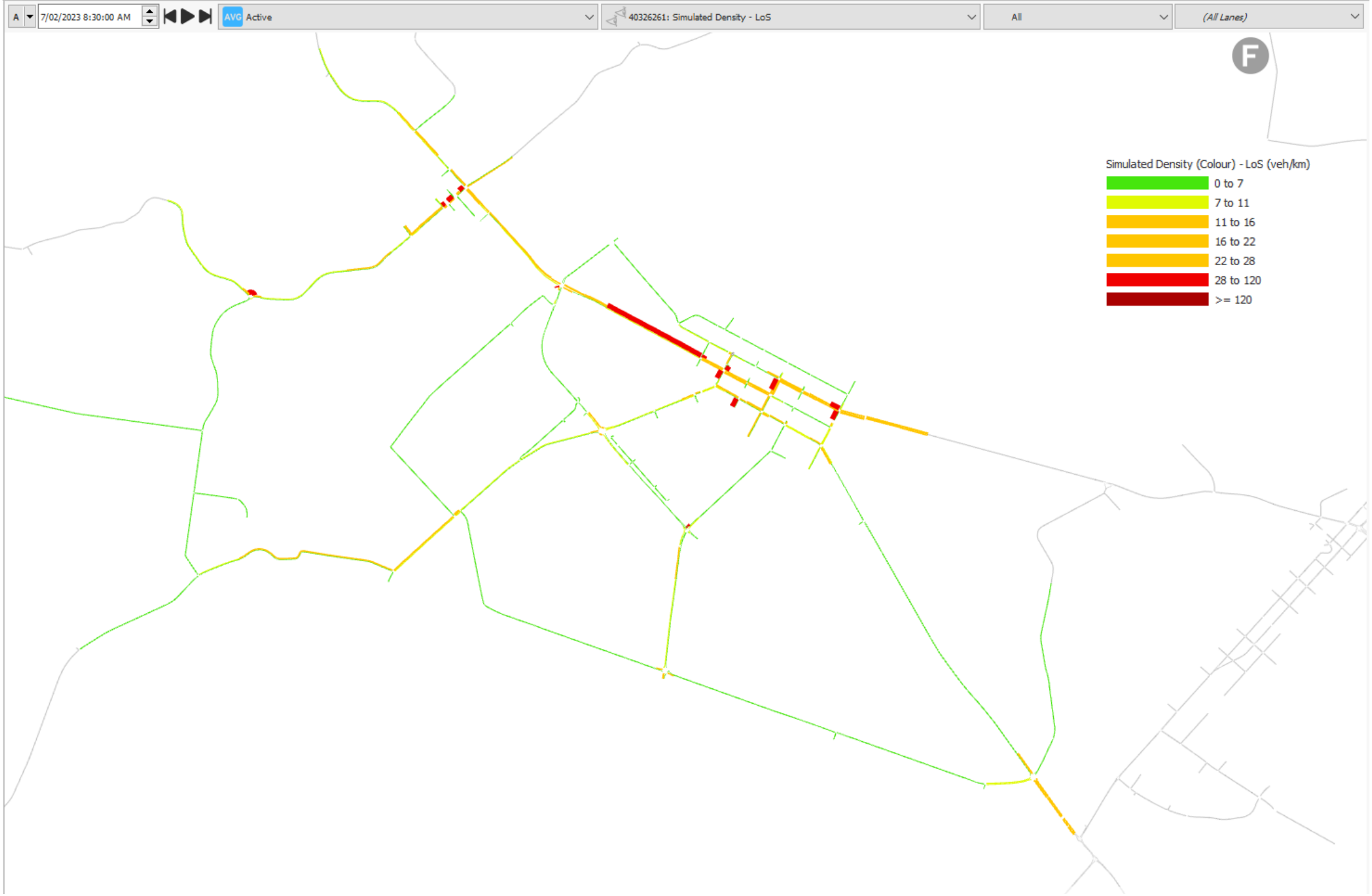
All
(All Lanes)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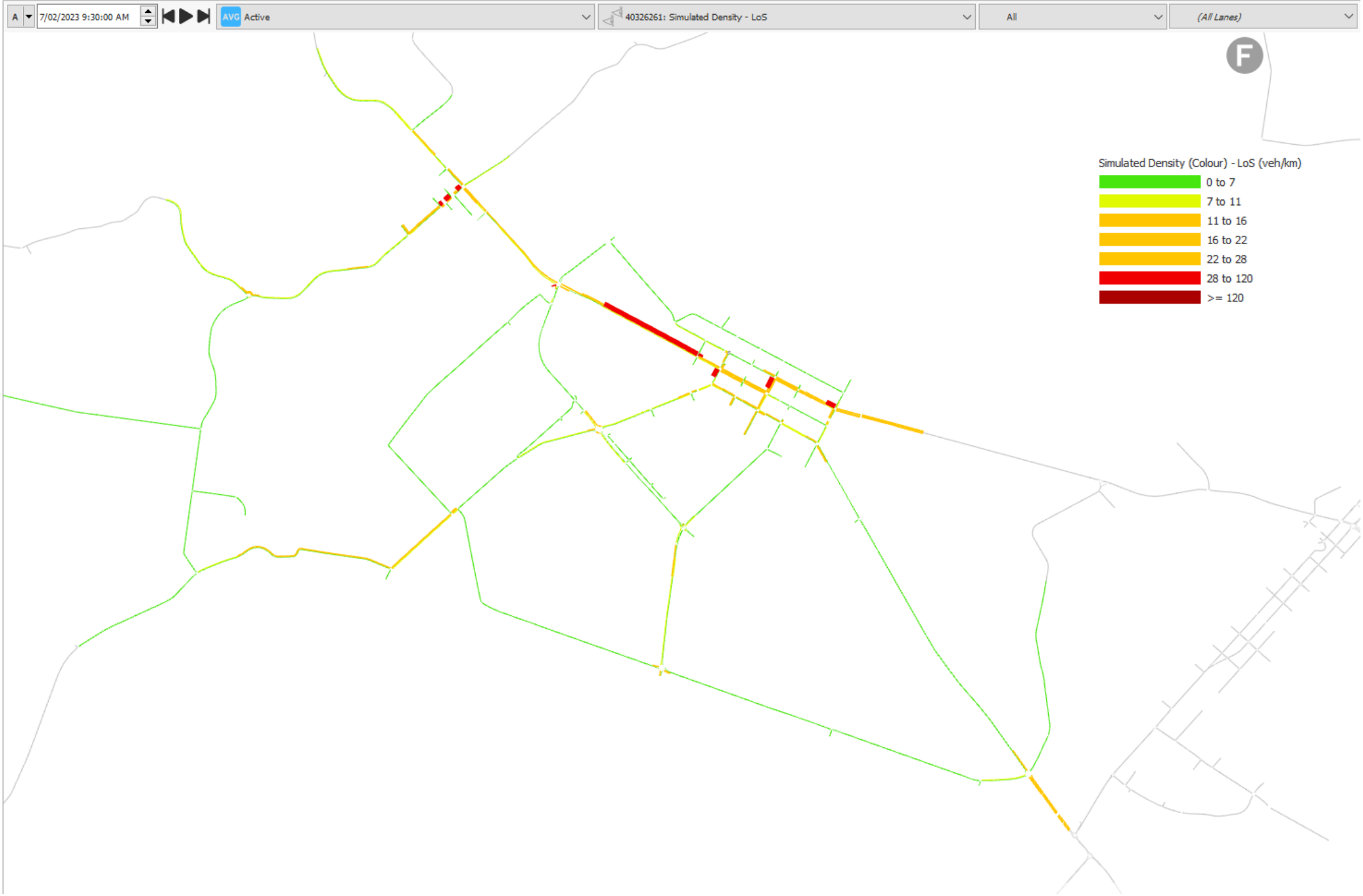
AVG Active
40326261: Simulated Density - LoS
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120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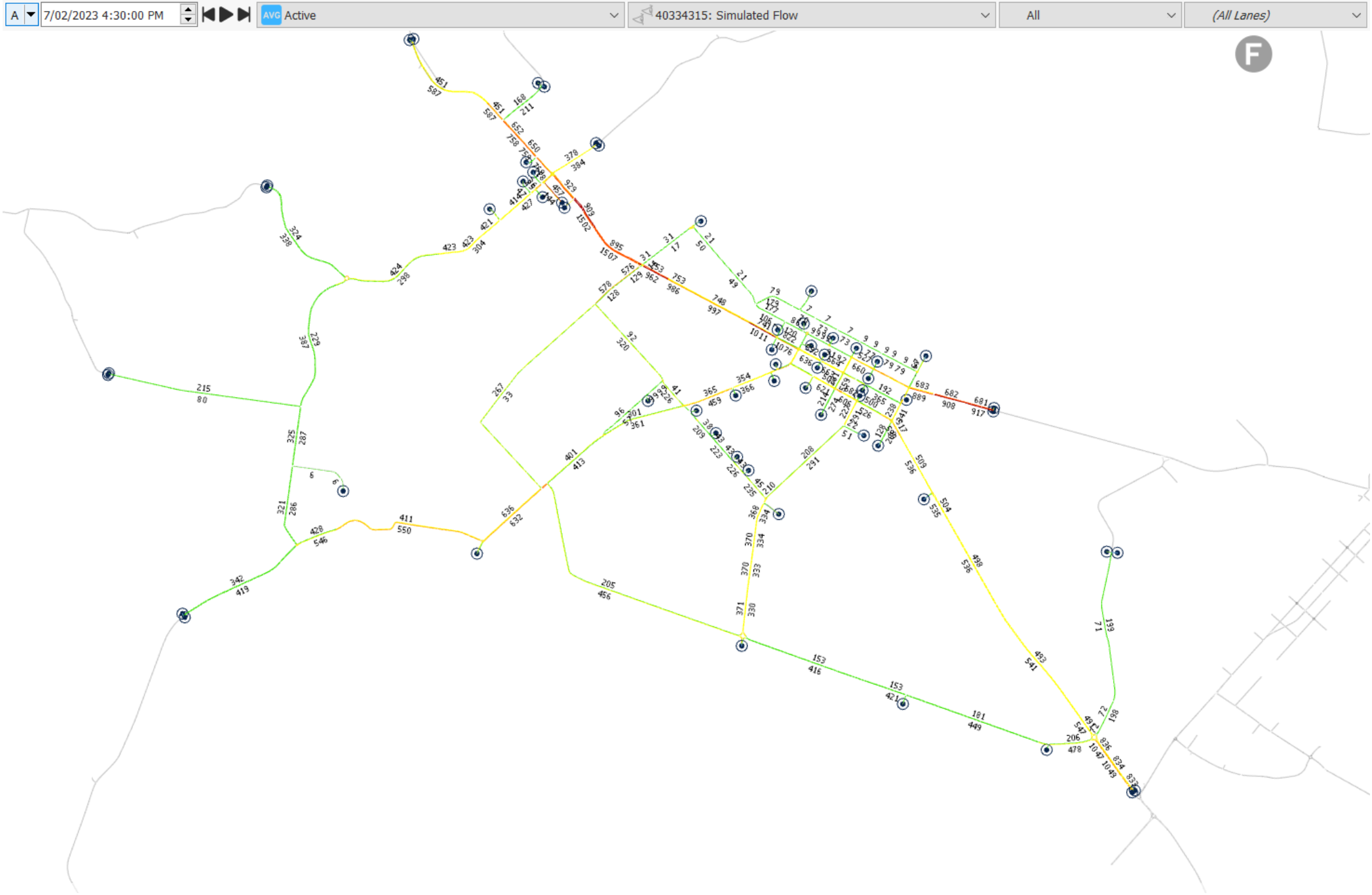
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120

2039 PM DM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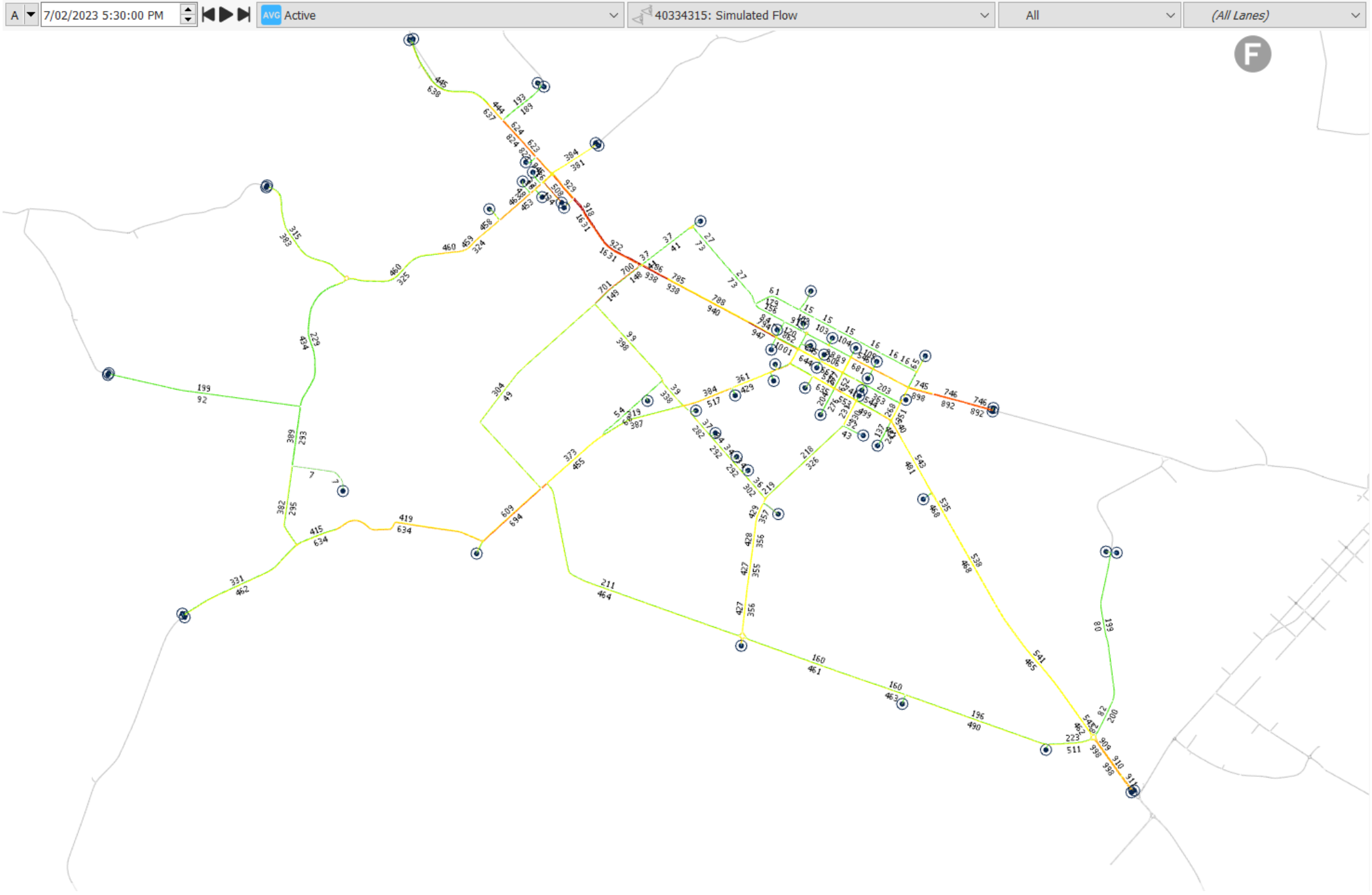
AVG Active
40334315: Simulated Flow
All
(All Lanes)
F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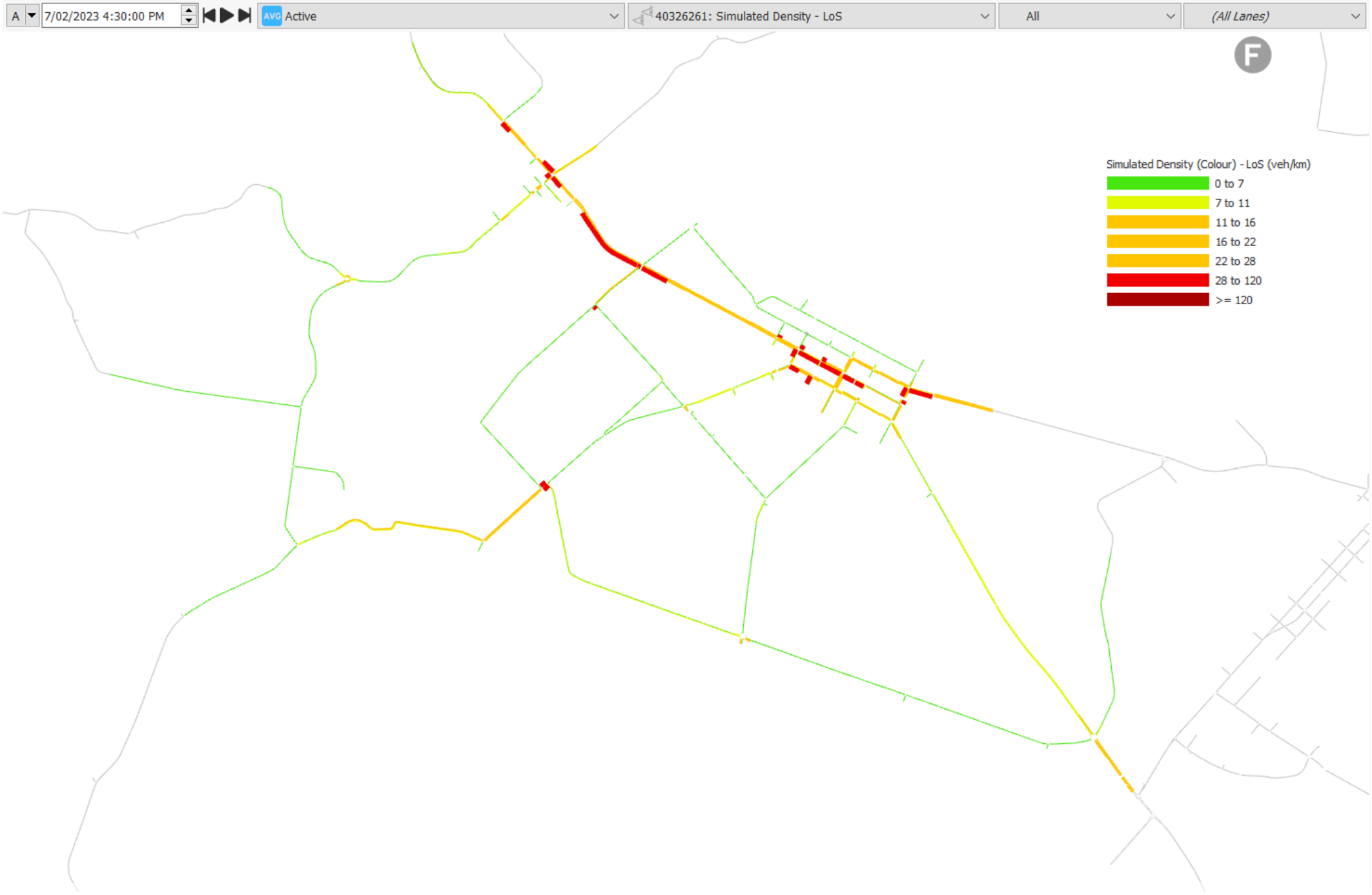
Active
40334315: Simulated Flow
All
(All Lanes)
F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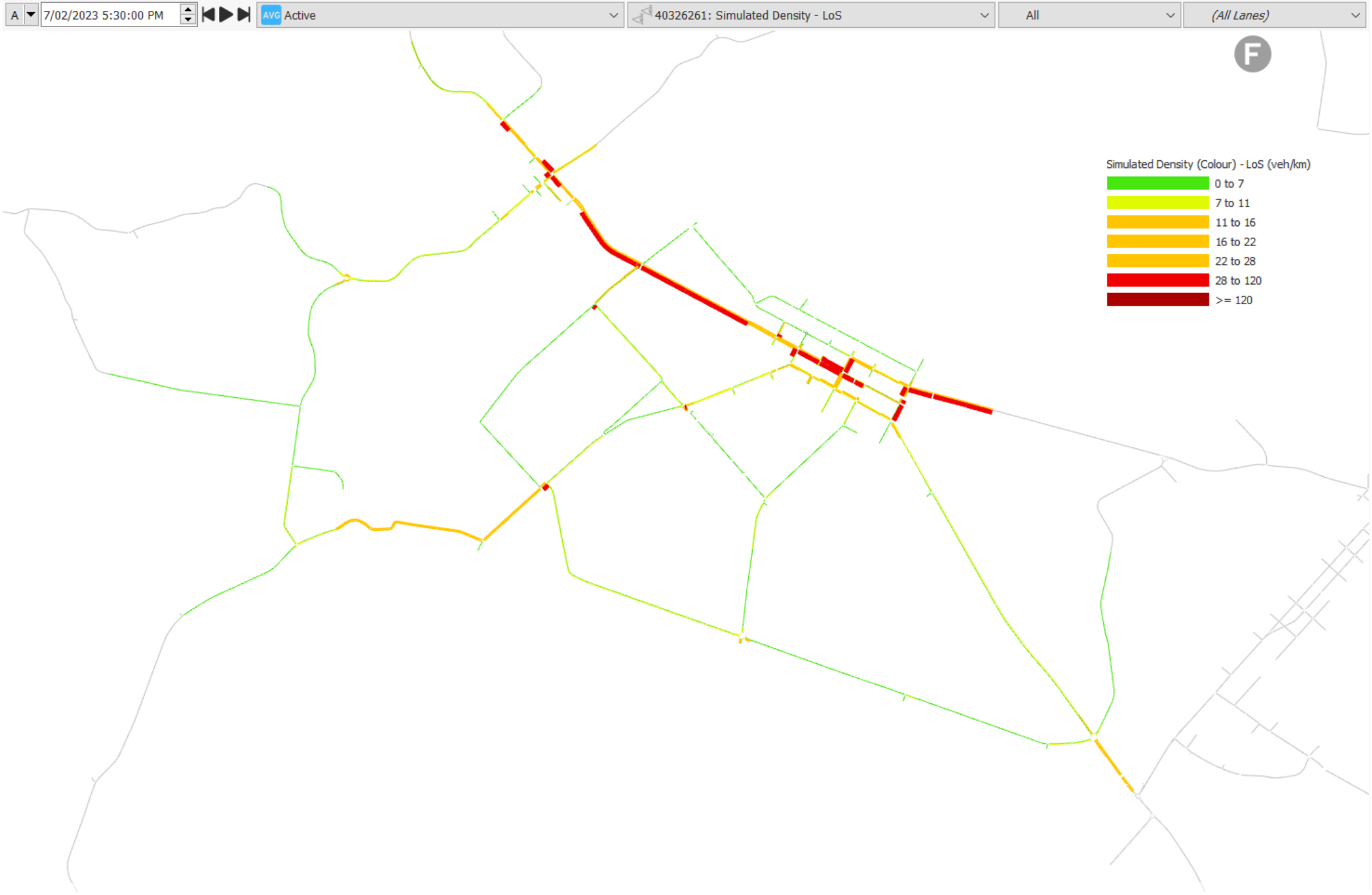
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120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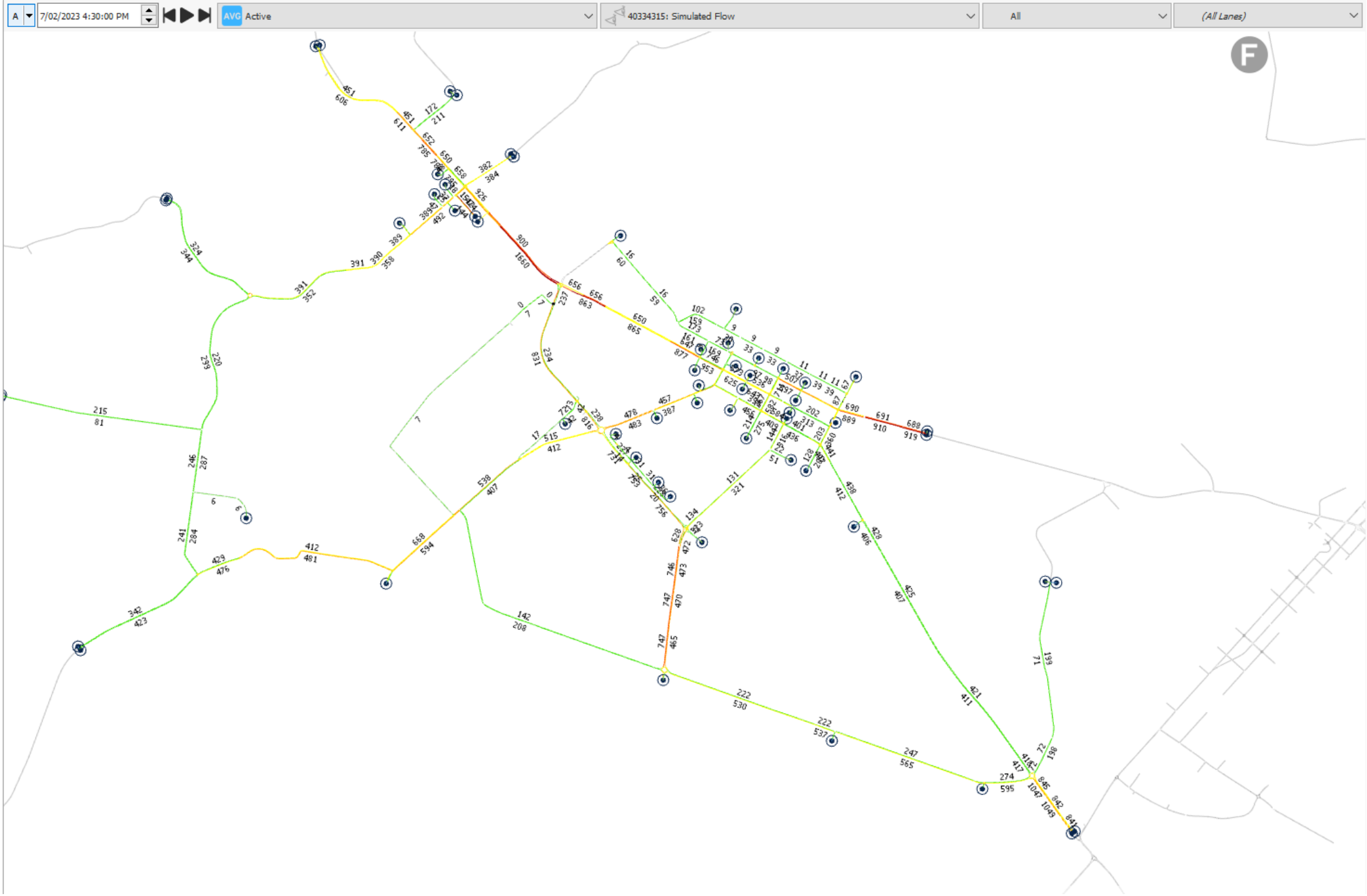
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120

2039 PM PC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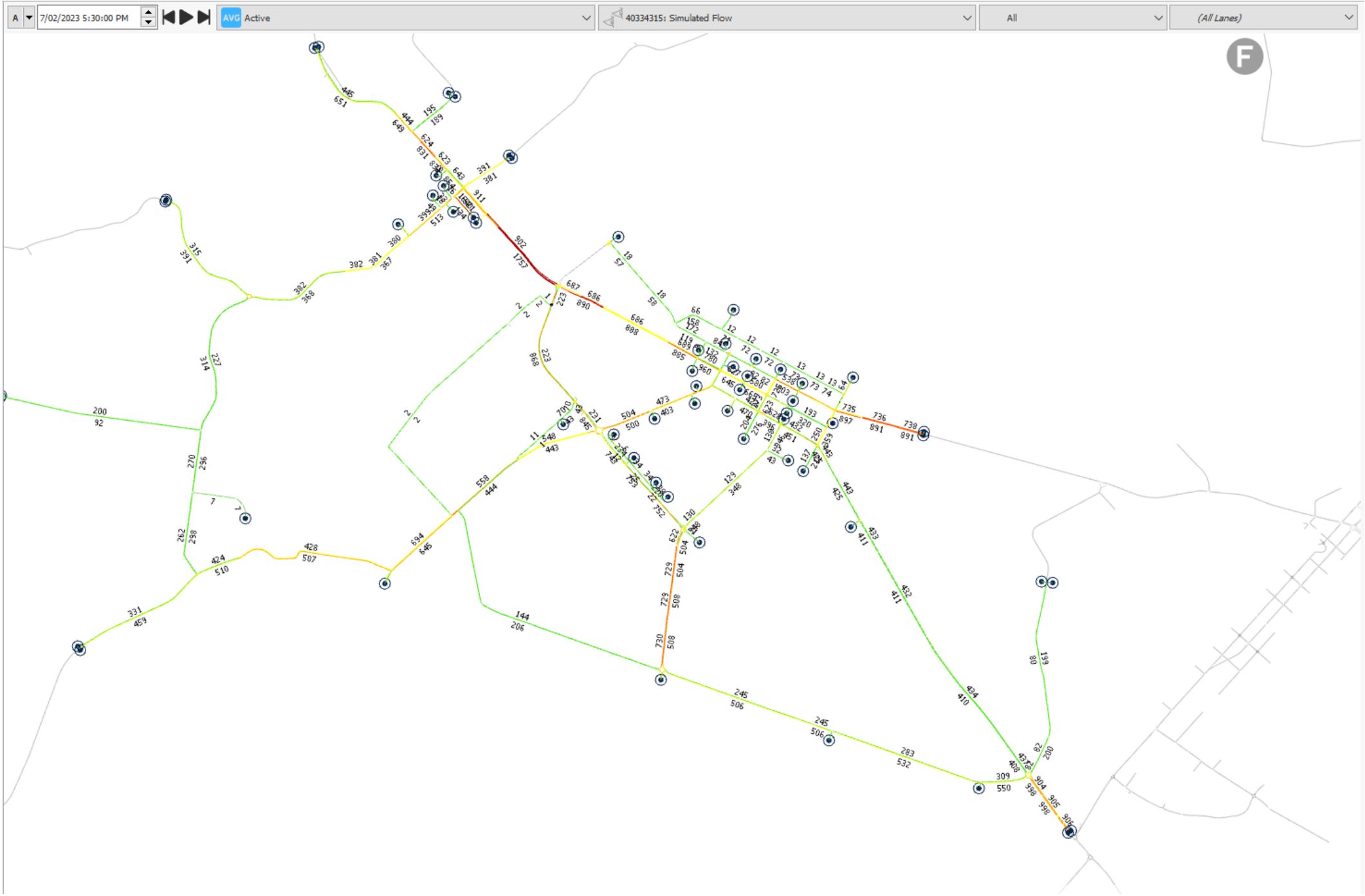
AVG Active
40334315: Simulated Flow
All
(All Lanes)
F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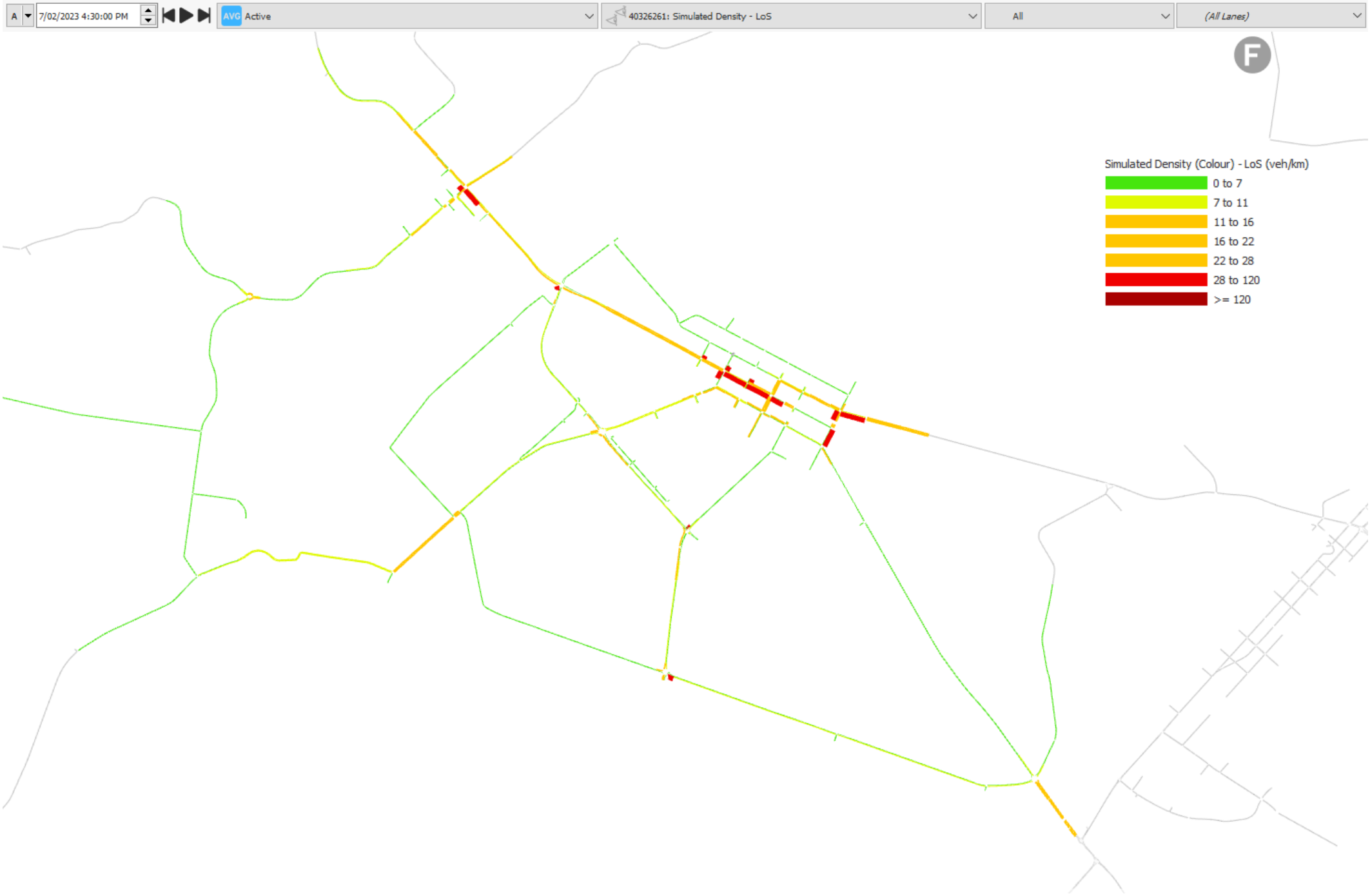
All
(All Lanes)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AVG Active
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All
(All Lanes)
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Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
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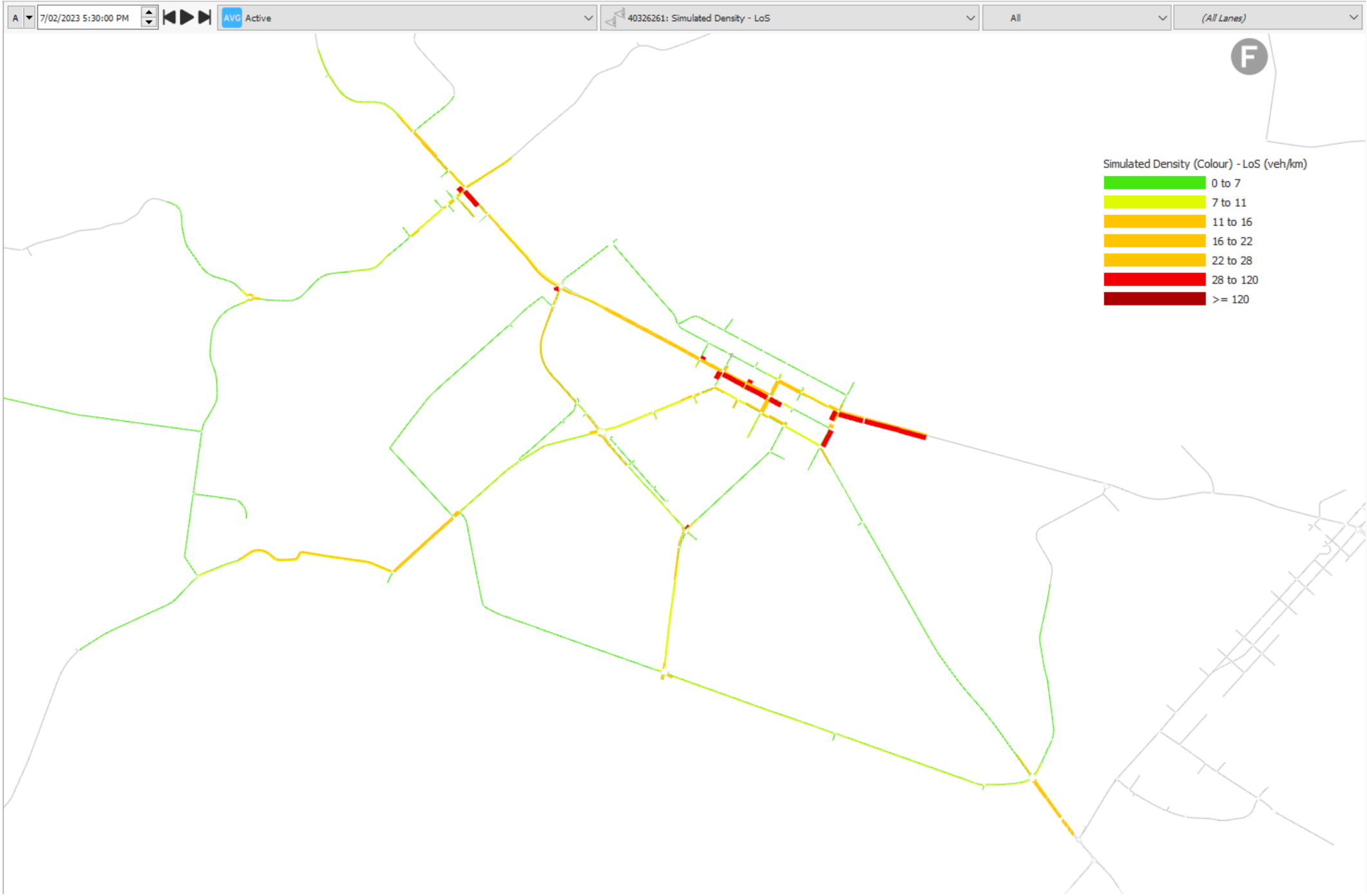
22 to 28
28 to 120
>= 120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AVG Active
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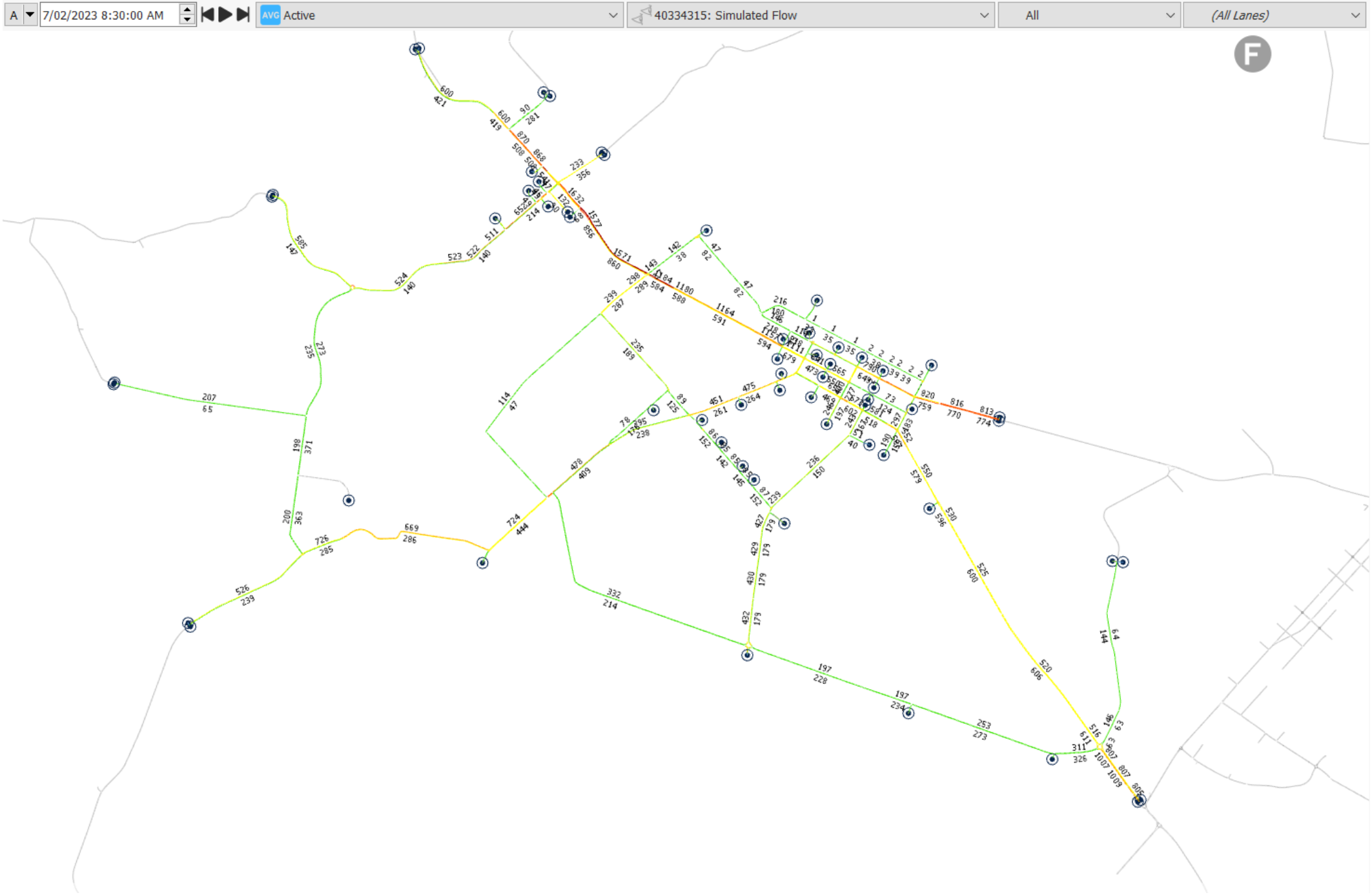
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120

2049 AM DM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AVG Active
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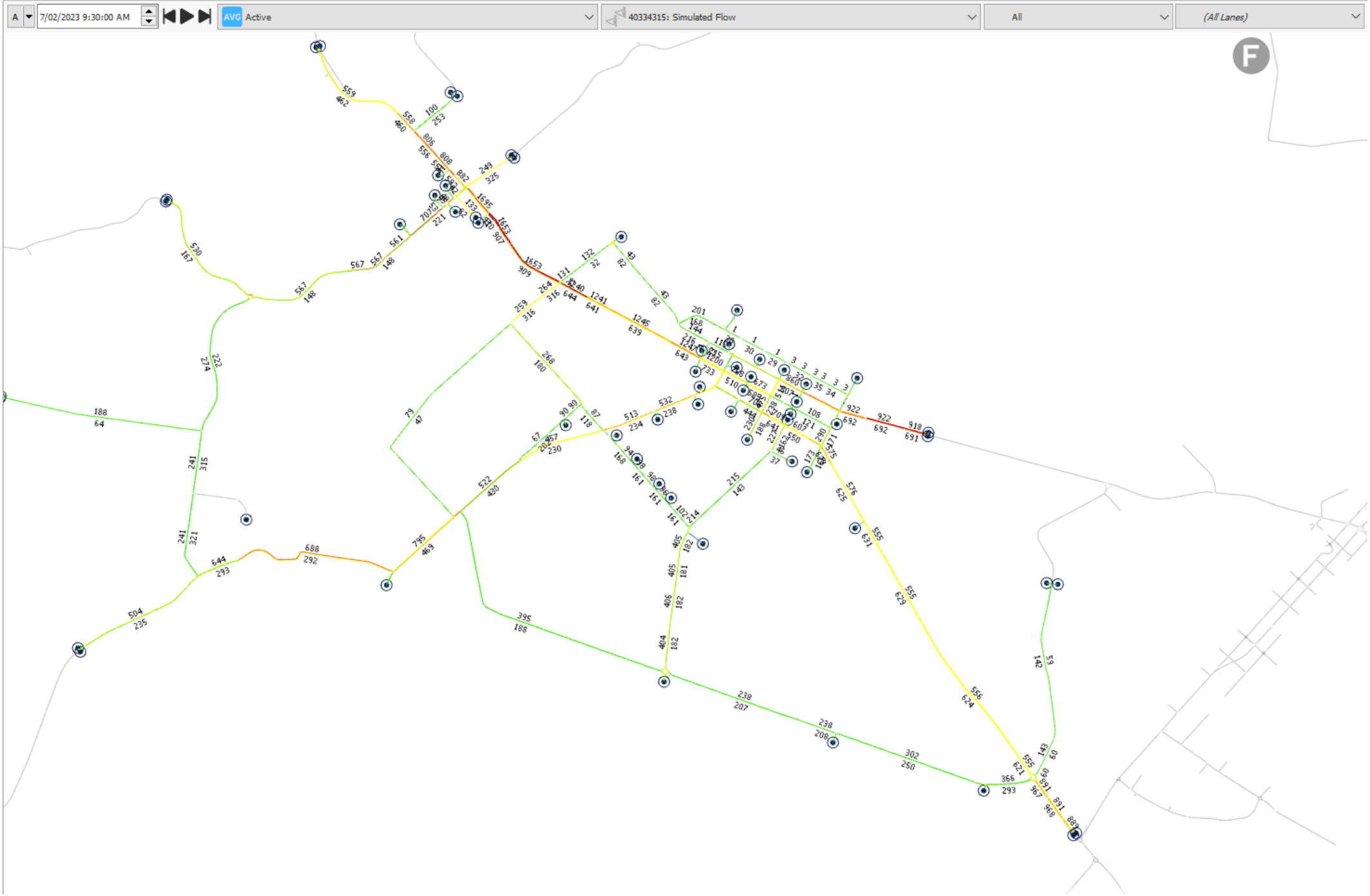
All
(All Lanes)
F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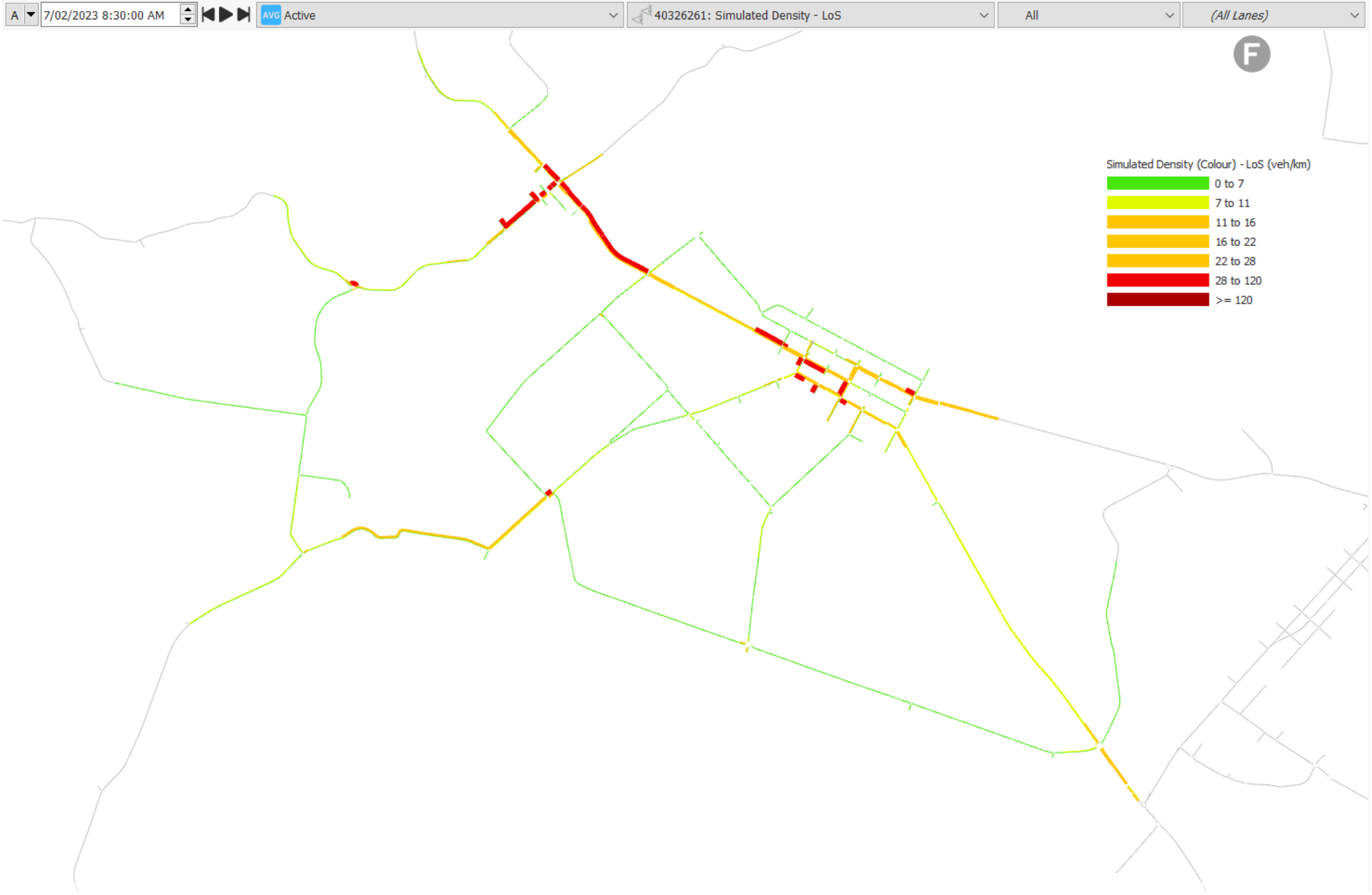
AVG Active
40334315: Simulated Flow
All
(All Lanes)
F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(All Lanes)
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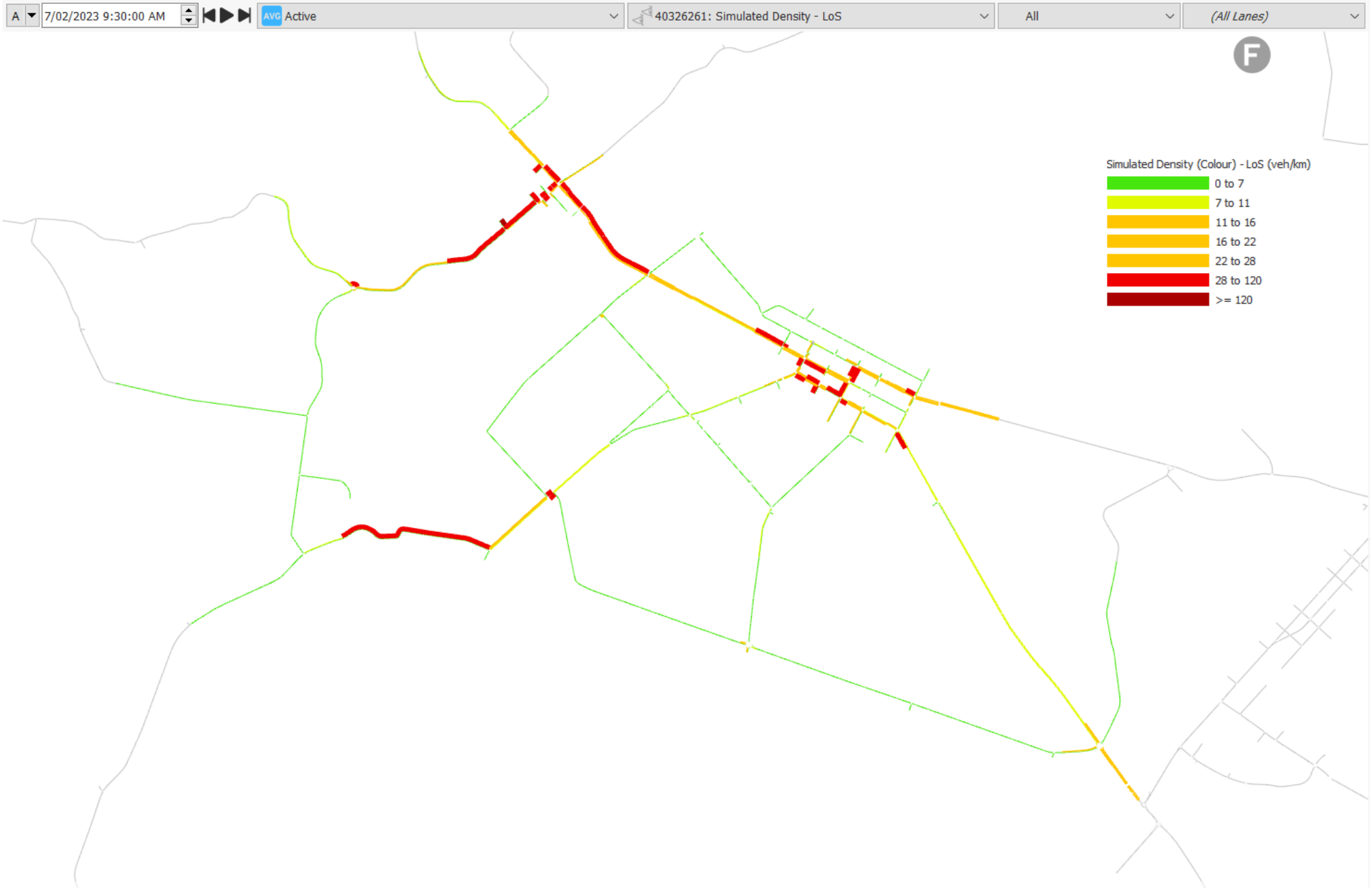
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120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All
(All Lanes)
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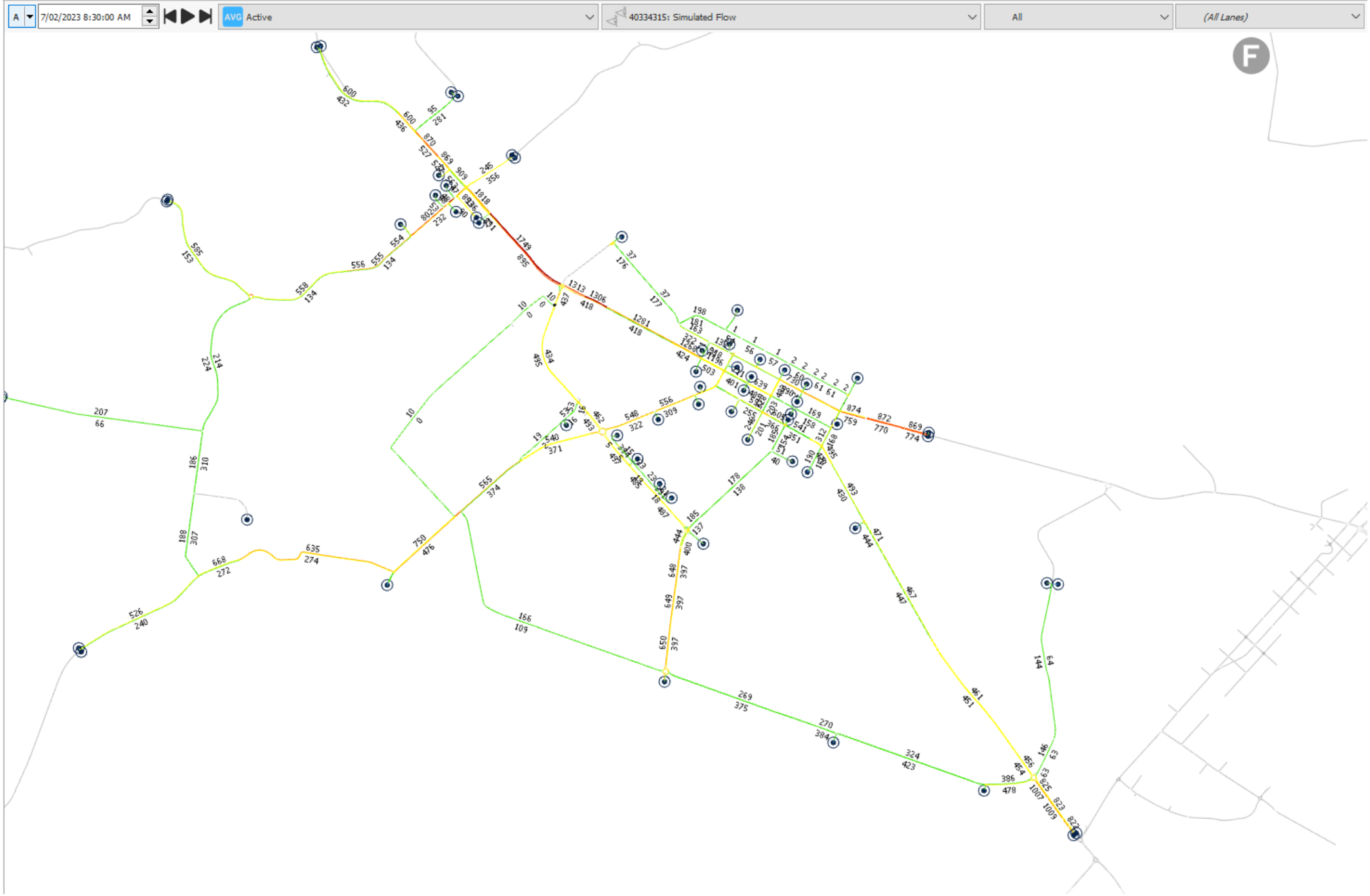
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120

2049 AM PC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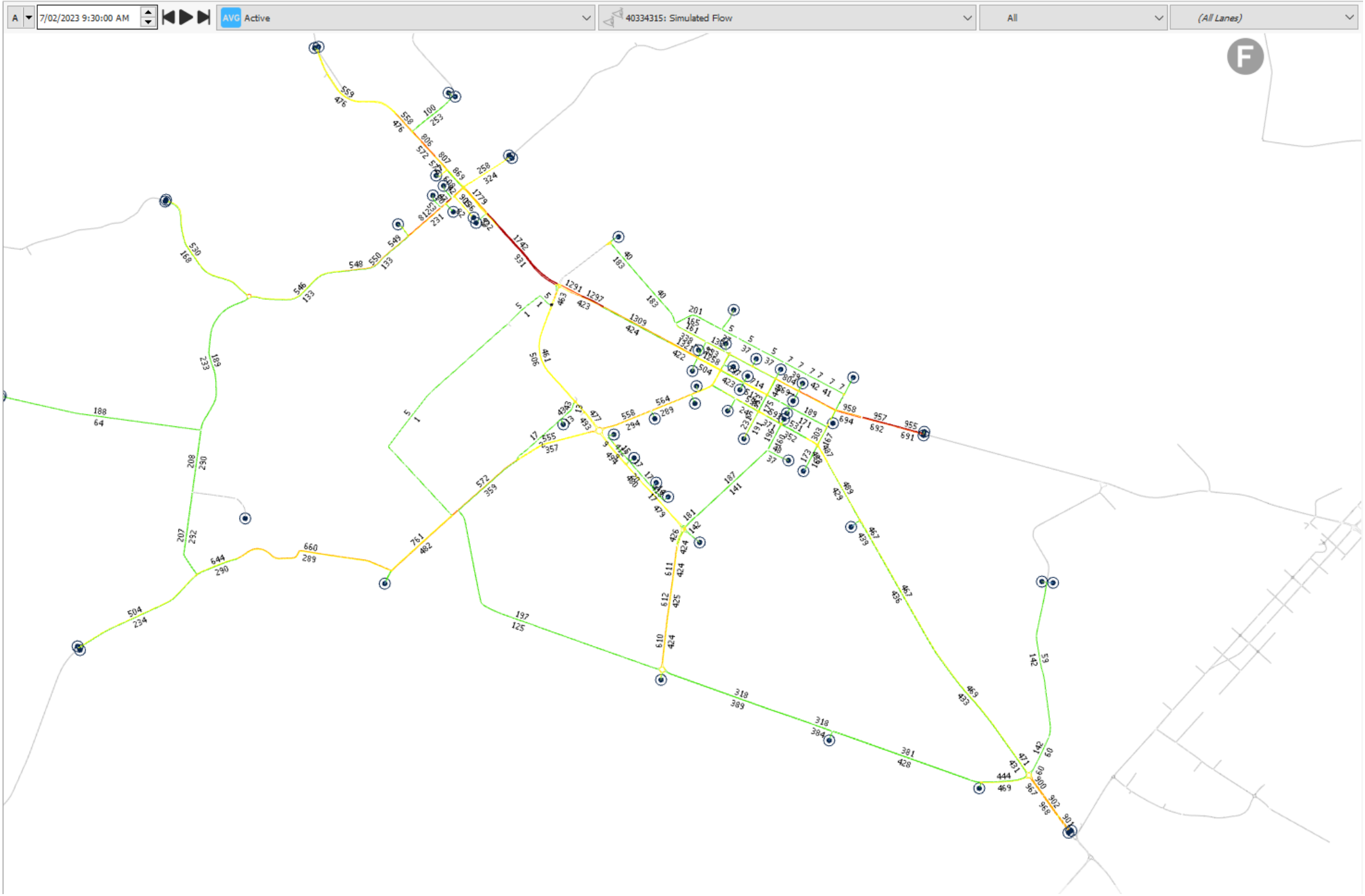
40334315: Simulated Flow
All
(All Lanes)
F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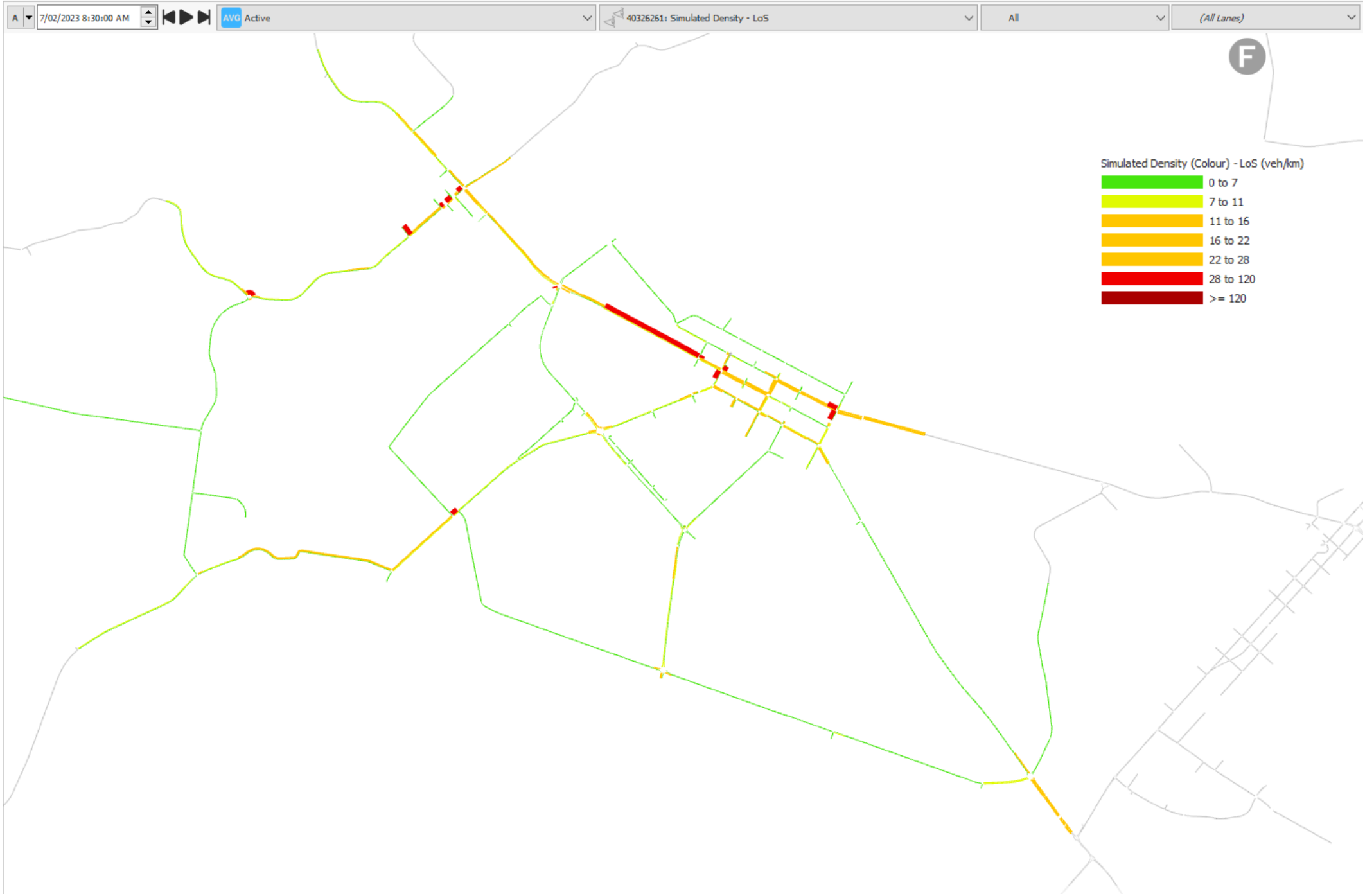
All
(All Lanes)
F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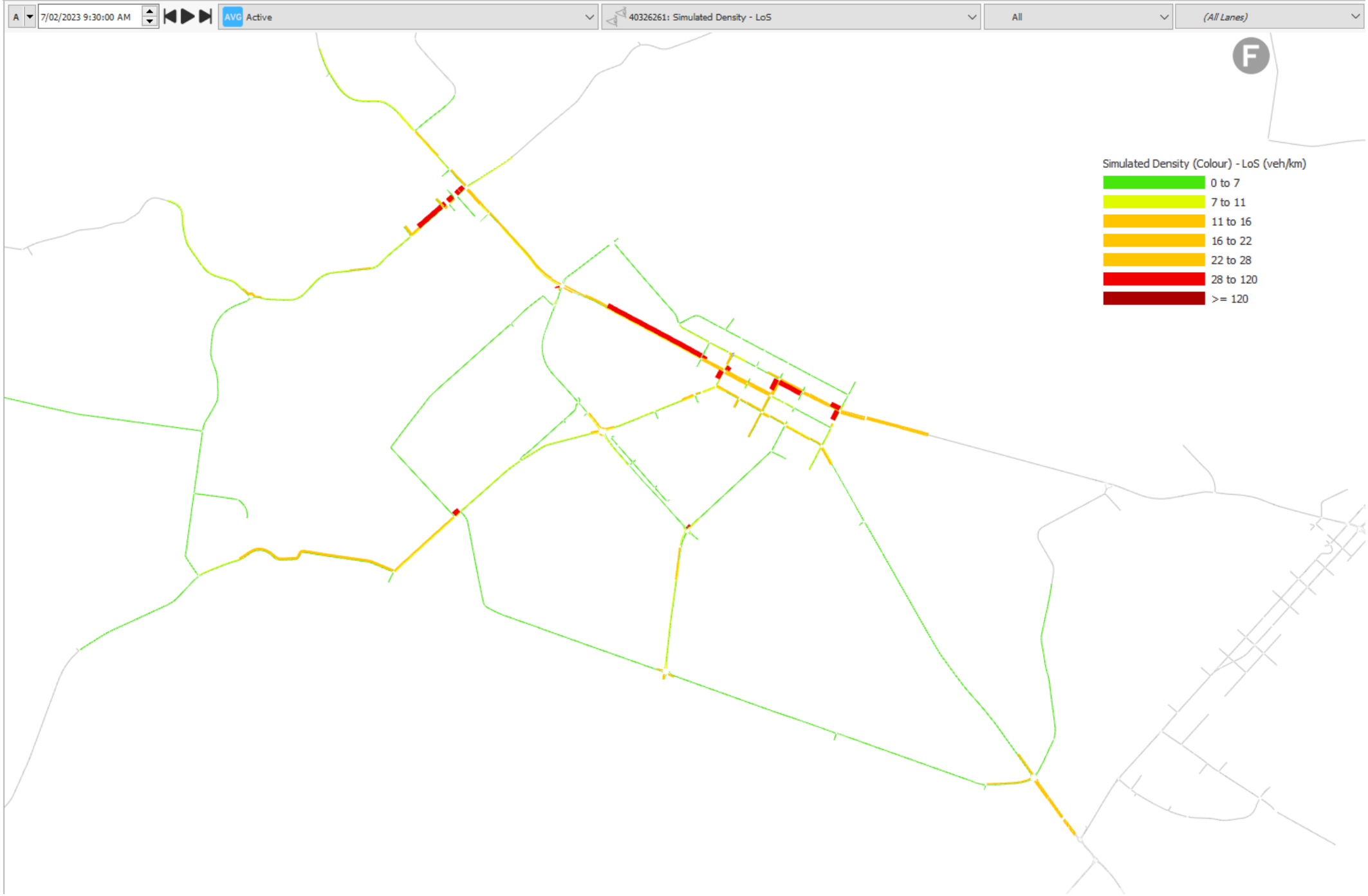
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120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All
(All Lanes)
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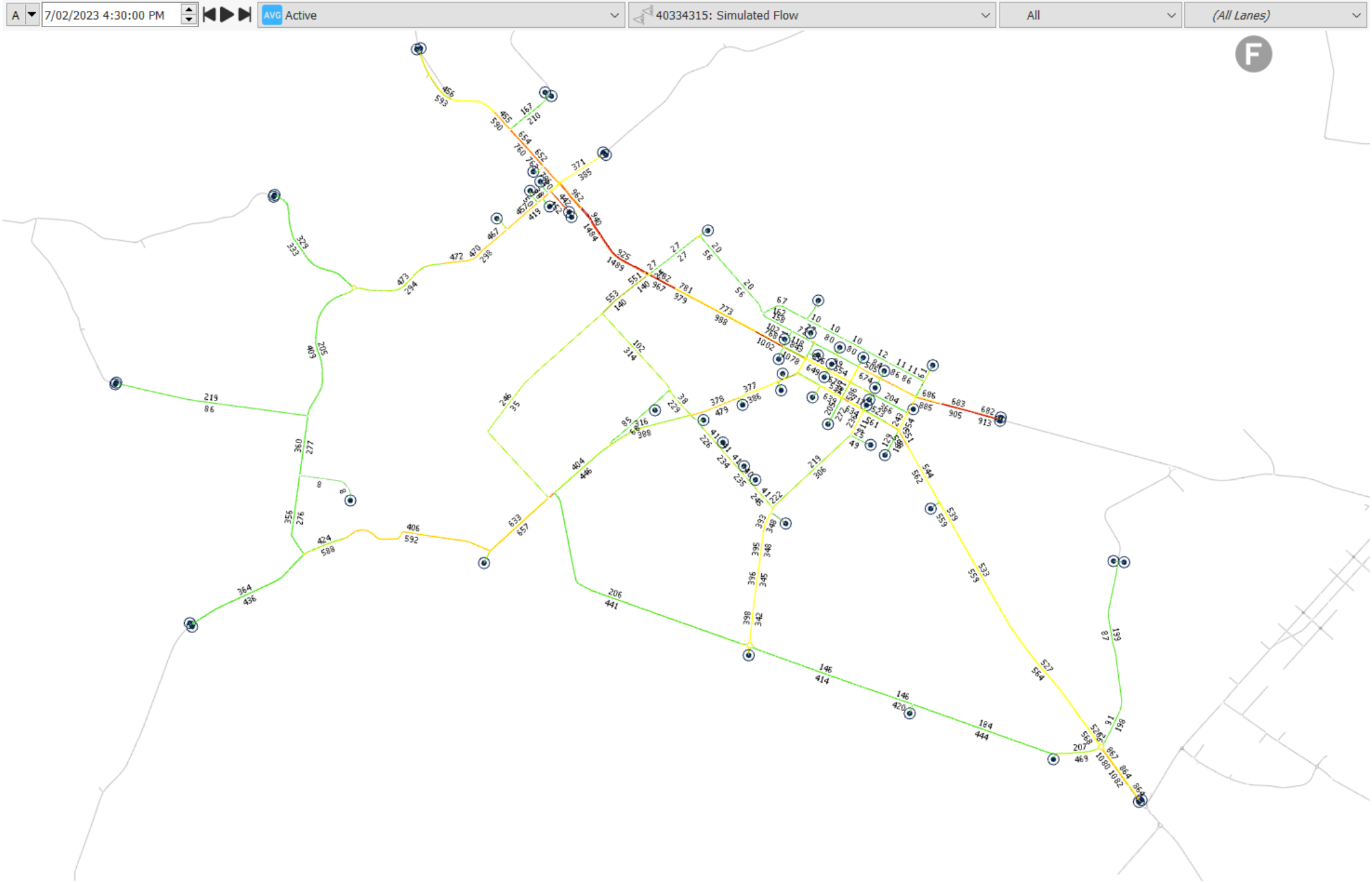
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120

2049 PM DM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40334315: Simulated Flow
All
(All Lanes)
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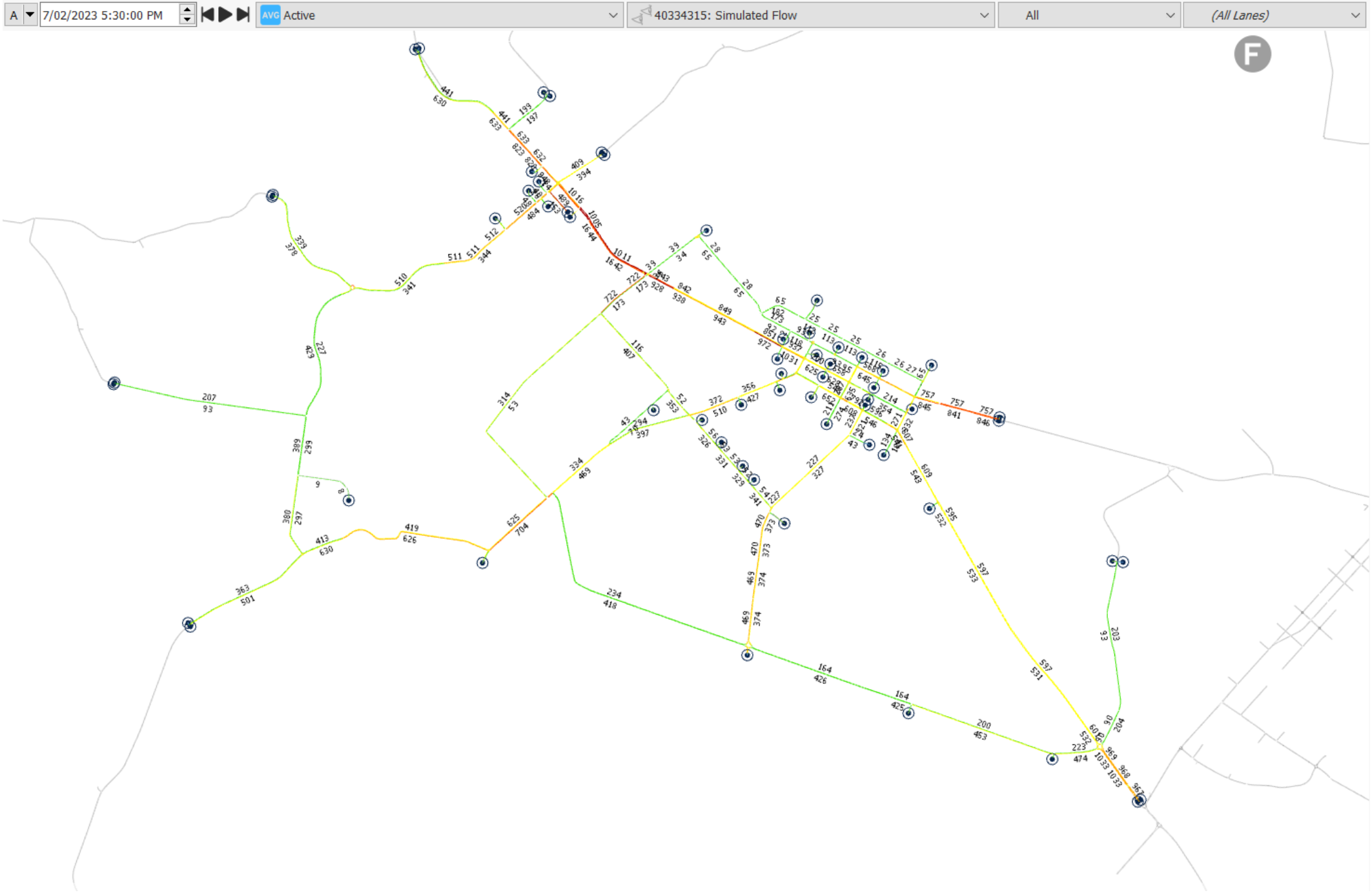
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All
(All Lanes)
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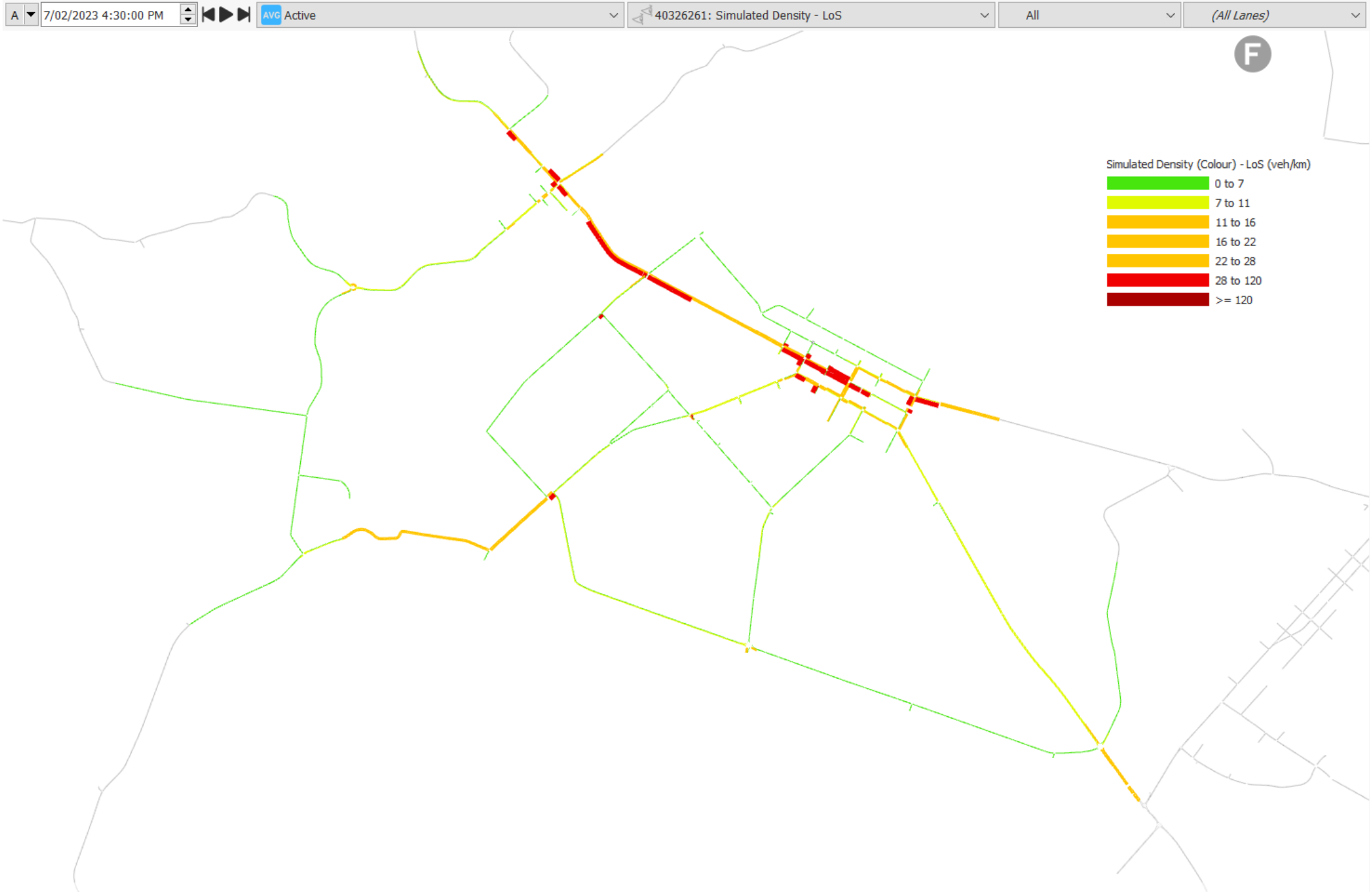
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All
(All Lanes)
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Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
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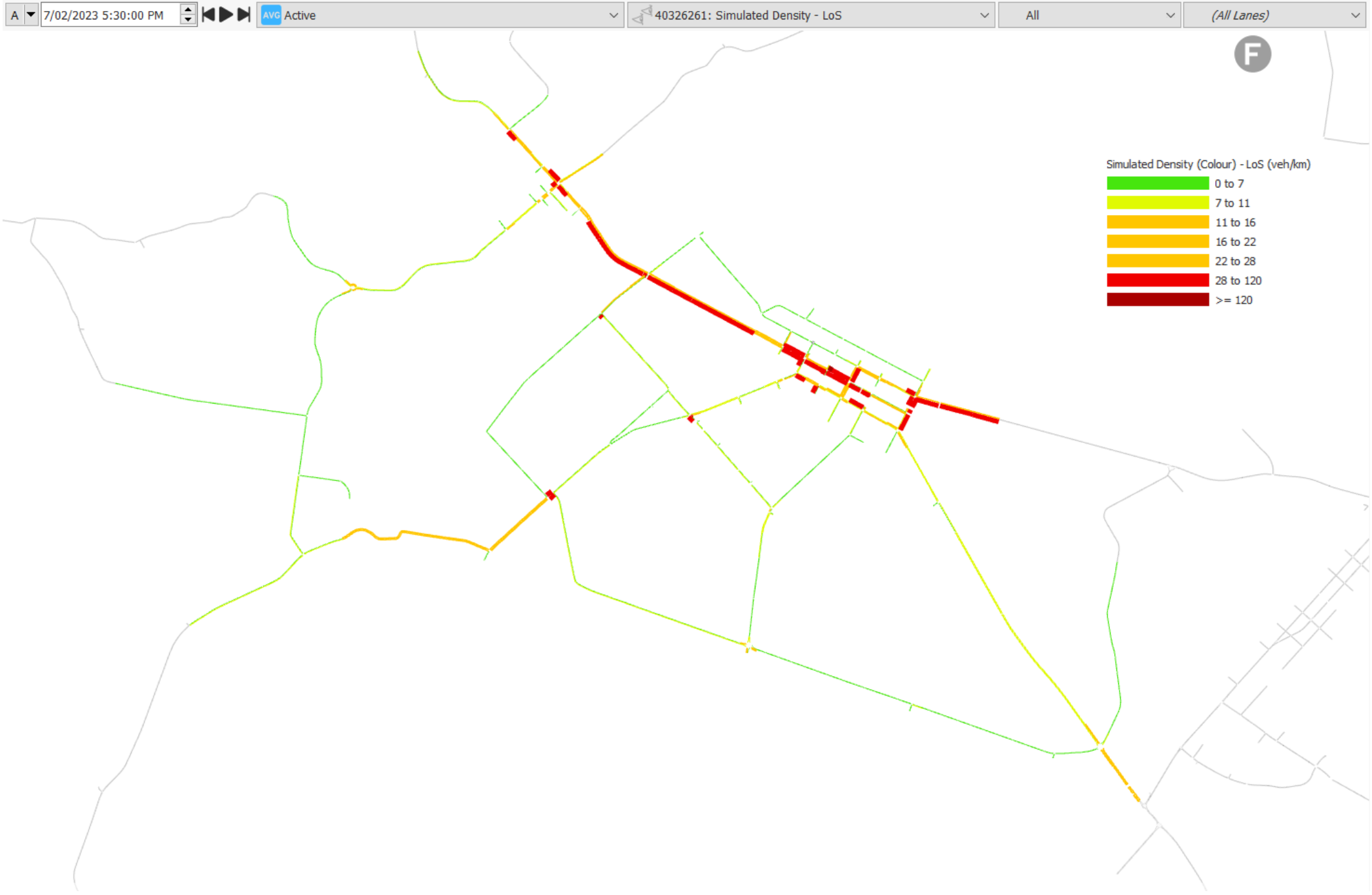
28 to 120
>= 120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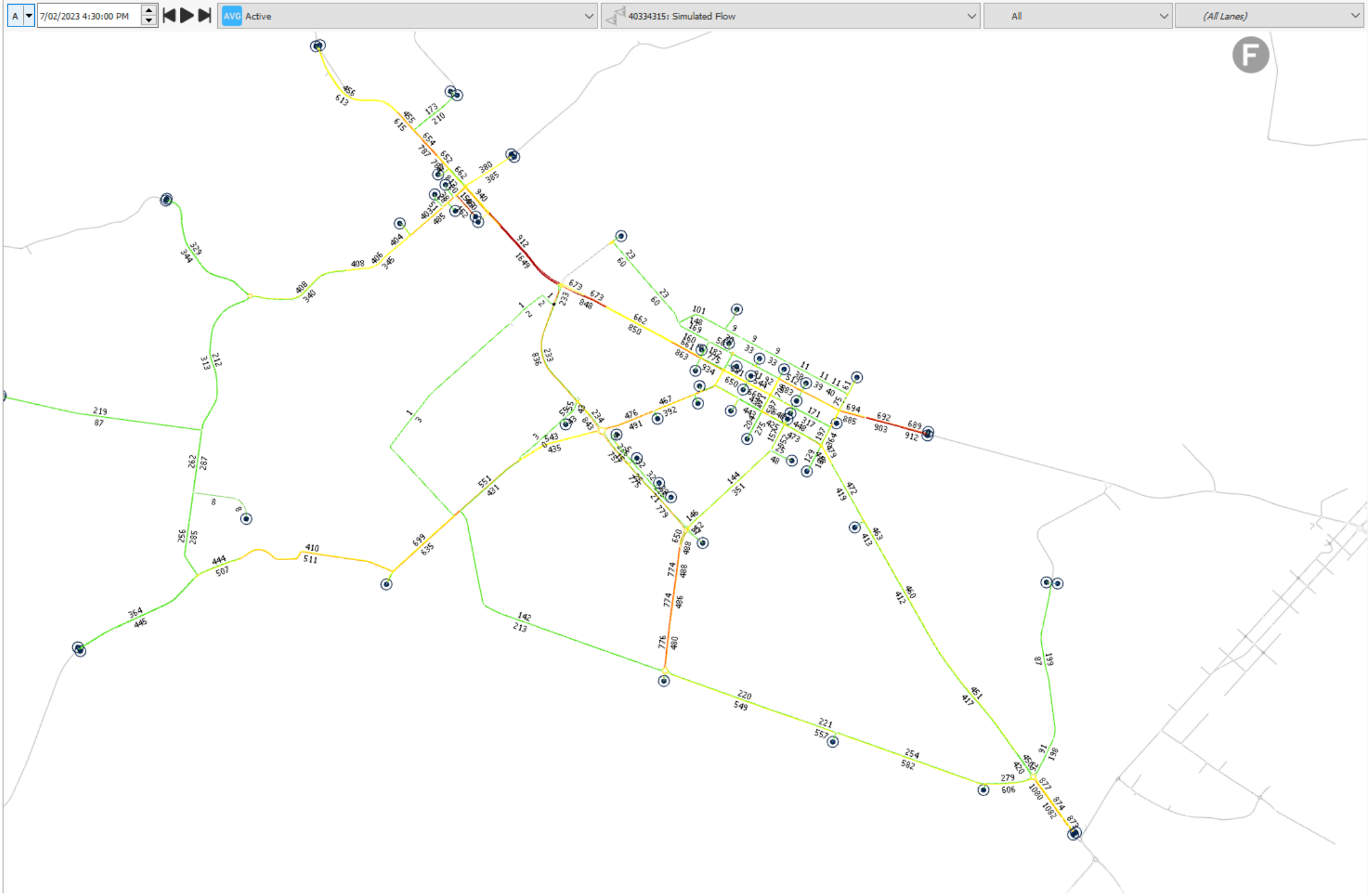
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120

2049 PM PC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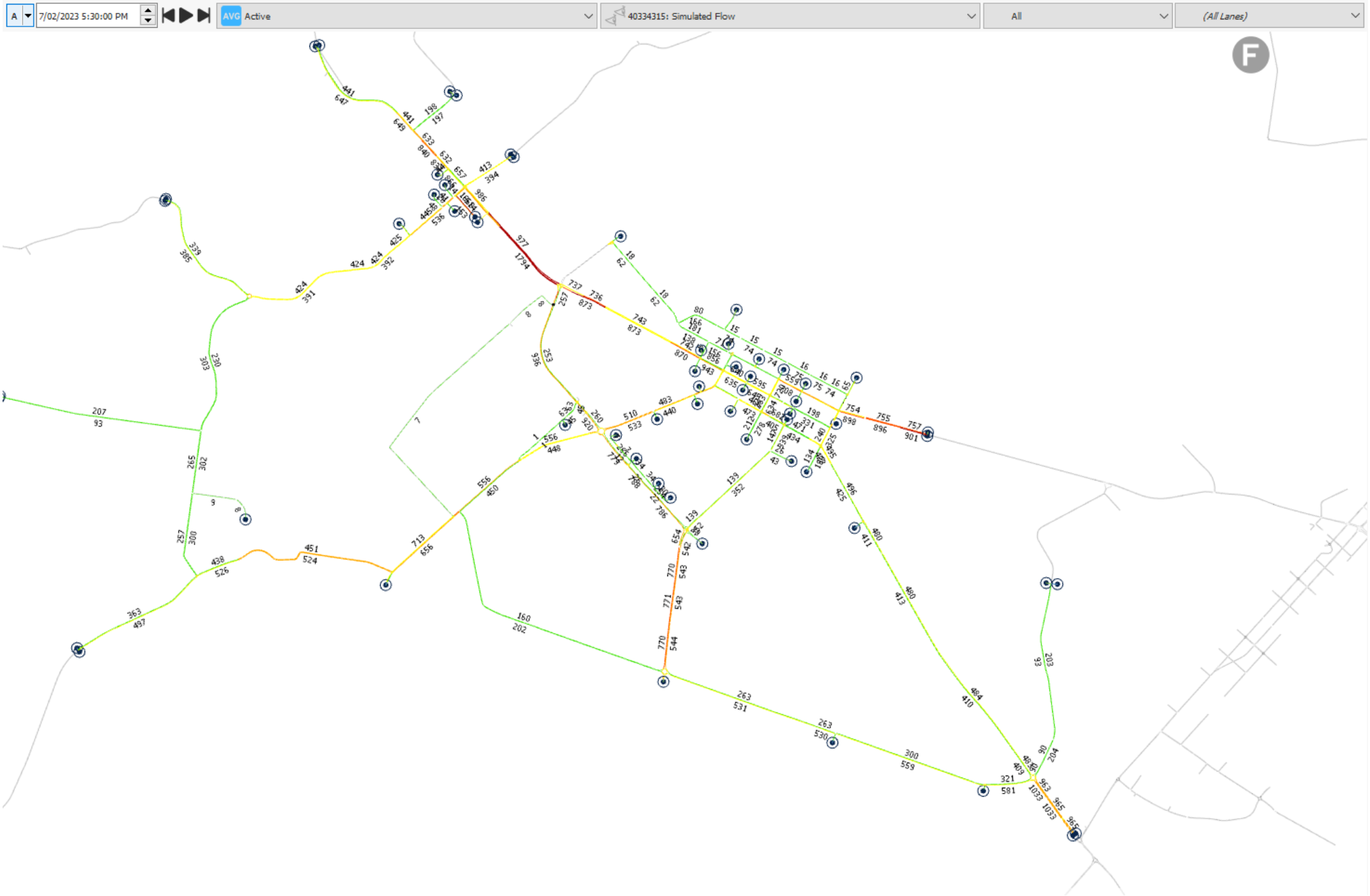
All
(All Lanes)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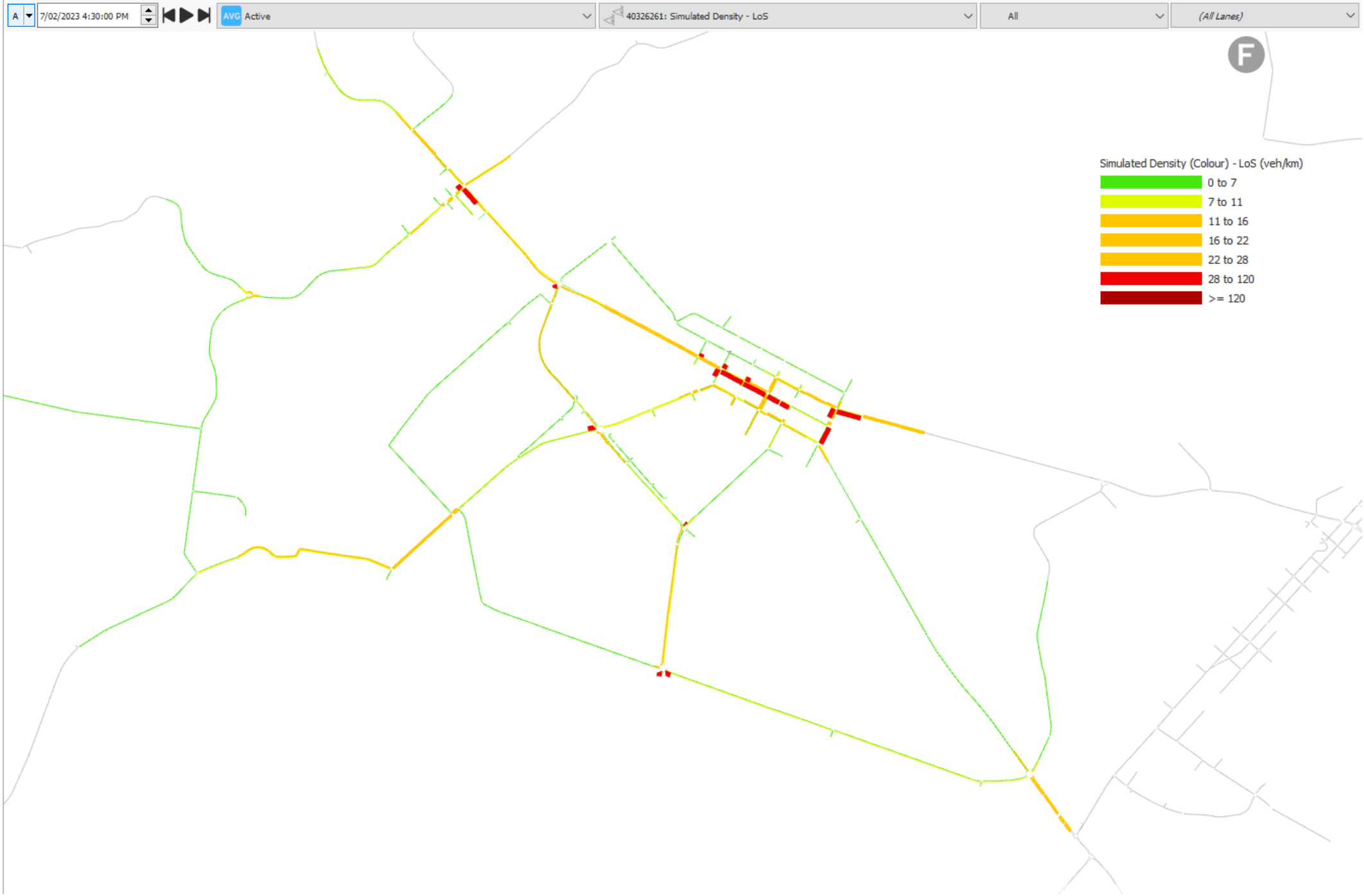
All
(All Lanes)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All
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Simulated Density (Colour) - LoS (veh/km)
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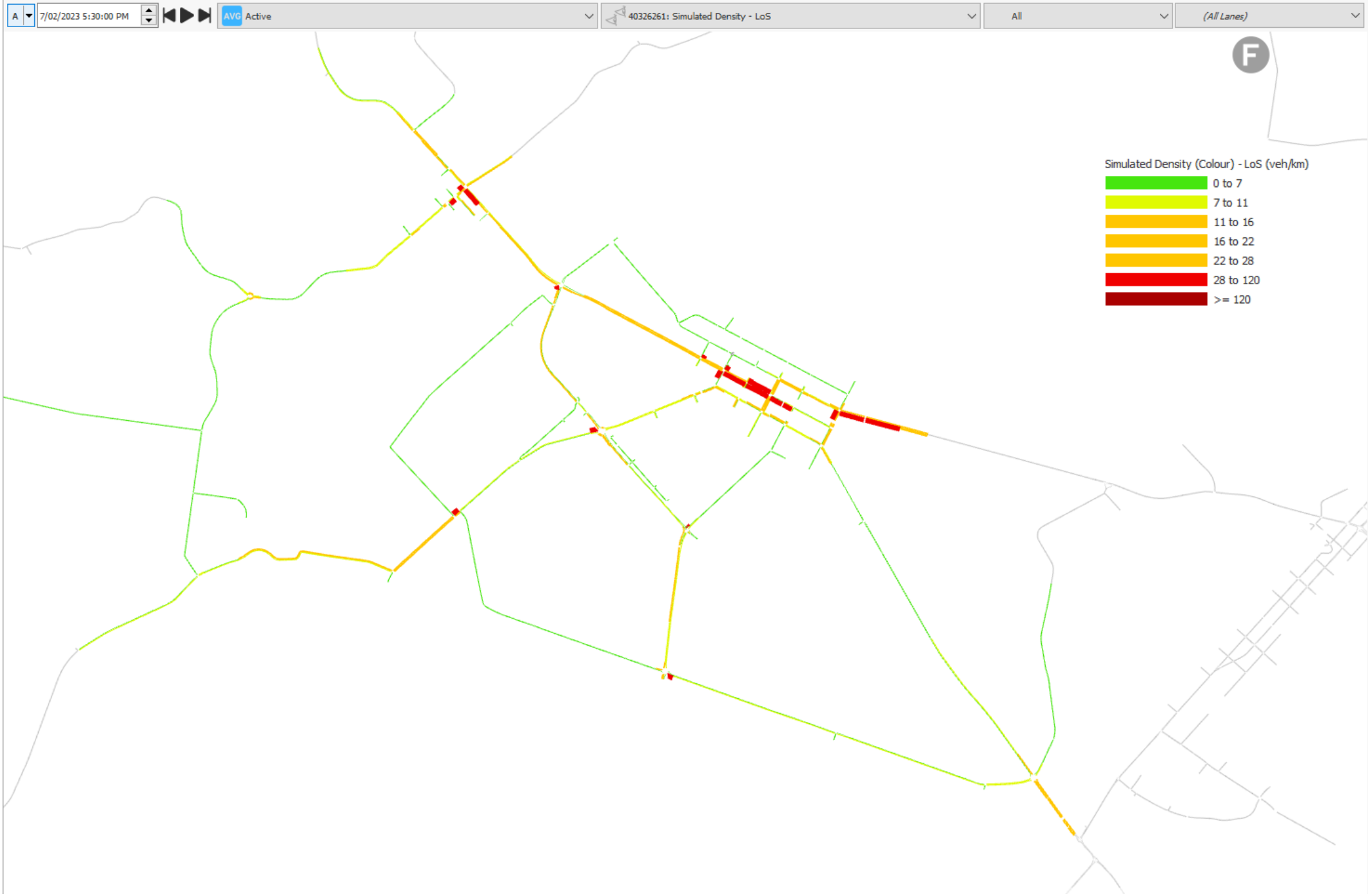
28 to 120
>= 120


A
7/02/2023 5:30:00 PM
AVG Active
40326261: Simulated Density - LoS
All
(All Lanes)
F
Simulated Density (Colour) - LoS (veh/km)
0 to 7
7 to 11
11 to 16
16 to 22
22 to 28
28 to 120
>= 120

Do Minimum 8:30 AM 9:30 AM

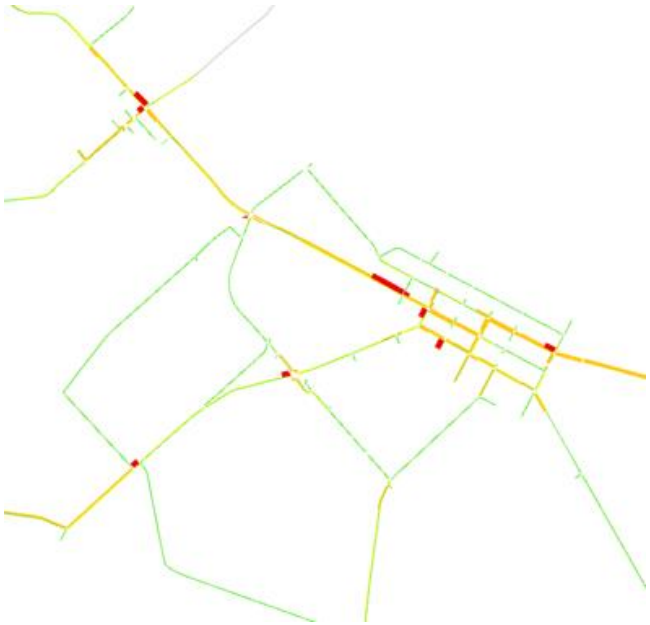
2029

2039

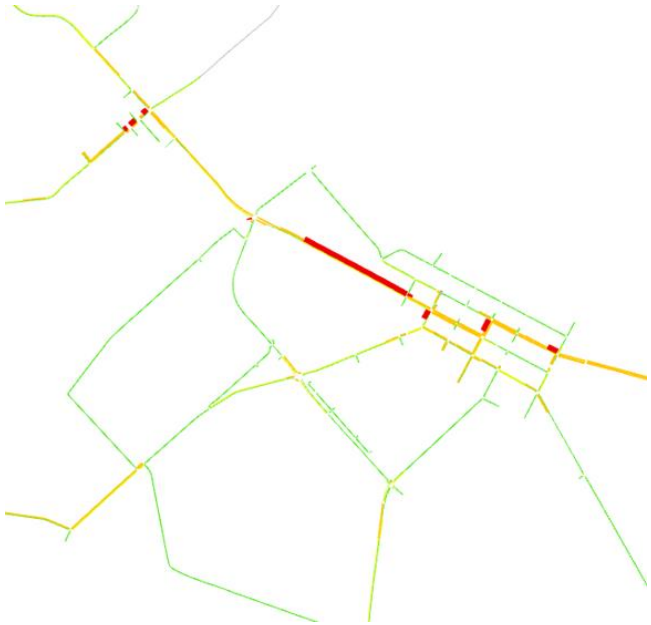
2049

Project Case 8:30 AM 9:30 AM

2029



2039



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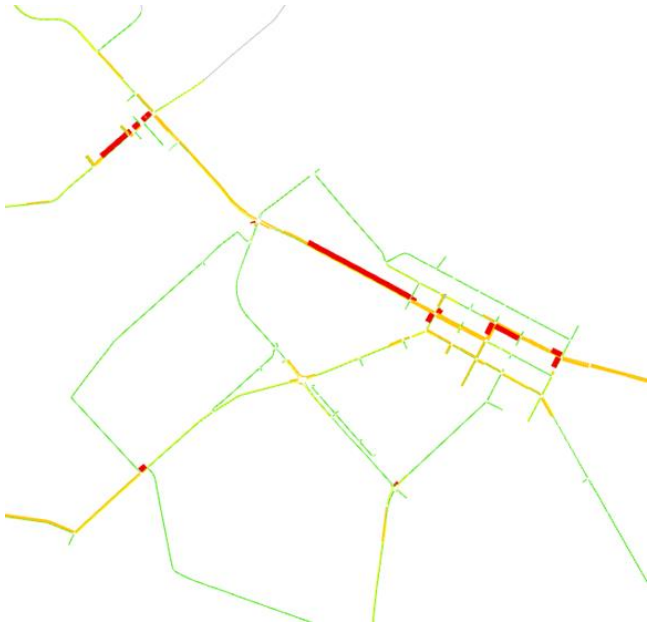
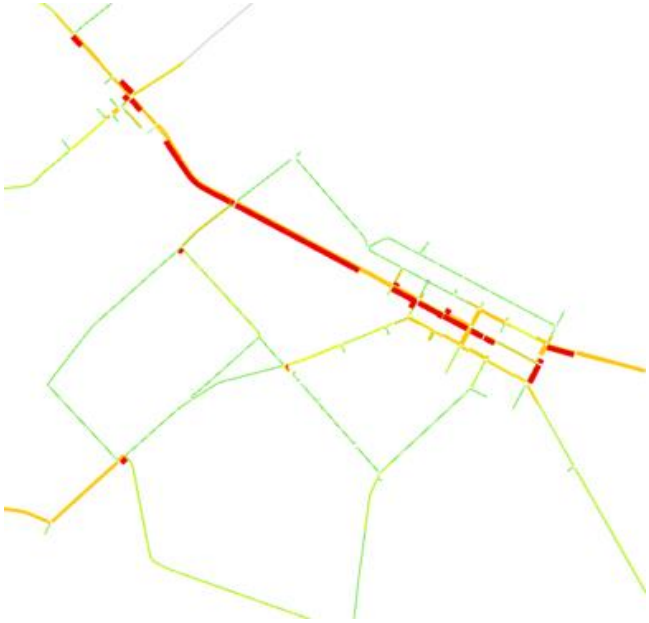


Do Minimum 4:30 PM 5:30 PM

2029



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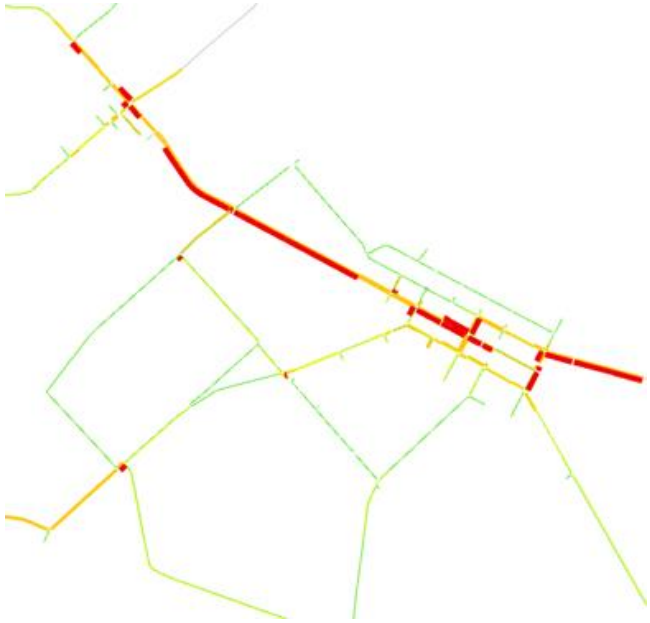

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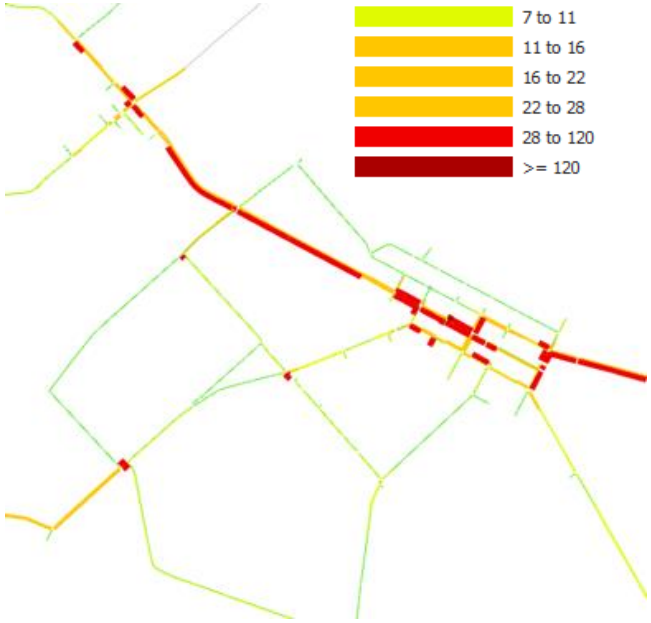
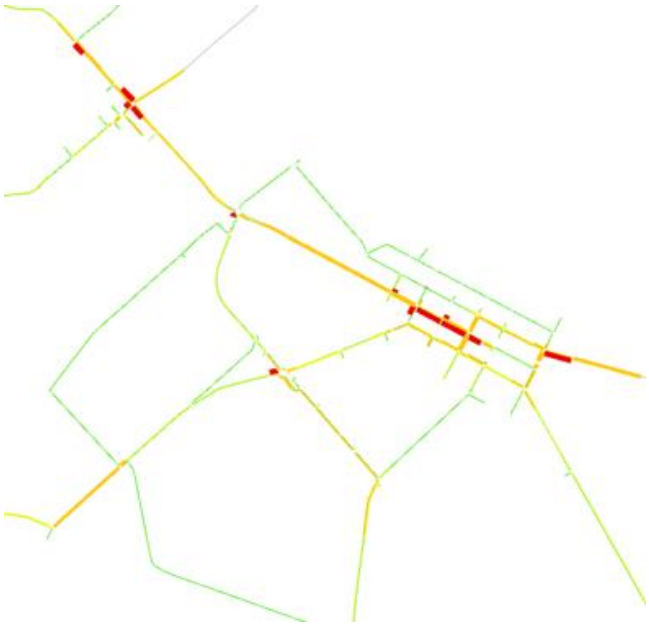


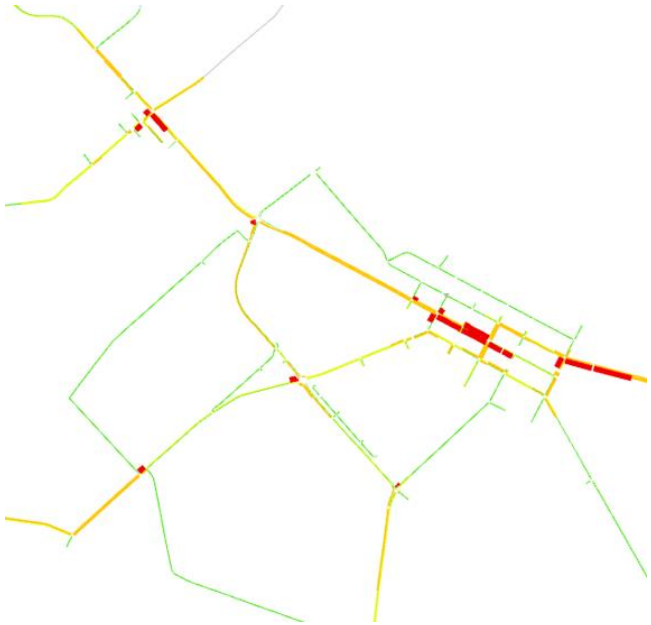
Project Case 4:30 PM 5:30 PM

2029



2039

2049



Appendix D – Detailed network performance

AM peak

Metrics	Unit	2023 AM Base			2029 AM Without proposal			2029 AM With proposal (Stage 2A)			2039 AM Without proposal			2039 AM With proposal (Stage 2B)		
		LV	HV	Bus	LV	HV	Bus	LV	HV	Bus	LV	HV	Bus	LV	HV	Bus
Vehicles Arrived	Veh	11,477	891	69	12,849	898	69	12,844	897	70	13,221	934	69	13,395	941	69
Vehicles Active	Veh	658	46	1	689	42	1	697	43	1	894	49	1	775	42	1
Latent Demand	Veh	4	-	-	0	-	-	0	-	-	53	0	-	1	-	-
Vehicle Kilometres Travelled (VKT)																
- VKT - Arrived Vehicles	km	61,059	5,498	314	71,331	5,562	316	71,641	5,516	317	74,185	5,797	316	75,103	5,798	316
- VKT - Active Vehicles	km	2,340	188	0	2,472	149	0	2,551	153	0	3,271	198	0	2,853	170	0
Vehicle Hours Travelled (VHT)																
- VHT - Arrived Vehicles	h	1,548	138	10	1,661	130	10	1,604	124	10	1,906	149	11	1,681	130	10
- VHT - Active Vehicles	h	57	5	0	55	3	0	57	3	0	107	5	0	64	4	0
Total Stops	Nos.	36,824	2,943	354	38,511	2,725	385	34,435	2,452	395	46,867	3,292	385	36,806	2,607	365
Average Speed	km/h	41	42	32	43	45	32	45	46	32	39	42	32	45	46	33

PM peak

Metrics	Unit	2023 PM Base			2028 PM Without proposal			2028 PM With proposal (Stage 2A)			2038 PM Without proposal			2038 PM With proposal (Stage 2B)		
		LV	HV	Bus	LV	HV	Bus	LV	HV	Bus	LV	HV	Bus	LV	HV	Bus
Vehicles Arrived	Veh	13,854	696	54	15,095	688	53	15,207	690	54	15,755	703	53	15,875	706	54
Vehicles Active	Veh	803	47	5	1,008	43	5	895	40	5	1,068	47	5	950	43	5
Latent Demand	Veh	0	-	-	2	-	-	0	-	-	5	0	-	3	-	-
Vehicle Kilometres Travelled (VKT)																
- VKT - Arrived Vehicles	km	68,388	3,917	236	78,715	3,841	232	78,216	3,814	239	82,475	3,887	228	82,474	3,893	239
- VKT - Active Vehicles	km	2,643	149	6	3,451	148	6	3,079	138	6	3,655	162	9	3,165	146	6
Vehicle Hours Travelled (VHT)																
- VHT - Arrived Vehicles	h	1,656	93	8	1,857	89	8	1,786	86	8	2,014	94	8	1,868	87	8
- VHT - Active Vehicles	h	66	4	0	100	4	0	72	3	0	102	4	0	78	4	0
Total Stops	Nos.	38,623	1,964	320	43,215	1,867	316	40,286	1,728	334	48,336	2,073	310	43,389	1,813	323
Average Speed	km/h	41	44	32	42	46	32	44	46	32	40	45	32	44	46	32

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