Cardno
Shaping the Future

SANDON POINT
LAWRENCE HARGRAVE DRIVE
PARAMICS MODELLING

MODEL DOCUMENTATION REPORT

Prepared for
STOCKLAND DEVELOPMENTS PTY LTD

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TABLE OF CONTENTS

Appendices

List of Tables

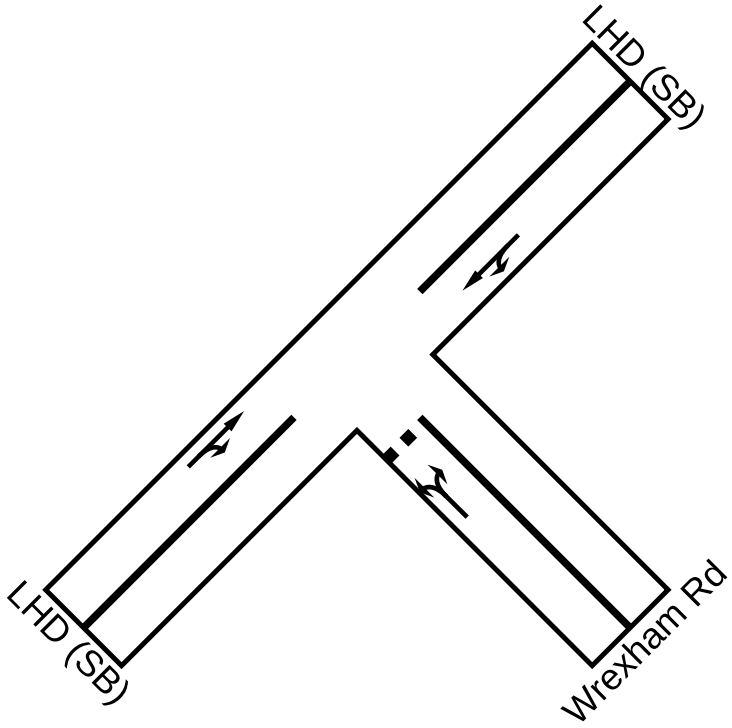
List of Figures

1 INTRODUCTION

1.1 BACKGROUND

Cardno has been commissioned by Stockland to develop a Paramics model as part of a response to comments made by the Roads & Traffic Authority of NSW (RTA) in respect to the proposed junction layout at Lawrence Hargrave Drive (LHD)/Wrexham intersection at Thirroul. The existing junction of LHD/Wrexham Road is a priority controlled junction with one effective traffic lane in each direction on LHD, as shown in Figure 1.1.

Figure 1.1 Conceptual Layout of LHD/Wrexham Road – Existing



It is proposed to upgrade this junction configuration to allow for projected increases in background vehicular traffic growth over the next 10 years, as well as that traffic which is likely to be generated by the proposed development adjacent to Wrexham Road, including the Sandon Pont Development.

As part of the development assessment (DA) of the Sandon Point Development, Stockland committed to upgrading the LHD/Wrexham Road intersection to a signalised junction. The original commitment included providing two through traffic lanes on Lawrence Hargrave Drive in both directions (northbound and southbound), as shown in Figure 1.2.

An alternate intersection configuration has been proposed and put before the RTA for consideration, which includes only one through traffic lane southbound on LHD, as shown in Figure 1.3.

Figure 1.2 Conceptual Layout of LHD/Wrexham Road – Signalised

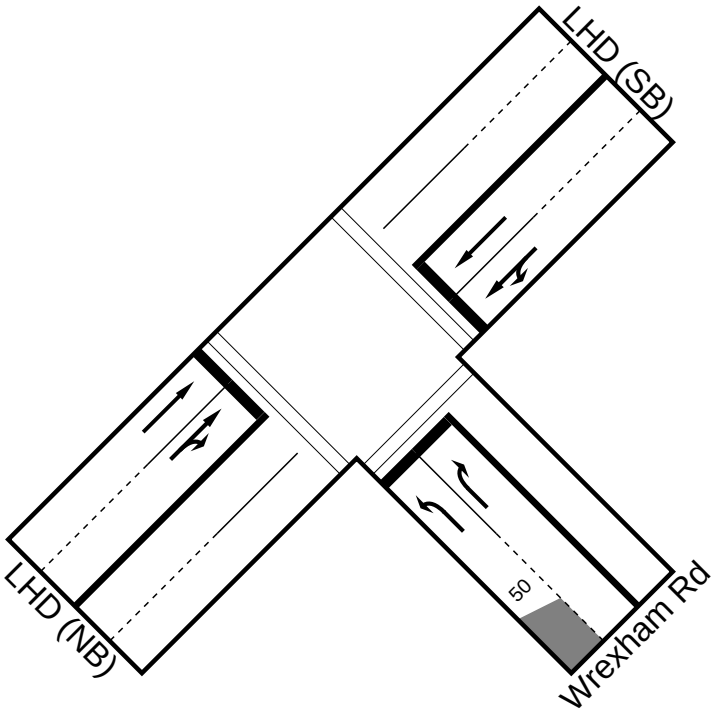
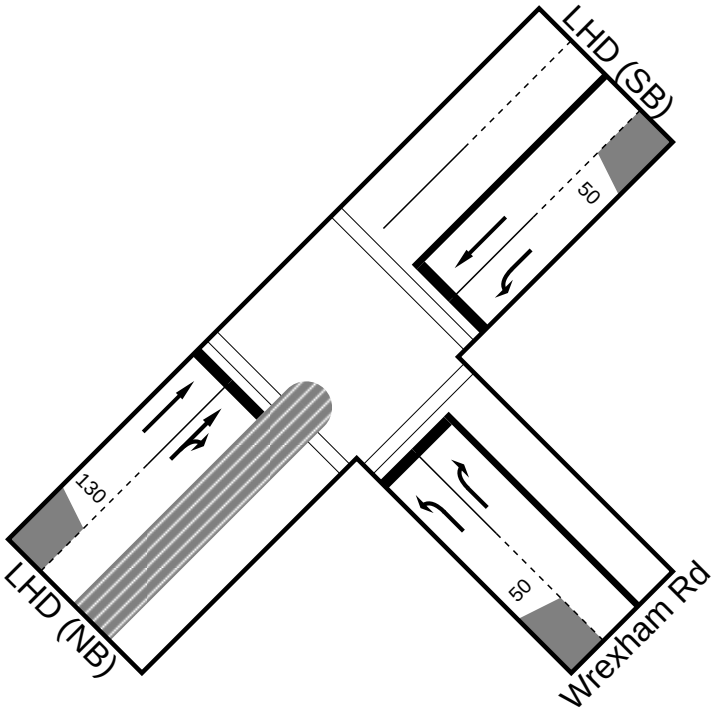


Figure 1.3 Conceptual Layout of LHD/Wrexham Road – Alternate Signalised



The RTA raised concerns about the future performance of this intersection and its impact on the coordinated signals through the Thirroul town centre. The purpose of this study therefore is to assess the operation on Lawrence Hargrave Drive (LHD) with the proposed alternate layout configuration, for the proposed signalised intersection of LHD/Wrexham Road which serves as the main access to the proposed Sandon Point development in Thirroul.

In doing this we have also taken into consideration the interactions of other junctions upstream and downstream from the proposed changes at LHD/Wrexham Road. This was done through the application of micro-simulation modelling software (Paramics) which helped with assessment of likely impacts that various treatment types would have on Lawrence Hargraves Drive and neighbouring junctions.

The level of detail taken into account at the micro level of traffic modelling means that each vehicle interacts with other vehicles and the network itself, in a unique way on each model run when different seeds are applied. Using different seeds simply means that variability is introduced into the modelling (and results) and is therefore more likely to give a better representation of the randomness found in traffic behaviour. Importantly, it gives a better appreciation of the impacts that changes at one location in the network could likely have on other locations, even those which are seemingly significant distances away.

1.2 STUDY AREA

The modelled study area comprises of LHD between Hewitts Avenue to the south and Raymond Road to the north as shown in Figure 1.4.

Within this study area there are

- Three (3) existing signalised intersections
  - LHD/Phillips Street.
  - LHD/Railway Parade.
  - LHD/Raymond Road.
- Six (6) existing priority-controlled junctions
  - LHD/Hewitts Avenue (upgraded to roundabout with below junction in future scenarios).
  - LHD/Prince Street (upgraded to roundabout with above junction in future scenarios).
  - LHD/High Street.
  - LHD/Wrexham Road (upgraded to signalised in future scenarios).
  - LHD/Lachlan Street.
  - LHD/Station Street.

Figure 1.4 Study Area

1.3 PURPOSE OF REPORT

The purpose of this modelling report is to document the process carried out to build, calibrate and validate the current situation models for the 2101 AM and PM peaks hours, and also to present the subsequent analysis and findings in relation to several assessments carried out for the road network with and without the proposed development in place.

A further purpose was to improve where possible the operations of LHD through using the opportunities that new and progressive development brings.

To this end, the report is divided into the following sections:

- Section 2 - Paramics Model Development outlines the development process of the 2010 base AM and PM peak models.
- Section 3 - Model Calibration and Validation provides detailed information and results for the model calibration and validation process.
- Section 4 – Describes the model scenarios that have been developed.
- Section 5 - Model Outputs & Findings presents and discusses the qualitative and quantitative outputs and findings of the various treatment options relative to the 2010 existing scenario and also relative to future year 2020 treatments.
- Section 6 - Conclusions and Recommendations provides a summary of the findings along with the study recommendations.

1.4 REFERENCE DOCUMENTS

The following documents have been referenced for this study:

- Review of Traffic Access to Sandon Point – Intersection of LHD & Wrexham Road written by Christopher Hallam & Associates Pty Ltd (4th December 2008).
- Traffic Access to Sandon Point – Intersection of LHD & Wrexham Road, Thirroul written by Christopher Hallam & Associates Pty Ltd (7th April 2009).
- Commission of Inquiry into Sandon Point Traffic & Transport Report Christopher Stapleton Consulting Pty Ltd (Feb 2003).
- Sandon Point Concept Plan 2006 Traffic Review - Christopher Stapleton Consulting Pty Ltd (May 2006).
- Sandon Point Part 3A Project Plan Application Traffic Impact Report – Christopher Stapleton Consulting Pty Ltd (June 2007).

2 MODEL DEVELOPMENT

2.1 INTRODUCTION

Paramics micro-simulation software was selected as the modelling tool of choice to deliver the required tasks for this project. Paramics is a suite of high performance software tools for microscopic traffic simulation. It represents a radical approach to the understanding, representation and analysis of vehicle traffic, where individual vehicles are modelled in fine detail for the duration of their entire trip, providing the accurate traffic flow information and the visual observations necessary for the analysis of congested road networks.

Paramics represents traffic flow from the standpoint of the individual driver; therefore traffic engineers are able to distinguish between minor sub-optimal design variations without resorting to deterministic proxy. All known components likely to significantly affect traffic flow are represented, across the full range of road network types.

Cardno is committed to micro-simulation modelling and in particular Q-Paramics, and has a strong capability in its application with staff involved in its use varying between 1 and 10 years experience.

2.2 SCENARIO 1 (S1) – EXISTING MODELS 2010

Paramics models were calibrated and validated to represent average weekday conditions for the current conditions during the AM and PM Peak Hours, 2010.

A current model is simply one that represents the existing average conditions for a designated period; the existing year for this study is 2010.

Paramics models which represent the existing conditions as at June 2010 (named in this report as Scenario 1 (S1)) were built to represent the following Peak Hour time periods:

- 2010 Current AM Peak 08:00 to 09:00 (Full model period: 07:00-10:00)
- 2010 Current PM Peak 15:30 to 16:30 (Full model period: 14:30-17:30)

Note that each model was also built with a 1-hour warm up and 1-hr cool down period to ensure a good representation of traffic conditions either side of the peak hour modelled.

All models have been calibrated and validated to provide a good representation of existing conditions. The criteria and results for which are provided later in this report.

2.3 DATA SOURCES

Some data was made available for use by RTA during the model build process, including the proposed layouts of the Bulli overpass and the proposed roundabout intersection at LHD/Hewitts Avenue/Prince Street.

In addition, we also used the traffic control signals (TCS) plans supplied by RTA to code up the layout and phase arrangements of the signalised intersections in the study area. All existing and proposed intersection layouts are shown in Appendix A.

Additional data also had to be collected for the current year during the AM and PM peak periods in order to provide a complete reliable data set, which could be used for calibrating and validating the 2010 Existing Models. Data was collected on Thursday 10 June 2010 at Lawrence Hargrave Drive, Thirroul. Survey Times were 3 hour periods in the AM and PM peaks:

- 06:00 to 09:00
- 15:30 to 18:30

This additional data collected includes the following.

Full Intersection Counts (separated into heavies and lights and included pedestrian counts) were done at the following signalised junctions:

- LHD/Raymond Road.
- LHD/Phillip Street.
- LHD/Railway Parade.

Turning Volumes Only - no through movements required (separated into heavies and lights) for the following priority controlled t-junction intersections:

- LHD/Station Street.
- LHD/Church Street.
- LHD/Lachlan Street.
- LHD/Wrexham Road.
- LHD/High Street.
- LHD/Laneway just north of High Street.
- LHD/Prince Street/Hewitts Avenue (currently operating as a staggered T).
- LHD/Hewitts Avenue (N).
- LHD/Laneway just north of Hewitts Avenue (N).
- LHD/Hewitts Avenue (S).

Queue Lengths were collected at all approaches at the following signalised junctions:

- LHD/Raymond Road.
- LHD/Phillip Street.
- LHD/Railway Parade.

Travel Time Surveys (Northbound and Southbound) were collected along LHD from King Street to Princes Highway with time taken at the following station intervals:

- LHD/King Street (Start/End).
- LHD/Raymond Road (Intermediate).
- LHD/Phillip Street (Intermediate).
- LHD/Princes Highway (Start/End).

At all signalised intersections throughout the study area, full vehicle movement and queue length traffic data was collected. The through traffic volumes at all other modelled intersections, where traffic counts were not provided, was determined based on site observations, surrounding land uses and anomalies identified with mid-block traffic flows calculated at the upstream and downstream signalised intersection(s).

2.3.1 Aerial Photographs

Aerial photography images from Google Earth were the source upon which the model network was built; the aerial photographs were also cross-checked with site inventories to ensure accuracy in the model network configuration.

2.3.2 Site Inspections and Video Inventory

Cardno carried out site inspections during the model build process to collect an array of data; a video survey was also carried out for the entire study area. Information collected includes:

- Parking restrictions.
- Turn bans.
- Lane configurations.
- Junction operations.
- Lane usage.
- Driver behaviour.
- Queues.
- Pedestrian activity.
- Car park operations.
- Shopping centre locations.
- Bus Stops.
- Public Transport.
- Signal timing.

Details of the service times and stop locations for all on-road public transport in the study area were collated using information available on the internet and / or from site inventories.

2.3.3 Restrictions / Pedestrians / Zoning

Lane allocation, Turn Bans, Restrictions

Site inventories were used to identify lane allocations, turn bans and restrictions, as well as how these may change during the simulation time period.

Pedestrian Activity

The important locations where pedestrians cause delays to traffic were identified through site inventories. The impacts were accounted for in the model where appropriate.

Zoning, Bus Stops, Taxi Ranks, On-Street Parking, Car Parking Restrictions

The above were coded into the model as they currently exist on the ground and were used to identify impacts on traffic movements.

2.4 MODEL DEVELOPMENT

Paramics assigns vehicles through the network on the basis of the lowest travel cost route. The travel cost of a route is calculated on the basis of travel time, travel distance and monetary cost. Cost factors are specified for each of these parameters and link specific cost factors can also be applied. Paramics also enables assignment on the basis of "all or nothing" assignment, "stochastic" assignment or "dynamic feedback" or a combination of these.

The choice of assignment used for all models was the "all or nothing" assignment as there is no route choice in any of the models.

2.4.1 Major/Minor Routes and Familiarity

Paramics enables the user to define 'major' and 'minor' links and the proportion of drivers, which are either familiar or unfamiliar.

The effect is that all familiar drivers see the link costs as they are calculated whereas unfamiliar drivers see the cost of all minor links factored by two. This results in unfamiliar drivers preferring major routes to minor routes, whilst familiar drivers have no preference. Given that there is no route choice in the models for this assessment, the major / minor routing has minimal impact for modelling purposes.

2.4.2 Zoning System

Zones are defined as locations where vehicle trips originate and terminate, i.e. trip ends. The zoning system for the Paramics model is detailed, with the all important access/egress points coded in.

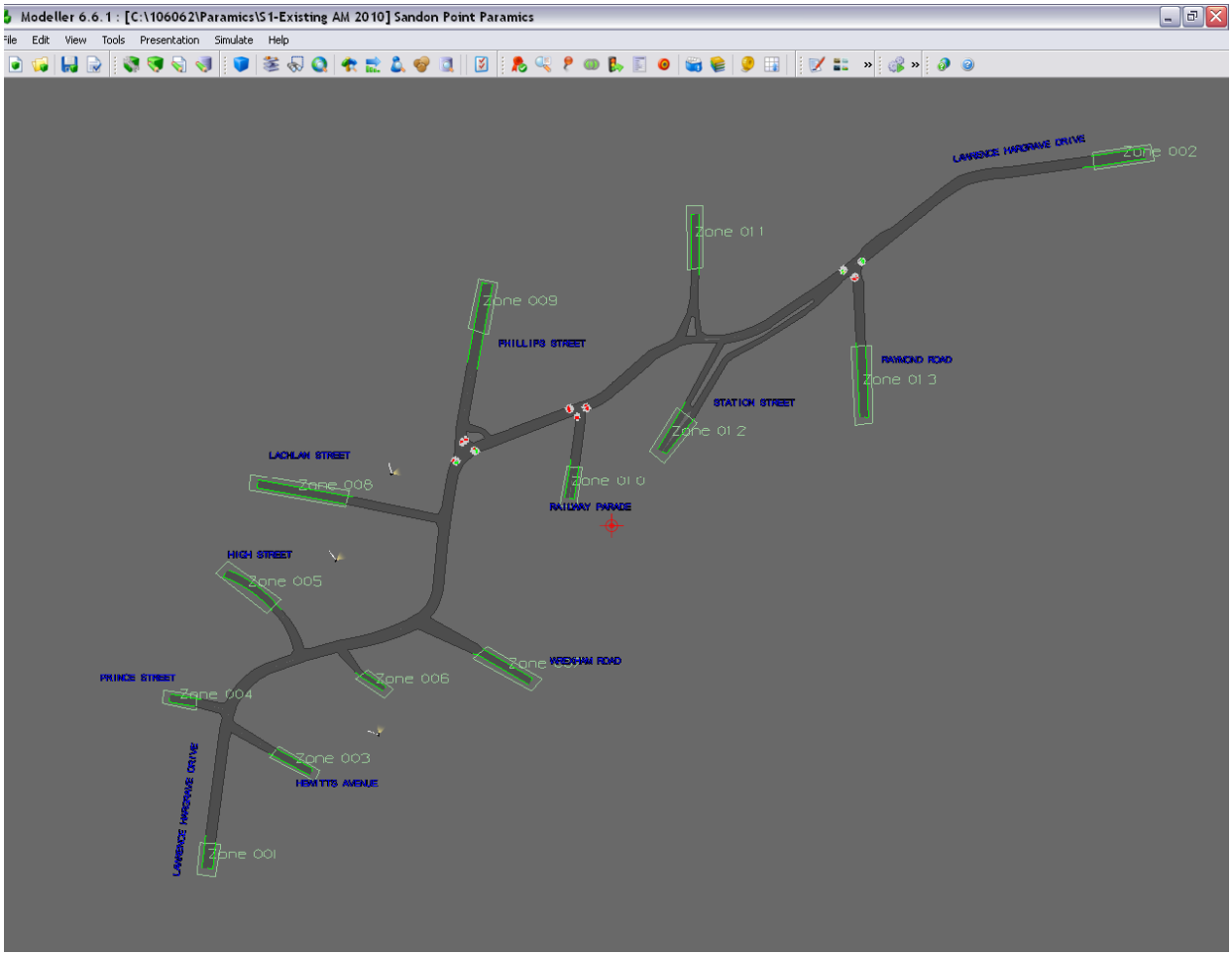
In total, 13 zones have been coded into the models with Zone 001 and Zone 002 as the zones for Lawrence Hargraves Drive north and south respectively. Other zones are as shown in Figure 2.1.

2.4.3 Traffic Signals

In the 2010 Base modelling, signal phasing, green splits and inter-greens were coded into the Paramics model based on site data taken from Cardno site inventory visits on 16th June 2010 Wednesday in the AM and PM peak periods. Given that there were no SCATS history files made available for our modelling, this method of extracting signal information regarding cycles, phases, sequences and timings was the best available.

The SCATS system used along LHD allows for adaptive phase lengths at intersections to improve the efficiency of individual junctions and corridors. In Paramics the signals were coded to reflect a fixed time average during the peak periods and the linkages between signals were maintained.

Figure 2.1 Zone Numbering



2.5 TRAFFIC DEMAND & ASSIGNMENT

The AM and PM peak demand matrices were developed to produce a one hour peak matrix, with a ramp up period to ensure that the peak hour matrix represents the busiest hour in both the morning and evening periods, not simply the busiest clock hour.

The traffic assignment method used for the base modelling is 'All-or-Nothing'. This method was considered to be the most appropriate given there is no route choice within the modelled study area. Major and minor links are still coded in for good practice.

2.5.1 Demands Matrix Development

The trip matrices for each of the models (AM and PM) have been calculated from the following sources:

- Surveyed Turning Movement Counts.
- Cordon Link Counts.

2.5.2 Matrices

Two (2) Matrices were developed for each of the 1 hour AM and PM peak models. Matrix 1 represents the background traffic demands and Matrix 2 represents the development traffic demands.

2.5.3 Smoothing

Smoothing was applied to the recorded traffic flows in order to ensure a well calibrated & validated Paramics model was achieved.

Smoothing is a process of good practice in micro-simulation modelling where, if flows out of one junction and flows into the next are unequal, and then one set of figures is adjusted to ensure that both sets are equal. The exercise is carried out throughout the network on a proportional basis until all flows match. Paramics is a model, and as such it requires that the flows throughout the network match up, especially for the matrix estimation process to be utilised; it is therefore essential for this smoothing process to take place. The balanced AM and PM peak traffic flows are presented in Appendix B.

2.5.4 Demand Profile

A 15 minute demand arrival profile was applied to the matrices. The shape of the profile for both the AM and PM peak was based on the traffic count data as surveyed by SkyHigh on 10 June 2010.These profiles specify the timing of proportional release of vehicles into the models, and were developed from the 15-minute interval turning movement counts. Different individual profiles were applied to all external zones based on the numbers of vehicles released during each 15 minute period, relative to the total amount released in the peak hour being modelled.

Using this methodology provides a robust representation of the varying local dynamics within different locations in the model. For example the profile of vehicle releases from Phillip Street may be completely different to the release profile from the Railway Parade area, and the release profile from the zone covering Lawrence Hargraves Drive south, may be completely different to both of these again. Applying these types of localised profiles therefore, allows more accurate simulation of trips and local issues; this profile technique is applied to all of the Base models.

3 MODEL CALIBRATION & VALIDATION

3.1 SIMULATION PARAMETERS AND ADJUSTMENTS

A major element of successful calibration was to ensure that the LHD between Princes Highway and King Street route was being simulated accurately, and also that signal operations within the model area were realistically represented. In order to produce goodness of fit in each model, numerous model attributes were carefully checked and driver behaviour and lane usage monitored to ensure accurate representation of model conditions was achieved.

3.2 MODEL CALIBRATION

There are no adopted standards in Australia for calibration and validation of traffic models, although there are standards in NSW developed by the RTA. Some of the most up to date standards are often taken from the RTA and UK Design Manual for Roads and Bridges where calibration criteria for traffic models require **85% of GEHs to be <5**.

In reality, traffic volumes vary from day to day and from location to location. The GEH statistic was developed to cope with these types of different ranges in flows. Instead of comparing absolute or relative flow differences therefore; a wide range of flows can confidently be deemed as being statistically accurate using the GEH formula. For example, where an absolute difference of 100 vehicles/hr can be important in a flow of 200 vehicles/hr, it is largely irrelevant in a flow of several thousand vehicles/hr.

The purpose of the above calibration criterion for the existing models is to match the traffic volume information at all key junctions and links with the following requirements for each hour for each of the three models:

- GEH statistics for Zone release, turns and other volumes with no fewer than 85% less than 5.

GEH compares the differences between observed flows and modelled flows on a link by using the following formula:

$$GEH = \sqrt{(V_O - V_A)^2 / (0.5 \times (V_O + V_A))}$$

Where:

V_O = Observed traffic flow (vehicles/hour)

V_A = Assigned (or modelled) hourly traffic flow (vehicles/hour)

The model calibration was carried out for each modelled hour in each of the 2 Existing Models. The following section provides the calibration results for each of the 2 Existing Models for the AM and PM peak period.

In accordance with best practice, all modelled scenarios for this study were run with RTA's recommended seed values of 28, 560, 2849, 7771 and 86524 to ensure robustness of the models. The results for each scenario presented in this report are based on the average of 5 model seed runs.

3.3 CALIBRATION RESULTS

Table 3.1 and Table 3.2 show the calibration summary for each of the existing models. As can be seen, the calibration criteria have been exceeded significantly for each hour of each model. Detailed modelled flows and GEH statistics are attached in Appendix B.

Table 3.1 AM Peak Calibration Results Summary

Data Type	GEH < 2	GEH < 5
Intersection Counts	97%	100%
Link Counts	96%	100%
Overall	**96%**	**100%**

Table 3.2 PM peak Calibration Results Summary

Data Type	GEH < 2	GEH < 5
Intersection Counts	95%	100%
Link Counts	96%	100%
Overall	**96%**	**100%**

3.4 MODEL VALIDATION

Once the Paramics model was calibrated, a data set separate to that used during the calibration process, was used to validate the model. The method used was to compare the modelled travel times of vehicles through the network with the actual observed times.

3.4.1 Travel Time Validation

The required criterion for travel time validation was:

- 85% of movements to have modelled travel times within 15% (or 1 minute, whichever is higher) of the observed travel times.

In this case, where a corridor model is built, we aimed to have travel times north and south through the model to be within 15% or 1 minute whichever was greater. Model travel times on Lawrence Hargrave Drive were therefore compared with the actual times as recorded on site by SkyHigh Traffic Survey Consultants. As was done during calibration, the validation was carried for each modelled hour using the average of 5 seed runs, in both the existing AM and PM peak hours.

The sections that were subject to travel time validation tests were:

- Vehicle travelling northbound on LHD from Princes Highway to King Street.
- Vehicle travelling southbound on LHD from King Street to Princes Highway.

3.4.2 Travel Time Validation Outputs

The model validation outputs for each of the AM Peak and PM Peak models were robust, with travel times in both directions giving a solid representation. A summary of the validation results for each of the models is described in Table 3.3, Graph 3.1 and Graph 3.2, which show the validation summary for each of the existing models. The validation criteria have again exceeded the validation criteria.

Table 3.3 Travel Time Validation Results Summary

Southbound Through the Model

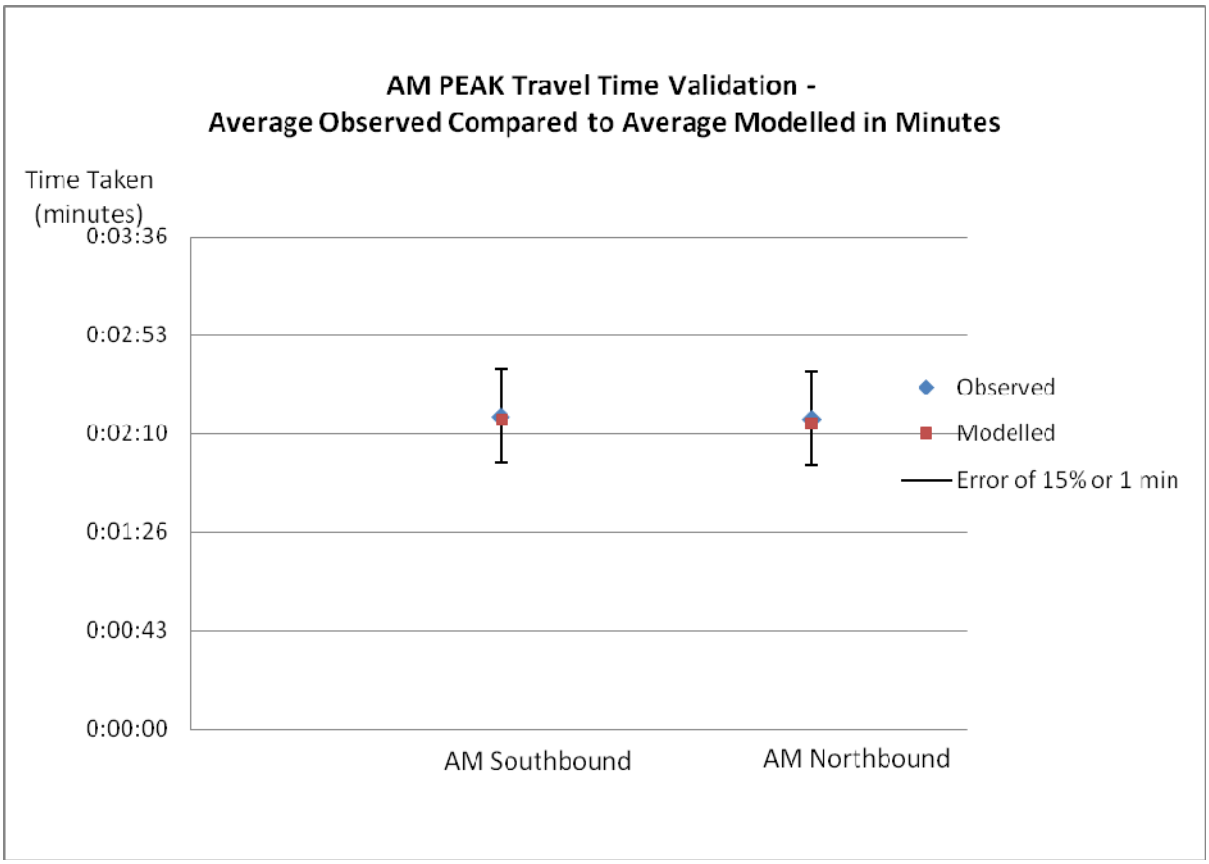
LHD SB from King St - Princes Hwy	AM	PM
Averaged Observed Time (mins)	0:02:17	0:02:16
Averaged Model Time (mins)	0:02:16	0:02:20
Averaged Difference (mins)	0:00:01	0:00:04
Averaged Travel Time Difference (%)	**0.73%**	**2.94%**

Northbound Through the Model

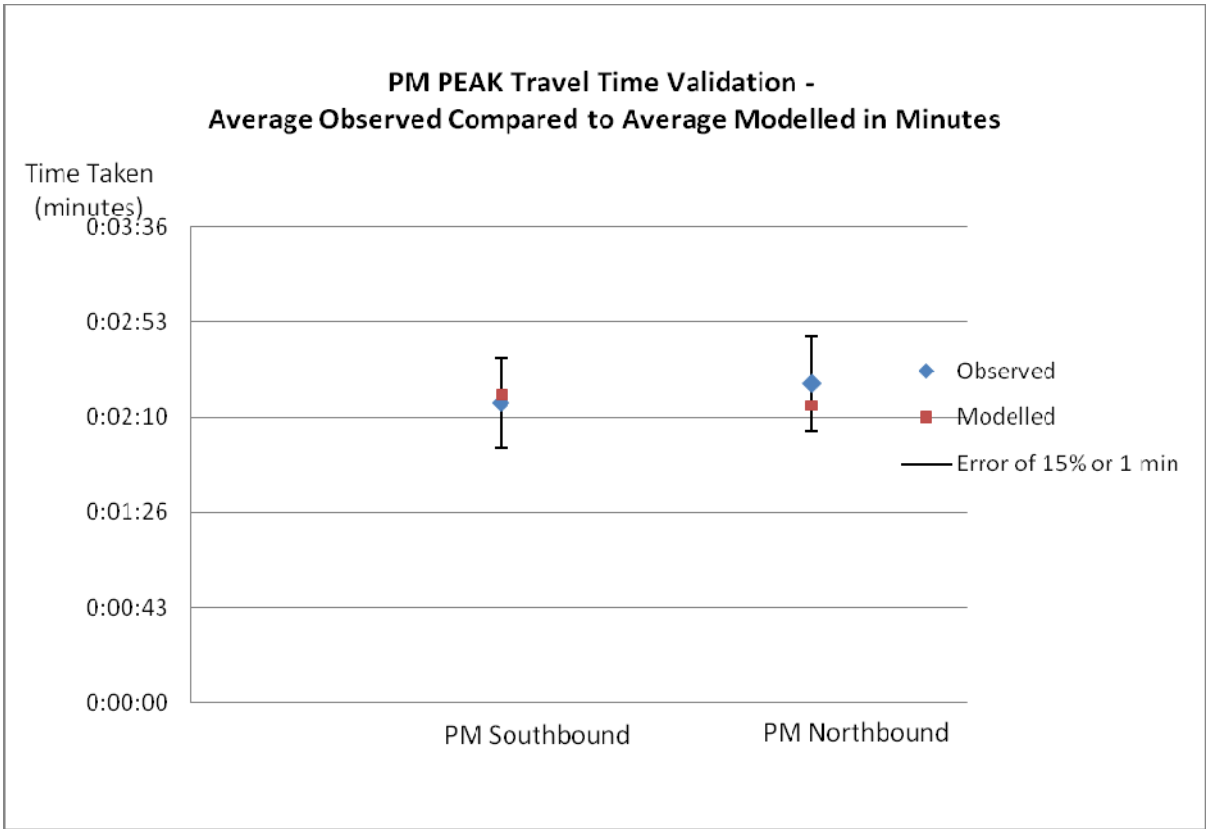
LHD NB from Princes Hwy - King St	AM	PM
Averaged Observed Time (mins)	0:02:16	0:02:25
Averaged Model Time (mins)	0:02:14	0:02:15
Averaged Difference (mins)	0:00:02	0:00:10
Averaged Travel Time Difference (%)	**1.47%**	**6.90%**

Travel times to be within 1 minute or 15% (whichever is higher) of the observed travel times

Graph 3.1 AM Peak Travel Time Validation



Graph 3.2 PM Peak Travel Time Validation



The matching of modeled and observed traffic volumes and travel times give strong calibration and validation results, which represent models that are accurately replicating existing conditions within the study area.

3.4.3 Queue Length Validation

Modelled queue lengths along Lawrence Hargraves Drive were compared qualitatively for signalised approaches at the intersection of LHD/Phillips Street, LHD/Railway Parade and LHD/Raymond Road and compared to the corresponding observed values on site. This additional validation was carried for each modelled hour using the average of 5 seed runs, in both the existing AM and PM peak hours.

The model validation queuing checks for each of the AM Peak and PM Peak models were robust with the difference between the maximum observed queue lengths and modelled queue lengths not exceeding more than 4 vehicles for any of the approaches. This is an excellent representation of queuing within the model.

A summary of the results for Queue Length Validation are illustrated in Table 3.4 and Table 3.5; as can be seen from the results, there are negligible differences between the observed and modelled in terms of operation.

Table 3.4 AM Peak Maximum Queue Lengths on Approach (vehicles)

Intersection	Approach	Surveyed	Existing 2010 (S1)
LHD/Phillips St	Northbound	12	15
	Southbound	13	16
	Phillips St	7	6
LHD/Railway Pde	Northbound	8	8
	Southbound	12	10
	Railway Pde	7	4
LHD/Raymond Rd	Northbound	8	11
	Southbound	12	10
	Raymond Rd	4	2

Table 3.5 PM Peak Maximum Queue Lengths on Approach (vehicles)

Intersection	Approach	Surveyed	Existing 2010 (S1)
LHD/Phillips St	Northbound	18	17
	Southbound	10	14
	Phillips St	9	6
LHD/Railway Pde	Northbound	11	7
	Southbound	12	10
	Railway Pde	8	7
LHD/Raymond Rd	Northbound	12	15
	Southbound	12	9
	Raymond Rd	3	2

3.5 SUMMARY

Each of the base micro-simulation models (AM and PM), for the existing situation, have been calibrated and validated to exceed industry guidelines.

The models therefore represent typical average conditions for the AM and PM weekday peak periods, and incorporate pedestrian impact on traffic delays in the modelled area where appropriate.

3.6 CONGESTION LOCATIONS AND POINTS OF NOTE

The following are brief descriptions of areas in the current year base models, where there are currently issues from a traffic operation perspective:

- Queues extend back from Phillips Street to Wrexham Road for northbound vehicles in the PM peak.
- Heavy right turning vehicle movement from LHD into Phillips Street results in queues extending back to Railway Parade and in some instances, back to the Railway Bridge.

4 MODELLING SCENARIOS

Once the 2010 Existing Models were qualified as being robust and representative of existing road conditions, it was then possible to develop the model scenarios including future 2020 models to produce representations of the same AM and PM peak hours to test the impacts of the development.

For the purposes of this study, the following models have been developed:

- Scenario 1 (S1) – Existing AM and PM Models as exist in June 2010.
- Scenario 2 (S2) – 2010 AM and PM Base Models (S1 + with known upgrades for 2010 included).
- Scenario 3 (S3) – 2010 Base with Development Models (S2 + Development).
- Scenario 4 (S4) – 2020 Base Models (2020 with no development).
- Scenario 5a (S5a) – 2020 Base with Development Models (S4 + development).
- Scenario 5b (S5b) – 2020 Base with Development Models (S5a with signal optimisation).
- Scenario 5c (S5c) – 2020 Base with Development Models (S5b with lane widening on LHD at Phillip Street junction).

The following provides more details of each of the future models.

4.1 SCENARIO 2 (S2) – 2010 BASE MODELS

With the Bulli overpass near to completion and scheduled to open in late 2010, it has been agreed with the RTA that the 2010 Base Models for this project would be developed to include the operational impacts of the Bulli Overpass and a new Roundabout at the currently staggered junction where Hewitt's Avenue and Prince Street intersect with LHD.

The base models are as per S1 models with the addition of the following:

- Bulli Overpass – modelled using dummy signals south of Hewitts Avenue to allow simulation of the bunching effect of the Bulli overpass operation as requested by RTA.
- Roundabout at the intersection of LHD/Hewitts Avenue/Prince Street.

The purpose of doing this was to create baseline conditions in the future with the Bulli Bypass Overbridge and new roundabout in place, which could then be further developed to include the proposed development and any associated road network and/or signalised changes. Then all scenarios could be compared with each other objectively.

After coding up Base models for 2010 with the bypass and roundabout in place and also coding up the Development scenarios, visual and quantitative analyses were carried out to determine the issues and develop possible treatments to test. These treatments mitigate for the additional vehicular impacts in terms of both safety and operation, with development in place.

4.2 SCENARIO 3 (S3) - 2010 BASE WITH DEVELOPMENT MODELS

The 2010 Base with Development model consists of the same model network as that for S2 with the addition of the following:

- Signalisation of LHD/Wrexham Road Intersection (Refer to Appendix C for proposed intersection layout). The signalised intersection operates with 3 phases and does not allow right turn filters from LHD into Wrexham Road.
- Signals are optimised and coordinated with the upstream and downstream signalised intersections.
- Removal of car parking on LHD between High Street and Wrexham Road in the northbound direction.
- Removal of car parking on LHD between Wrexham Road and the lane way access in southbound direction.
- Removal of 3-4 car parking spaces on LHD on both sides of LHD immediately north of Wrexham Road.
- Increased traffic flows on Wrexham Road representing development traffic to and from the Sandon Point Development (including other developments potentially using this access also). Development traffic flows are based on turning volumes into/out of Wrexham Road as presented in the "Review of Sandon Point Access" report by Christopher Hallam & Associates Pty Ltd dated 4th December 2008 (Refer to Appendix D).

4.2.1 LHD/WREXHAM ROAD JUNCTION TREATMENT

In 2010 with the development in place, the following changes were made to LHD/Wrexham Road junction in the Paramics models:

- Full signalisation installed.
- Signals linked into existing system.
- Provision on Wrexham Road for dedicated left and dedicated right turning lanes into LHD.
- On LHD northbound – additional though/right-turning lane added.
- The right turners from LHD into Wrexham Road receive no right-turn filter in a conflicting movement. Instead they turn right during the 'northbound-through and right-turn' phase which is dedicated to those movements with no conflicts.
- On LHD southbound – additional short left turn from LHD into Wrexham Road.
- Parking removal at various locations depending on Scenario being tested.

The LHD/Wrexham Road signalised junction is shown in Figure 4.1.

4.2.2 PARKING ON LHD

As previously noted Scenario 3 requires the removal of 3-4 car parking spaces on LHD on both sides of LHD immediately north of Wrexham Road. Figure 4.2 and Figure 4.3 following illustrates the removal parking between the Scenario 2 and Scenario 3.

Figure 4.1 2010 Wrexham Road LHD junction as coded into Paramics with signals

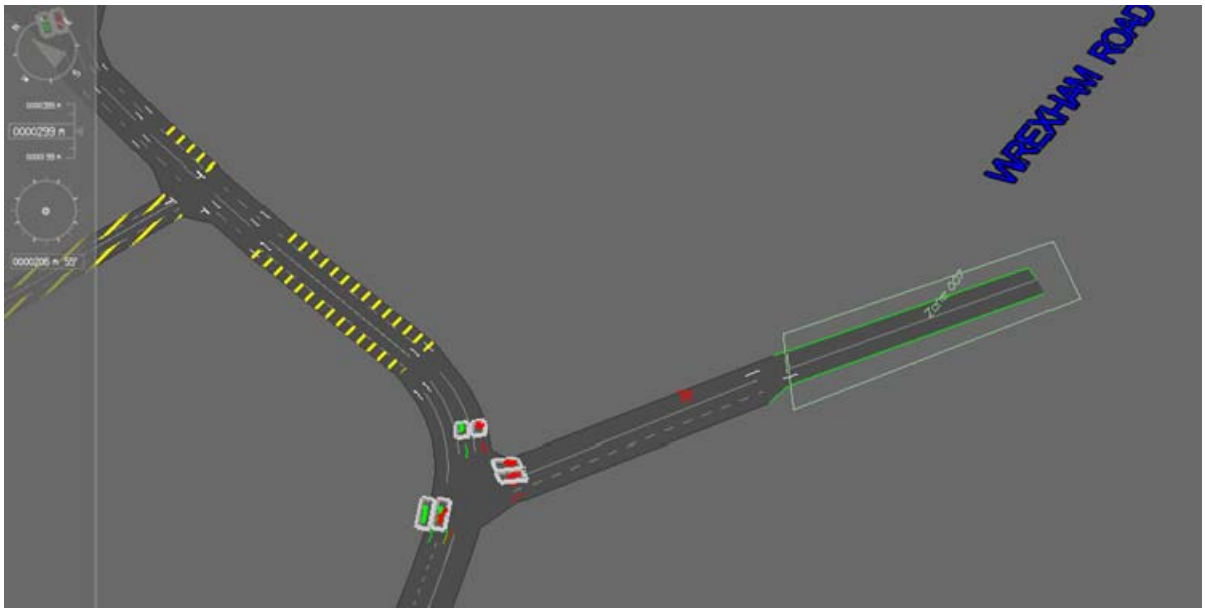


Figure 4.2 2010 Base Before Parking Removal (S2)

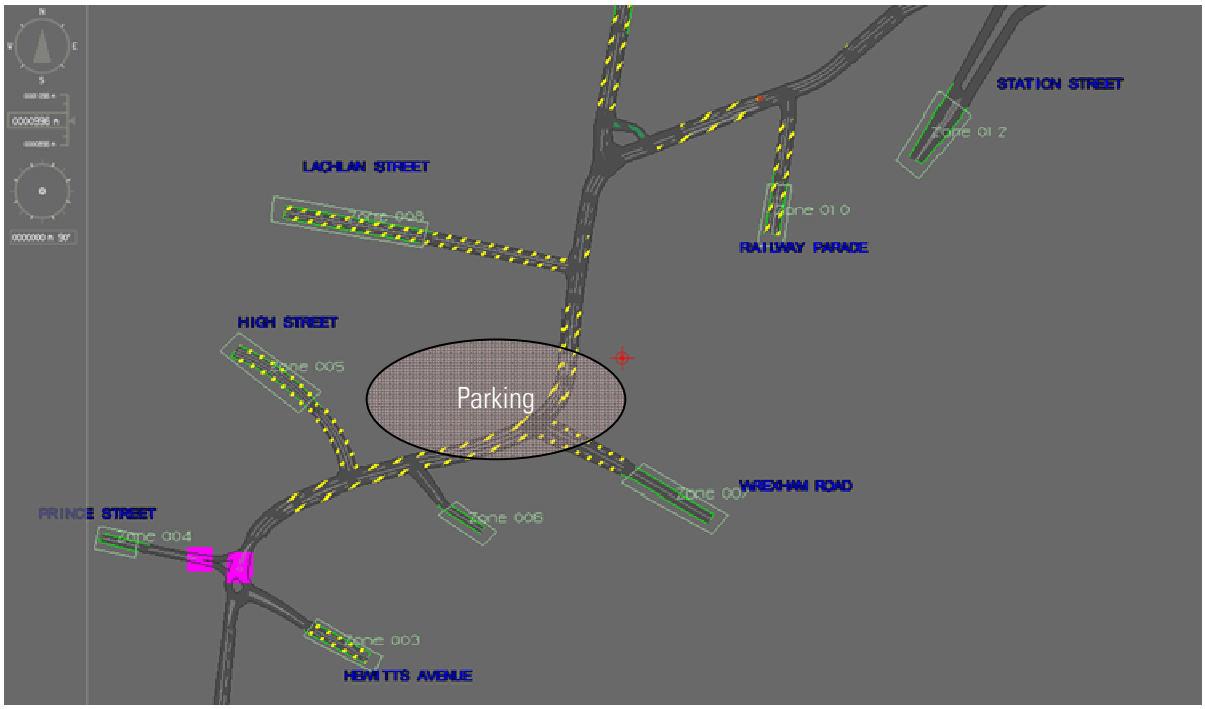
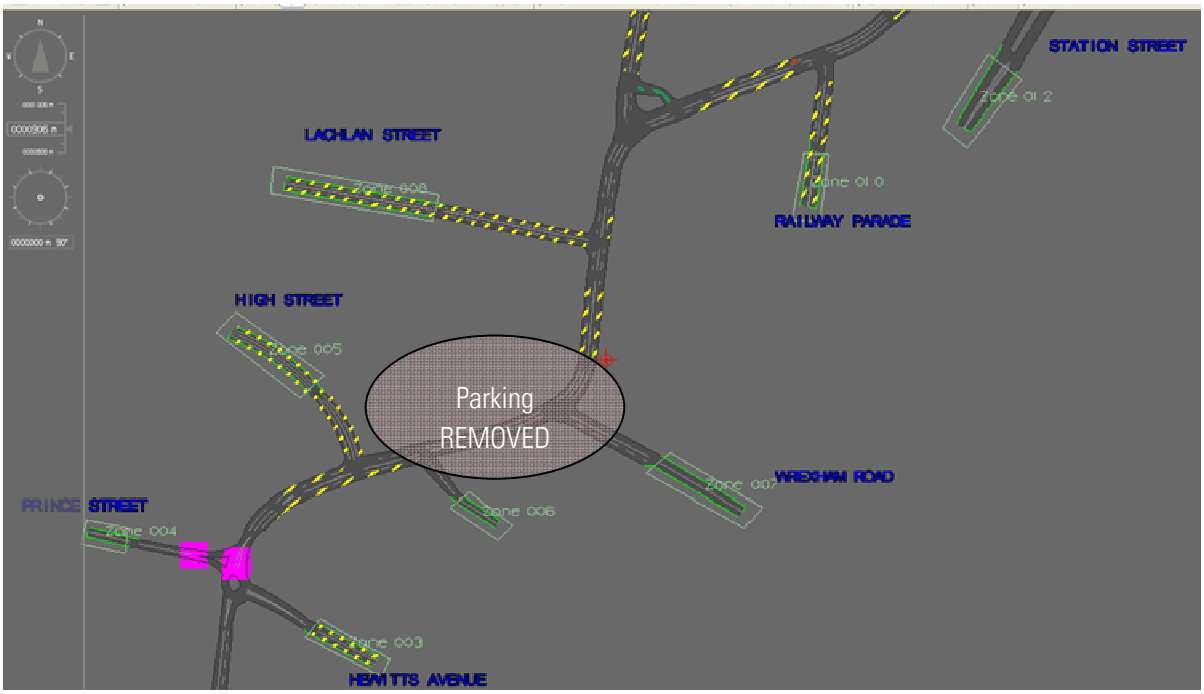


Figure 4.3 2010 Development Scenario 3 With Parking Removal



4.3 SCENARIO 4 (S4) – 2020 BASE MODELS

The Base modelling for 2020 consists of the same model network as that for S2, but with increased through traffic flows. The traffic flows that have been used in the Base models for 2020 were derived from growth factors as determined from guiding requirements as discussed with RTA. The assumption here is that through trips are likely to grow in the region or **3% linearly, per annum**. With this as a guide, the future year models for 2020 had this increase applied to all trips between the northern and southern ends of the model (i.e. between both ends of LHD northbound and southbound, and also between the southern end of LHD and the Philip Street zone.

A summary of 2020 Model setup, with no development in place and with **2020 through-traffic growth** therefore is:

- Model network as per S2.
- Increased through traffic flows (3% per annum) in both directions between the northern and southern ends of the model along LHD.
- Increased through traffic flows (1% per annum) in both directions between the southern end of LHD and the Phillips Street zone.

4.4 SCENARIO 5A (S5A) - 2020 BASE WITH DEVELOPMENT MODELS

The S5a models were developed to analyse the traffic operation of the future traffic flows on the existing road network with the signalisation of LHD/Wrexham Road and the additional development traffic. In summary, the model consists of the following:

- Model network as per S3 with same parking removals.
- 2020 base traffic demands.
- Added Development traffic demands associated with the Sandon Point development and other developments (this is in addition to 2020 base traffic demands).
- Optimisation and coordination of the upstream and downstream signalised intersections.

4.5 SCENARIO 5B/5C (S5B/S5C) - DEVELOPMENT TREATMENTS

Once the 2020 Base with Development Traffic models were built, visual and quantitative analysis was used to determine possible measures that could mitigate possible safety and operational impacts of increased delays to road based traffic. Each of the options developed contains a suite of adjustments such as amended road configurations and/or signal changes.

Ultimately, 2 treatments options were tested and are reported following; the elements of each treatment are detailed below.

Both options involved some signal optimisation. It is noted that Paramics does not have a signal optimisation module, so these changes were carried out manually and on an iterative basis until a balance was achieved.

It is acknowledged here that SCATS will do a more comprehensive task of adapting to changes in traffic flows and marriages between junctions, and so the signal optimisations carried out in our assessments are likely to be improved upon even more by the RTA's traffic management operations team.

4.5.1 Scenario 5b

- Removal of additional western side parking along LHD between Wrexham Road and Lachlan Street.
- Optimisation of signals to allow more green time for through traffic travelling on LHD.

The removal of further parking on LHD is shown in Figure 4.4.

4.5.2 Scenario 5c

- Removal of western side parking along LHD between Wrexham Road and Lachlan Street (as per S5b).
- Optimisation of signals to adjust the offsets.
- Currently the intersection LHD/Phillips Street operates with two northbound approach lanes south of LHD, one left only and one through only lane (refer to Figure 4.5). Under Scenario 5c it is proposed to convert the left only kerbside lane into a combined left-through lane. This requires some local widening of the northbound departure lane to accommodate two lanes on the departure (refer to Figure 4.6). A concept drawing of the proposed intersection upgrade is provided in Appendix E.

Figure 4.4 2020 Development Scenario 5b and 5c With Parking Removal

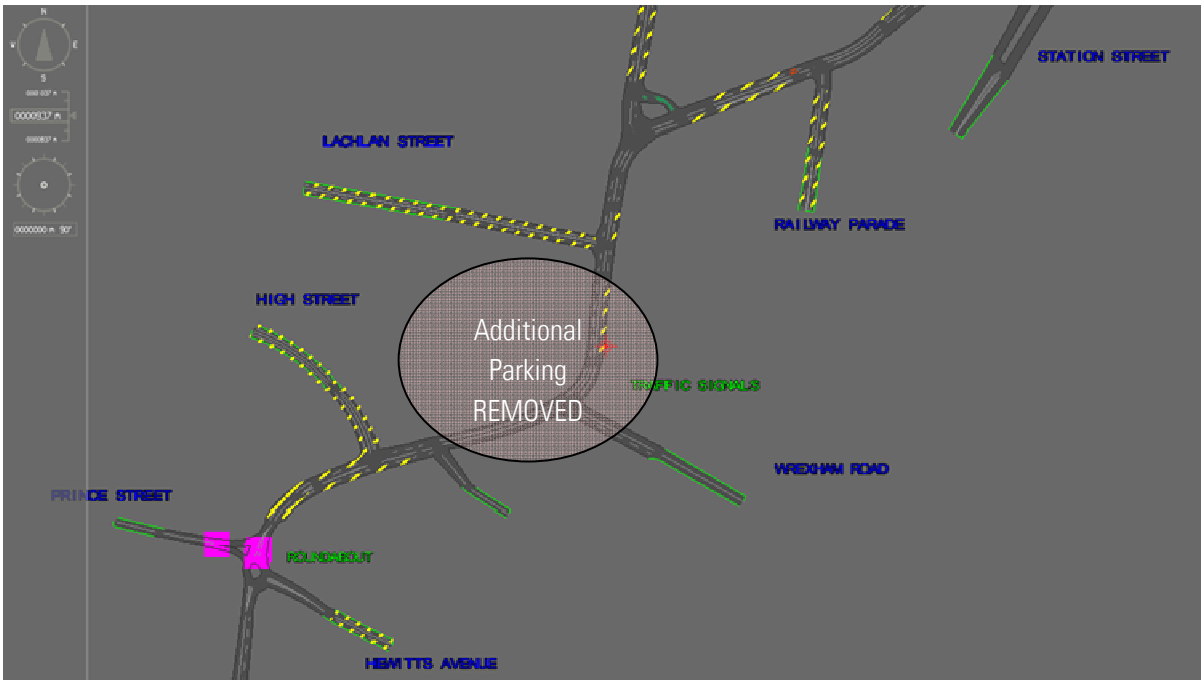


Figure 4.5 Conceptual Layout of LHD/Phillip Street – Existing

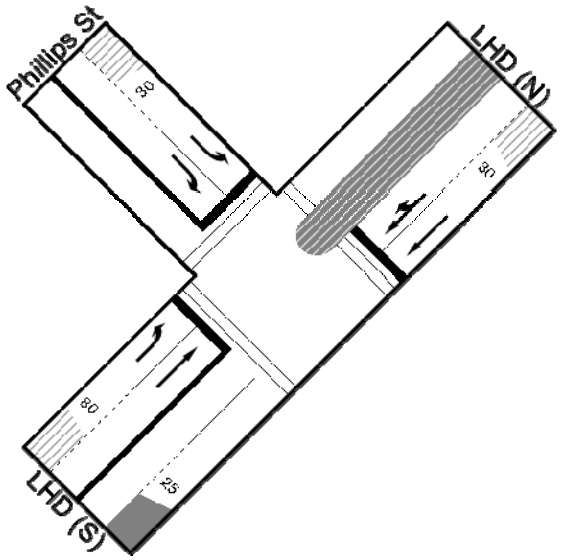
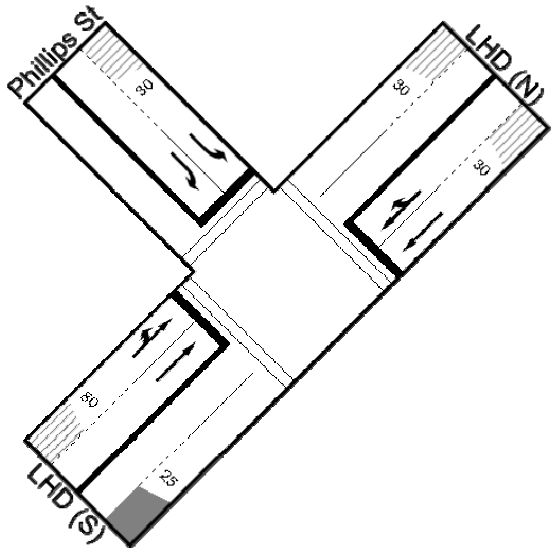


Figure 4.6 Conceptual Layout of LHD/Phillip Street – Scenario 5c



4.6 SUMMARY OF SCENARIO NETWORK CHANGES

Table 4.1 provides a brief overview of the key network changes between each of the scenarios.

Table 4.1 Summary of All Model Network and Signal Differences between Scenarios

MODEL SCENARIO	NETWORK / SIGNAL TREATMENTS	TRAFFIC DEMANDS
S1 - Existing 2010	Existing road network (pre-Bulli overpass)	Existing 2010
S2 - Base 2010	Existing road network + Roundabout @ LHD/Prince/Hewitt + dummy signals to represent the Bulli Overpass impacts	Existing 2010
S3 – Base + Dev 2010	As per S2 road network + Traffic Signals @ LHD/Wrexham with through/through-right lane on northern approach, some parking removed on LHD.	Existing 2010 + Development traffic demands
S4 - Base 2020	As per S2 road network	2020 Background traffic demands
S5a – Base + Dev 2020	As per S3 road network	2020 Background traffic demands + Development traffic demands
S5b – Base + Dev 2020	As per S5a + remove NB parking on LHD between Wrexham and Lachlan + Signal optimisation	2020 Background traffic demands + Development traffic demands
S5c – Base + Dev 2020	As per S5b + extra NB lane @ LHD/Phillips Street	2020 Background traffic demands + Development traffic demands

5 MODEL OUTPUTS

5.1 OVERVIEW

This section compares the performances of all 2010 and 2020 models for both the AM and PM peak periods based on several measureable criteria.

The criteria on which each of the AM and PM models were assessed quantitatively and qualitatively are:

- Vehicle Flows (junction throughputs).
- Queue Lengths (at signalised intersections).
- Travel Times - northbound and southbound.
- Intersection Level of Service (LOS).

The presented data are colour coded as per Table 5.1 to differentiate between each of the modelled scenarios.

Table 5.1 Colour Coding for All Modelled Scenarios

No.	Scenario Description
S1	Calibrated Existing Model
S2	Base Model 2010
S3	Base + Development Model 2010
S4	Base Model 2020
S5a	Base + Development Model 2020
S5b	Base + Development Model 2020 Option 1
S5c	Base + Development Model 2020 Option 2

5.2 VEHICLE FLOWS (JUNCTION THROUGHPUTS)

Vehicle flows were extracted from all models for each arm of the major junctions in the model. These were then compared against each other for each junction across all models; the results follow.

Figure 5.1 to Figure 5.4 illustrate vehicle flow differences between each of the AM Peak Models, at each of the major junctions. PM peak volumes are presented in Figure 5.5 to Figure 5.8. Full network volumes are presented in one sheet in Appendix F; this gives a good overview of the flows across the entire model in every scenario.

Results for LHD/Wrexham Road junction show that the vehicles in and out of the proposed development are broadly constant in each scenario with development in place in 2010 and 2020. This illustrates that the scenarios in 2020 which provide workable solutions with development in place, are including the full development generated traffic in the network as opposed to holding them back inside the development.

Given that this is robust micro simulation modelling with the variability of 5 seed runs in AM and PM for all models, there will always be variability between numbers; it is the broad sense of difference (or lack of) that is relevant and important here.

Figure 5.1 AM Peak Vehicle Flows for LHD/Wrexham Road

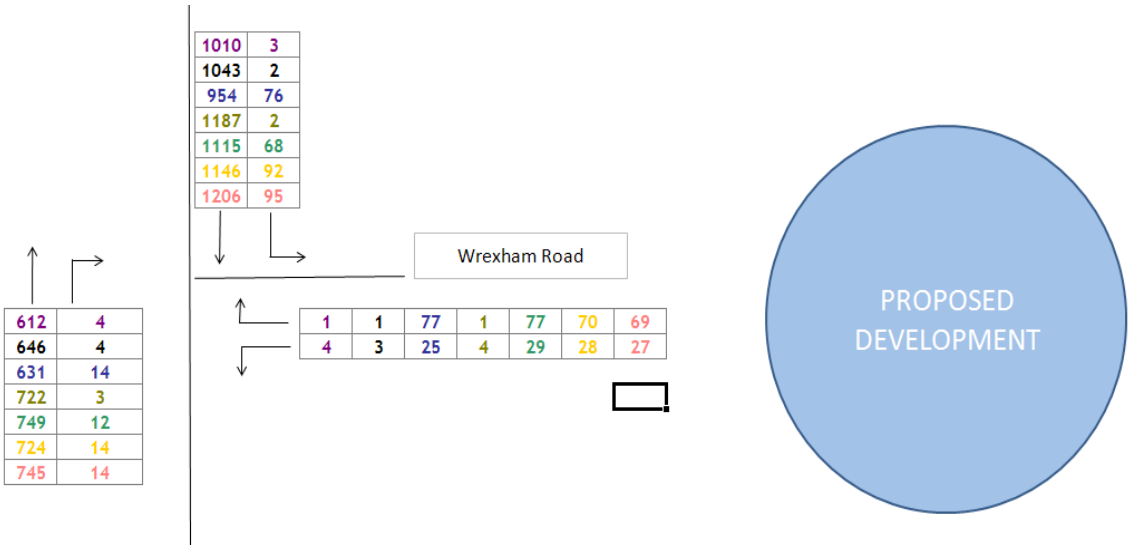


Figure 5.2 AM Peak Vehicle Flows for LHD/Phillips Street

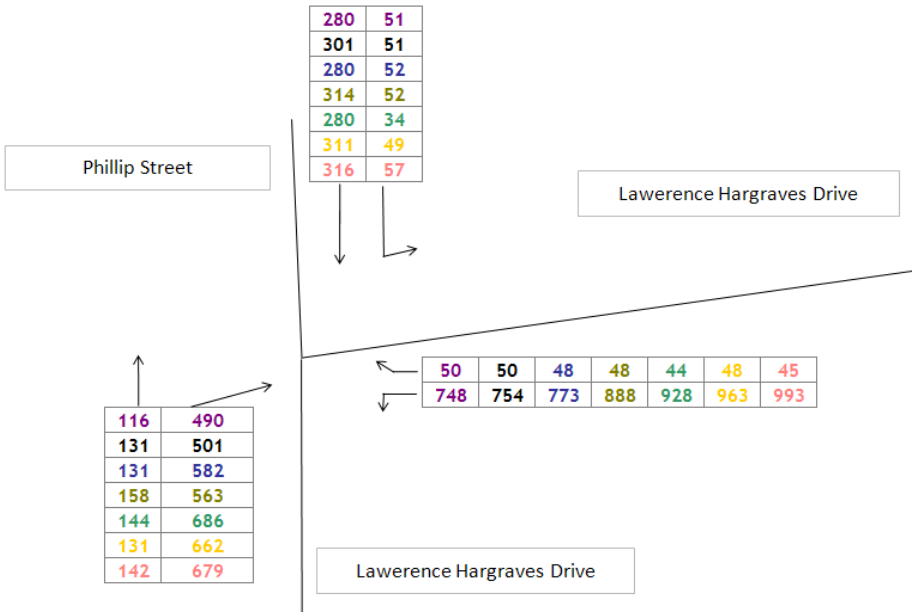


Figure 5.3 AM Peak Vehicle Flows for LHD/Railway Parade

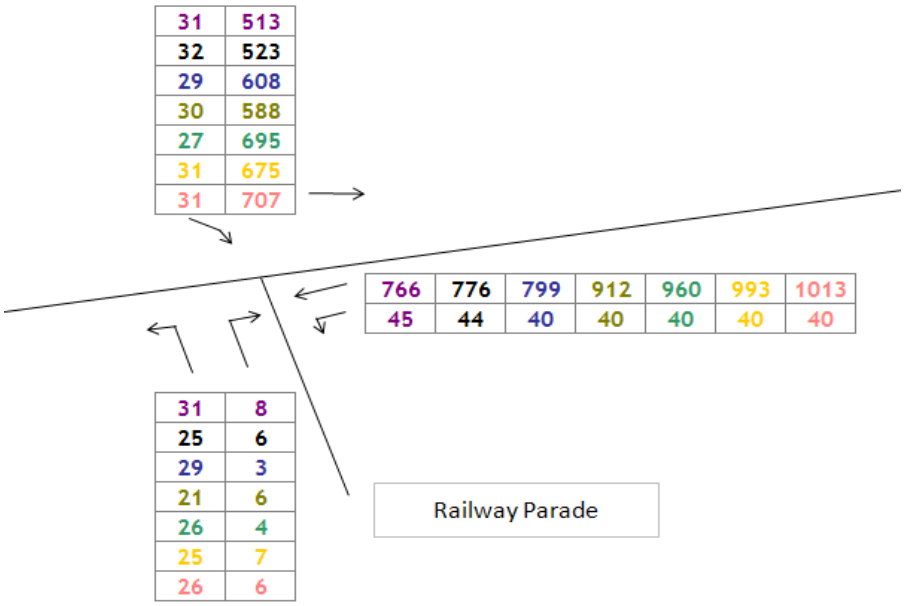


Figure 5.4 AM Peak Vehicle Flows for LHD/Raymond Road

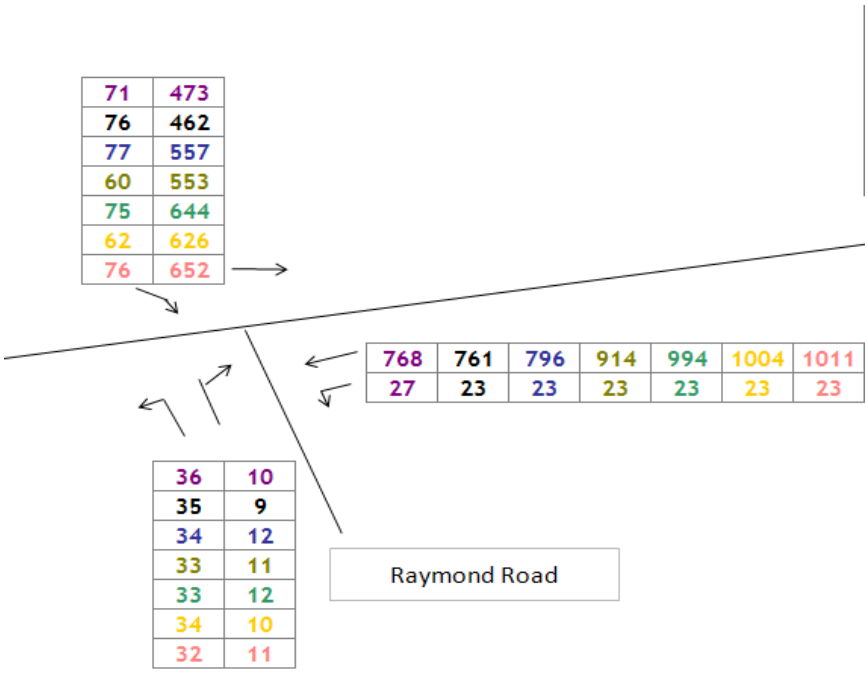


Figure 5.5 PM Peak Vehicle Flows for LHD/Wrexham Road

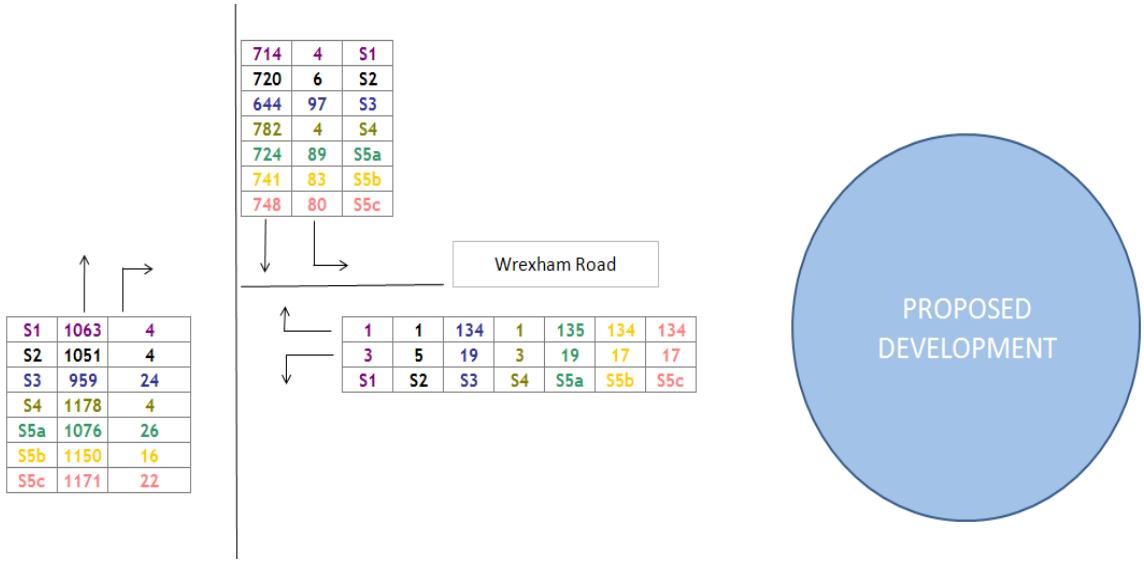


Figure 5.6 PM Peak Vehicle Flows for LHD/Phillips Street

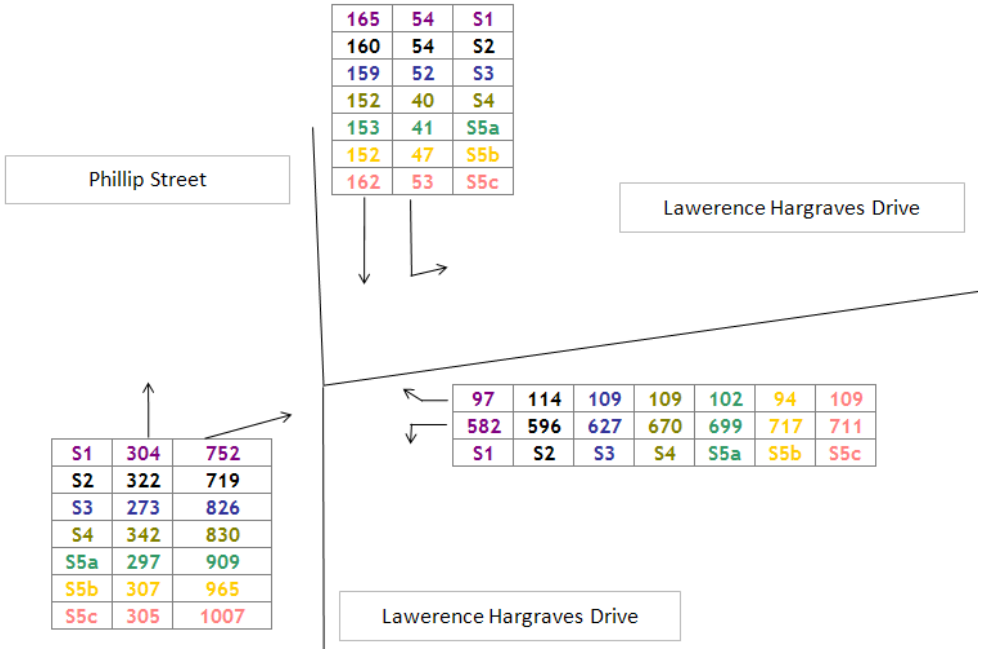


Figure 5.7 PM Peak Vehicle Flows for LHD/Railway Parade

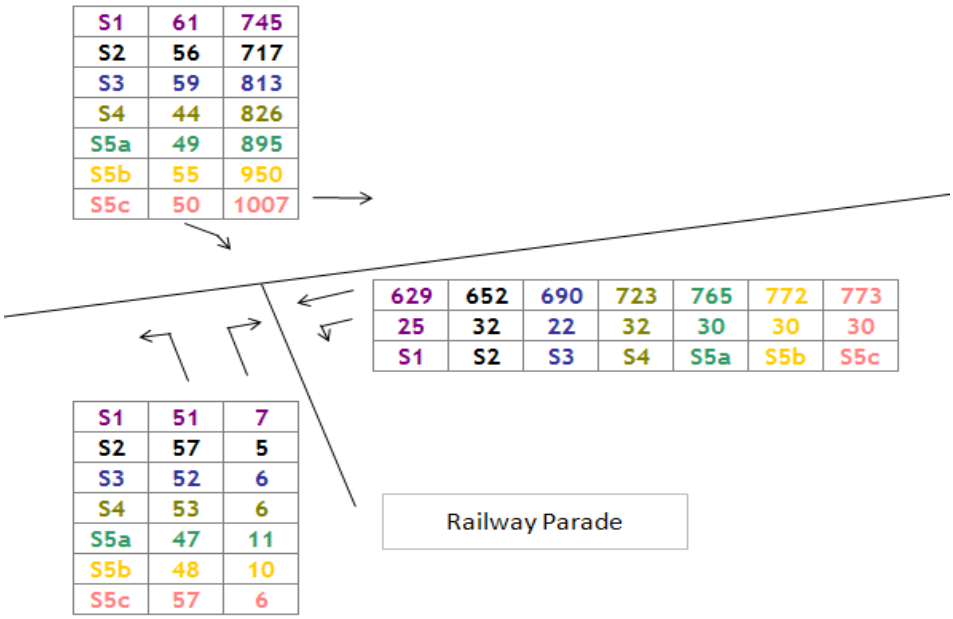


Figure 5.8 PM Peak Vehicle Flows for LHD/Raymond Road

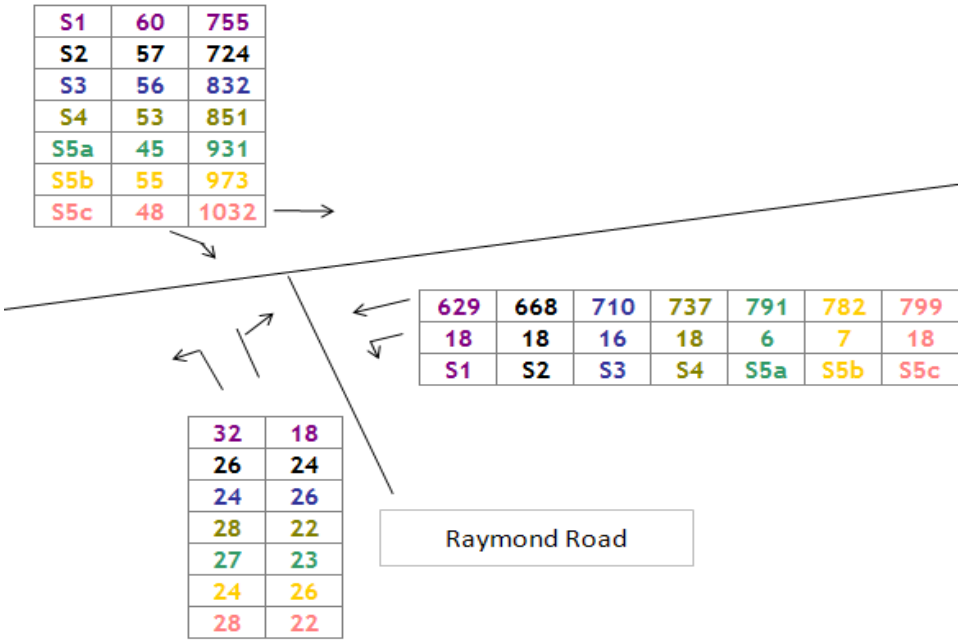


Figure 5.1 to Figure 5.8 showed the flow differences at the 4 main junctions; Appendix F shows the modelled differences across the network as a whole in more detail.

Generally, for both the AM and PM peak hour periods, it can be seen that the flows along LHD (northbound and southbound) are broadly the same in 2010 for the existing scenario (S1) and the 2010 scenario with the overbridge and roundabout in place (S2). This is to be expected as the changes in traffic release flows remained the same.

In S3, 2010 Base with the development in place, the development generated traffic is added and the flows through the network are increased, yet easily accommodated by the 2010 Base network with the signalised changes to the Wrexham Road / LHD junction. With these signals in place, and with linkages and signal optimisations, the flows within the model area in 2010 with the development in place are amply catered for.

The 2020 Base model (without the proposed development) when compared to the 2020 scenarios with development S5a, S5b and S5c, clearly shows the increase that the proposed development traffic add to the network. Generally there are similar levels of vehicles getting through the junctions and along the links (refer to Appendix F), in each of Scenarios 5a, 5b and 5c, with 5b (parking removed and signal optimisation) generally showing the best flows northbound on LHD with the signal optimisation in place.

Overall, the flows as illustrated above need to be placed into the broader context of travel time results, queue lengths and Level of Service (concerning intersection delay), in order to fully appreciate the impacts from year to year and between different scenarios; the following sections provide these outputs.

5.3 AM AND PM QUEUE LENGTHS

Table 5.2 and Table 5.3 show the queue lengths experienced at each approach for the signalised intersections, namely:

- LHD/Phillip Street.
- LHD/Railway Parade.
- LHD/Raymond Street.

As a result of the management of flows in the model by way of signal optimisation and car parking removal, the differences in queue lengths are negligible between the models at the signalised intersections.

On LHD, the increases are mostly in the range of 3-5 vehicles and on Philips Street there is some queuing back into the zone in all future scenarios. Regarding this, it should be noted that the use of fixed time signals in these Paramics models, although they are offset and linked to other signals, will actually perform better when switched to SCATS, as the adaptive capabilities of the SCATS system will be more responsive to queues and delays.

Notwithstanding this, the queues on Phillips Street occur anyway in 2020 with no development (S4). In some of the scenarios with development in place, notably the PM in all development scenarios, Philip Street actually operates better because of the signal optimisations, with development in place. When the RTA does optimise all future situations within SCATS, the results below will realistically be much improved.

Overall, the model operates as well in the future with the proposed development in place, with signals improved and parking removed.

Table 5.2 AM Peak Maximum Queue Lengths on Approach (in PCUs – Passenger Car Units)

Intersection	Approach	Surveyed	S1	S2	S3	S4	S5a	S5b	S5c
LHD/Phillips St	Northbound	12	15	15	14	14	17	17	12
	Southbound	13	16	17	17	17	17	15	18
	Phillips St*	7	6	6	5	(6)	(56)	(12)	(26)
LHD/Railway Pde	Northbound	8	8	10	10	13	13	12	20
	Southbound	12	10	12	13	13	15	14	12
	Railway Pde	7	4	4	2	2	2	2	4
LHD/Raymond Rd	Northbound	8	11	8	9	18	17	16	17
	Southbound	12	10	12	16	12	20	20	18
	Raymond Rd	4	2	3	0	0	0	0	0

* NOTE – the numbers in brackets show the number of vehicles queuing back into the model zone where relevant (i.e. blockages)

Table 5.3 PM Peak Maximum Queue Lengths on Approach (in PCUs – Passenger Car Units)

Intersection	Approach	Surveyed	S1	S2	S3	S4	S5a	S5b	S5c
LHD/Phillips St	Northbound	18	17	17	16	15	19	17	15
	Southbound	10	14	13	17	18	19	18	14
	Phillips St*	9	6	8	(12)	(28)	(18)	(20)	(4)
LHD/Railway Pde	Northbound	11	7	10	12	7	11	12	18
	Southbound	12	10	13	15	13	17	15	15
	Railway Pde	8	7	8	8	6	7	5	7
LHD/Raymond Rd	Northbound	12	15	15	18	14	20	18	18
	Southbound	12	9	8	15	9	20	20	19
	Raymond Rd	3	2	3	2	0	0	3	0

* NOTE – the numbers in brackets show the number of vehicles queuing back into the model zone where relevant (i.e. blockages)

5.3.1 LHD/Wrexham Road

Given that there are currently no signals at the Wrexham Road intersection with LHD, actual model screen shots are provided in Figure 5.9 to Figure 5.12, which illustrate the 2020 Base with no development in place compared to the 2020 with development in place, Scenario 5b.

The purpose of showing these comparisons is that with parking removed and also the optimisation of signals at LHD/Wrexham Road, 2020 S5b actually has a higher northbound throughput flow and no significant impacts on queuing.

Although there is a higher volume in 2020 PM with development in place in S5b, the additional road capacity caters for it and results in robust network performance. Additional queuing information is shown in Appendix G

Figure 5.9 AM 2020 Base with No Development

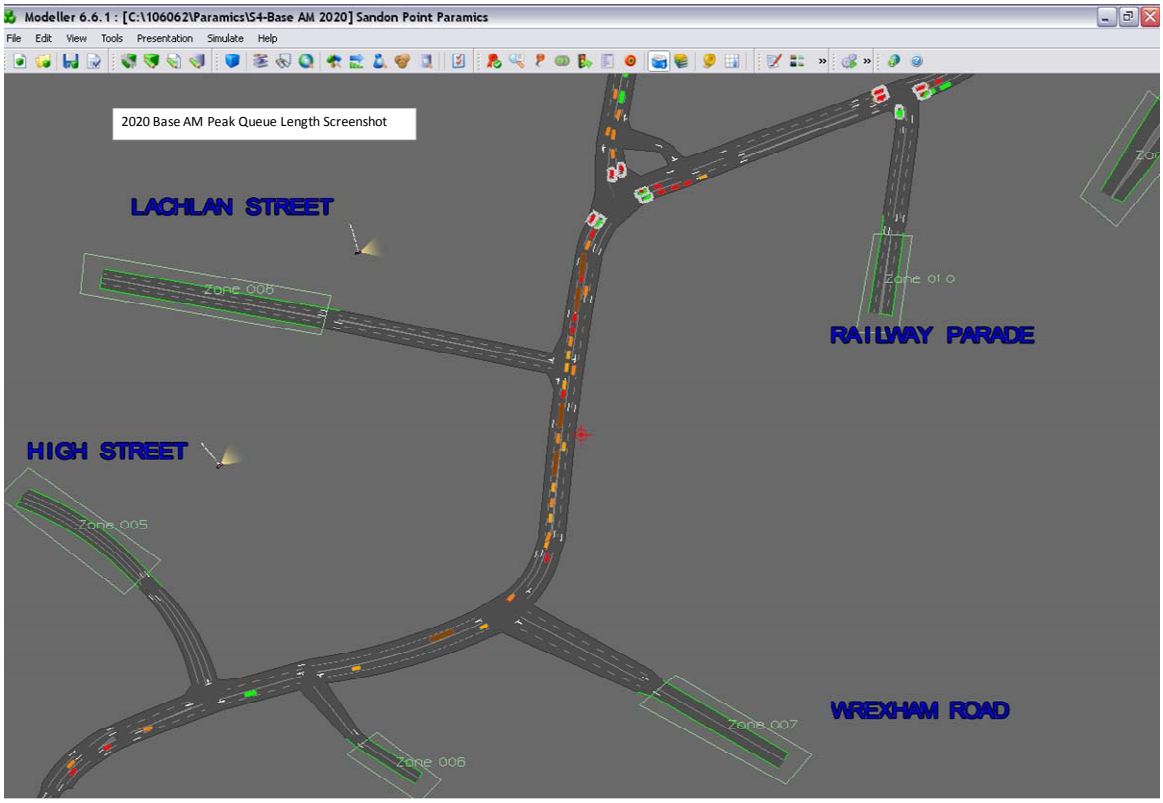


Figure 5.10 AM 2020 Scenario 5b with Development

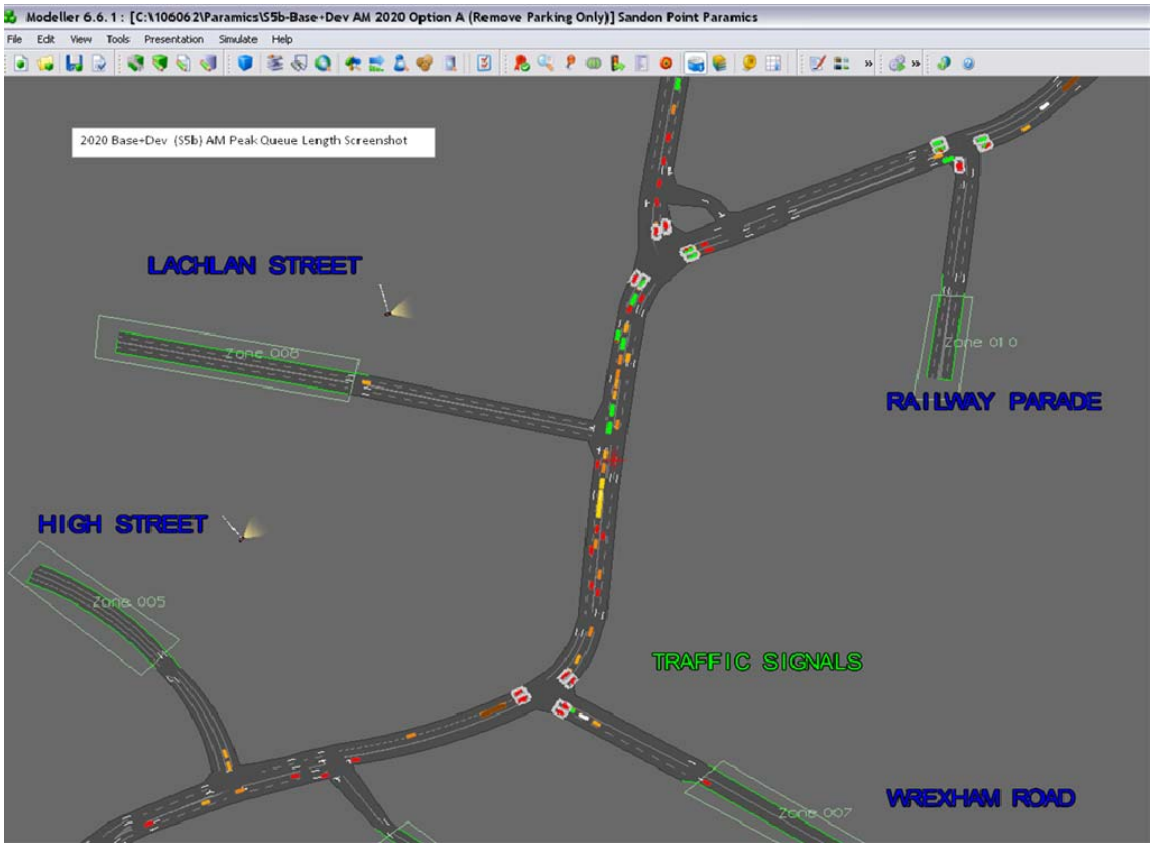


Figure 5.11 PM 2020 Base with No Development

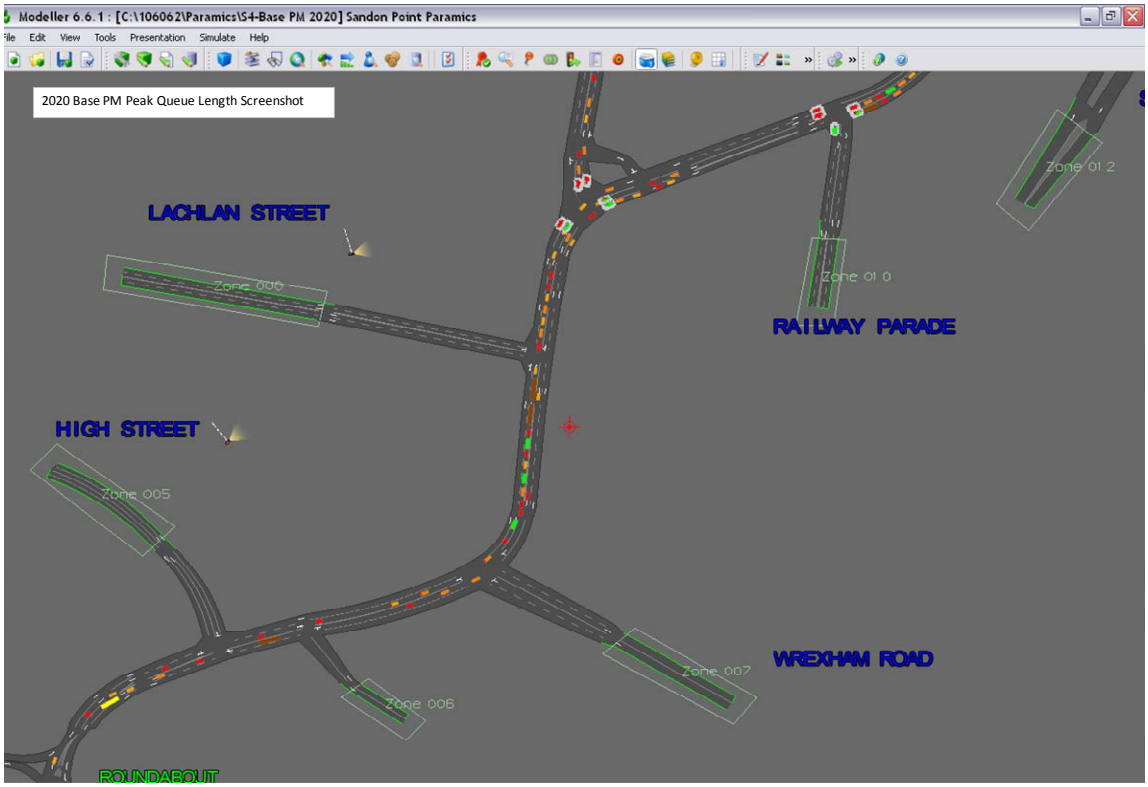
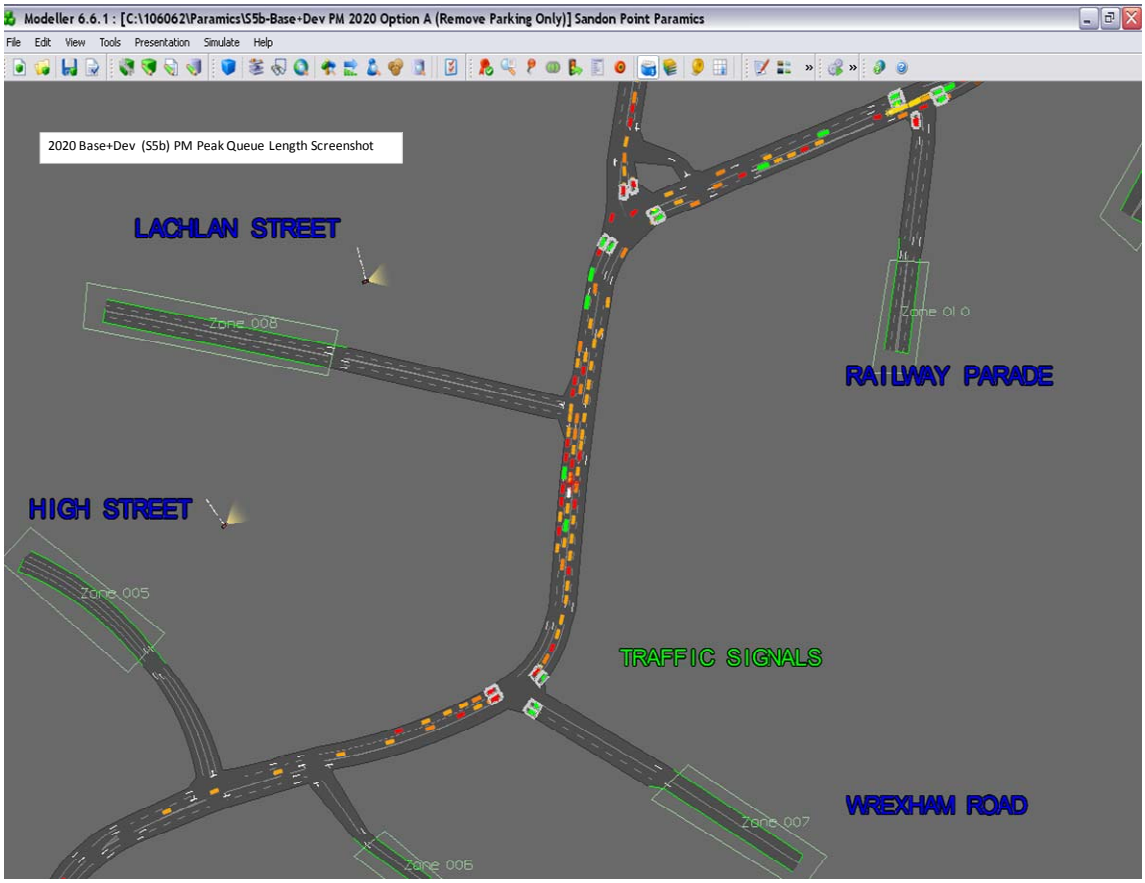


Figure 5.12 PM 2020 Scenario 5b with Development



5.4 AM AND PM TRAVEL TIMES

Average travel times were measured for vehicles travelling on LHD between Princes Highway and King Street during the AM and PM peak hours, both in the northbound and southbound direction. King Street is located at the position of the northernmost external Paramics zone.

The reason for measuring times from these zones is to analyse the impacts on the operation of LHD with the increased flows in various scenarios, through the entire model along the corridor mainline.

Table 5.4 and Table 5.5 show the travel times comparisons between all of the 2010 and 2020 AM and PM Peak Models for both the southbound and northbound directions.

Table 5.4 AM Peak Travel Times Comparison (mm:ss)

From-To	Surveyed	S1	S2	S3	S4	S5a	S5b	S5c
LHD NB from Princes Hwy - King St	02:16	02:14	02:21	02:34	02:29	02:42	03:11	02:55
LHD SB from King St - Princes Hwy	02:17	02:16	02:23	03:11	02:35	03:52	03:16	03:33

Table 5.5 PM Peak Travel Times Comparison (mm:ss)

From-To	Surveyed	S1	S2	S3	S4	S5a	S5b	S5c
LHD NB from Princes Hwy - King St	02:25	02:15	02:32	02:39	02:47	04:46	03:34	03:31
LHD SB from King St - Princes Hwy	02:16	02:20	02:27	03:11	02:53	04:37	03:42	03:53

The travel times show an increase in travel times between 2010 and 2020; this is expected given the increased volumes. Travel times in Scenario S5a, which has the development in place with no significant treatments, shows some significant increases. However, when treatment options are introduced in Scenarios S5b and S5c, these travel times are generally much improved.

5.5 AM AND PM INTERSECTION LEVEL OF SERVICE (LOS)

In an urban environment the performance of the road network is usually critical at intersections. The NSW Roads and Traffic Authority have adopted a method of assessing intersection performance using the level of service (LoS) criteria. LoS is a continuum from 'A' good operations to 'F' with unacceptable delays and queues. Table 5.6 provides a description of intersection level of service.

Table 5.6 Intersection Level of Service Criteria

LoS	Average Delay per Vehicle (secs/veh)	Traffic Signal/ Roundabout
A	< 14	Good operation
B	15 to 28	Good with acceptable delays & spare capacity
C	29 to 42	Satisfactory
D	43 to 56	Operating near capacity
E	57 to 70	At capacity; at signals, incidents will cause excessive delays Roundabouts require other control mode

Level of Service measurements were extracted from all models at the 4 critical signalised junctions along LHD. Table 5.7 and Table 5.8 below highlights the Level of Services differences between each of the modelled AM and PM Peak Models respectively. It should be noted that the LoS extracted from Paramics Analyser is based on the Highway Capacity Manual method. We have taken this as being acceptable given the RTA's request for Paramics to be used in these analyses.

The tables show that the intersections generally operate at a LoS A or B. LHD/Phillips Street is operating at LoS B in the AM and PM peak period in the future scenarios.

The results suggested that neither the background traffic growth or development traffic have impacted on the operation of the critical intersections along LHD in terms of level of service.

Table 5.7 AM Peak LoS Comparisons

Intersection	S1	S2	S3	S4	S5a	S5b	S5c
LHD/Wrexham Rd	A	A	A	A	A	A	A
LHD/Phillips St	B	B	B	B	B	B	B
LHD/Railway Pde	A	A	A	A	A	A	A
LHD/Raymond Rd	A	A	A	A	A	A	A

Table 5.8 PM Peak LoS Comparisons

Intersection	S1	S2	S3	S4	S5a	S5b	S5c
LHD/Wrexham Rd	A	A	B	A	C	B	B
LHD/Phillips St	A	A	B	B	B	B	B
LHD/Railway Pde	A	A	A	A	B	A	A
LHD/Raymond Rd	A	A	A	A	A	A	A

6 FINDINGS AND CONCLUSIONS

6.1 FINDINGS

Overall the findings from the Paramics modelling are positive, in terms of achieving development treatment scenarios in 2020 AM and PM, which operate on a par with the 2020 scenario with no development in place.

In order to achieve this, parking needed to be removed at several locations along LHD, signals installed at LHD/Wrexham Road, and signals optimised between junctions in the model. In addition, some minor additional capacity treatments were allocated at LHD/Wrexham Road junction, which facilitated ease of movement into and out of the proposed development.

6.1.1 Best Performer

The 2020 Scenario 5b (S5b) is the best performer. In terms of LoS it is results in similar delay as 2020 without the development in place.

The flows, LoS and queuing results, as well as the visual modelling observations carried out by traffic engineers and transport planners, clearly show that 2020 Scenario 5b ultimately performs on a par with the 2020 Base with no development, with the requirement that the network and signal adjustments are implemented.

It is our recommendation that the proposed development proceed with the traffic and network treatments as tested in Scenario 5b, implemented.

6.2 CONCLUSIONS

The purpose of this study was to use Paramics micro-simulation to assess the operation on Lawrence Hargrave Drive (LHD) in the vicinity of Wrexham Road, with the proposed development at Sandon Point, and the associated additional traffic in place.

Paramics traffic models were built for the existing conditions which were robustly calibrated and also validated with independent data, to exceed requirements.

Then 2010 Base models with the Bulli Overpass Bridge and the roundabout at Hewitt's Road in place, were built; it is these model networks which represent the 2010 Base, and upon which all future 2020 models were built.

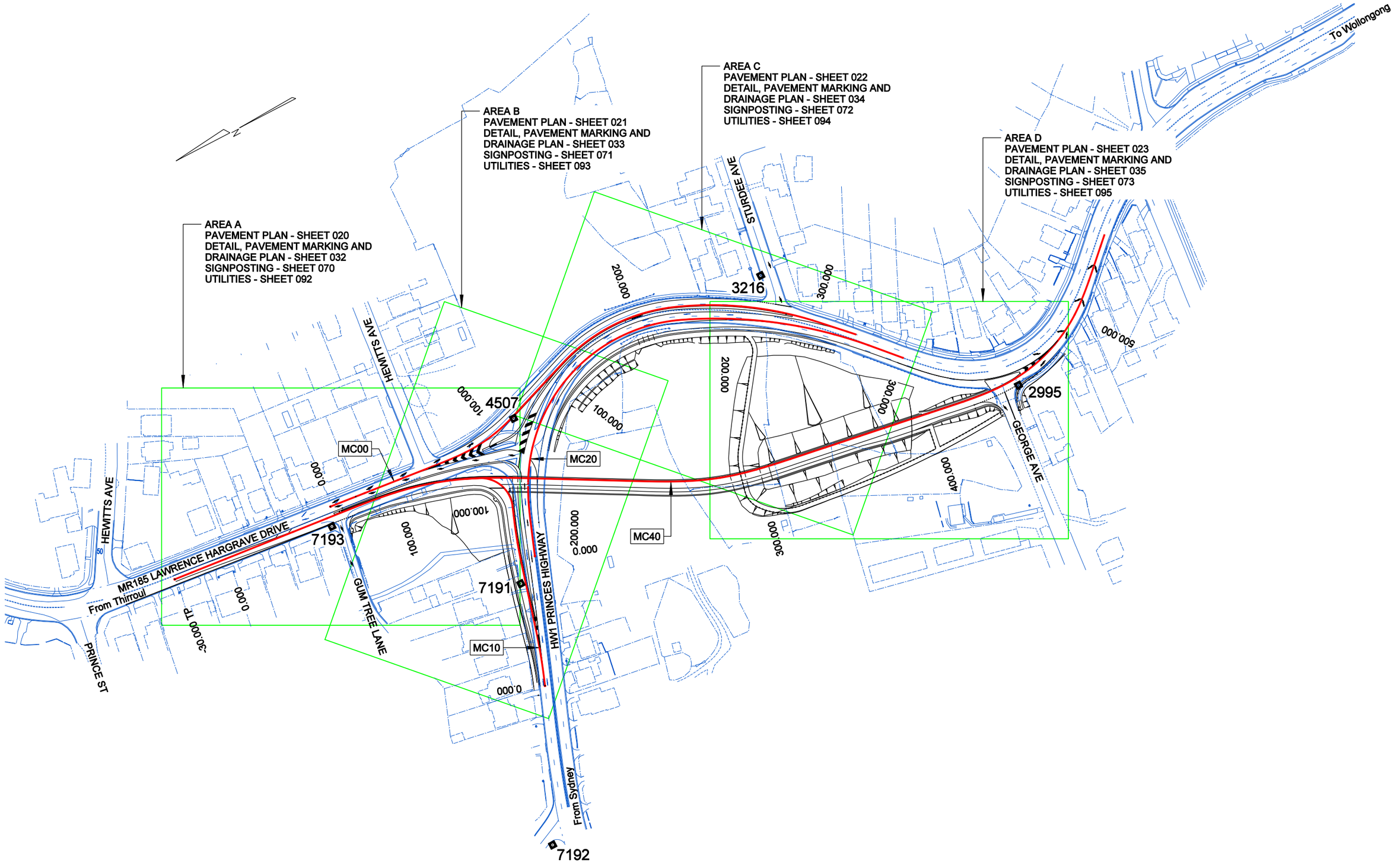
In line with RTA requirements background traffic was grown and the development traffic was added; all scenarios were independently tested and compared quantitatively and qualitatively in Paramics until a preferred solution emerged. This preferred solution, or best performer, clearly catered for the 2020 background traffic plus the additional traffic generated by the proposed development. The process was transparent; the solutions work and they are implementable and are cost effective and realistic.

Of all the models tested in 2020, Scenario 5b (with parking removed and signal optimisation) provided clear benefits to all road users, as well as amply catering for 2020 traffic with the proposed development in place. The signal optimisation in reality will be managed even more effectively when the RTA implements it into SCATS given the dynamic and adaptive capabilities within that system. The signals in this modelling were fixed time averages; having the adaptive capability of SCATS will likely improve even further upon these results.

APPENDICES

Appendix A

TCS Plans & Proposed Intersection Layouts from RTA



No.	Amendment Description	Initials	Date
A2	BB LINE IN GEORGE AVE AND 3 x UA1 TO HW1	SH	18/5/09
A1	SIGNATURE ISSUE	SH	18/5/09

A3 original | This sheet may be prepared using colour and may be incomplete if copied

SCALES
0 20 40 60 80 100
NOMINAL SCALE RATIO 1:2000

Co-ordinate System: MGA 56 | Height Datum: A.H.D.

RTA
PREPARED BY
ENGINEERING
TECHNOLOGY
SOUTHERN
PROJECT DESIGN

DESIGNED S. HARPER / C. BOUWENS

REVIEWED

ROADS AND TRAFFIC AUTHORITY OF NSW

CITY OF WOLLONGONG
HW 1 - PRINCES HIGHWAY, BULLI
INTERCHANGE AT JUNCTION WITH MR185
LAWRENCE HARGRAVE DRIVE, AT THE FOOT OF BULLI PASS
SHEET LAYOUT INDEX (AREA A - D)

FILE No.	DRAWING	PRINTED DATE	SHEET No.
1/497.11489	A2_KEYPLAN PLAN	28/05/2009	004

REGISTRATION NUMBER
0001.497.RC.6071

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General Sheet

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DRAWN BY CADD
DO NOT AMEND MANUALLY

DATE IN SERVICE : 26/06/09

R T A

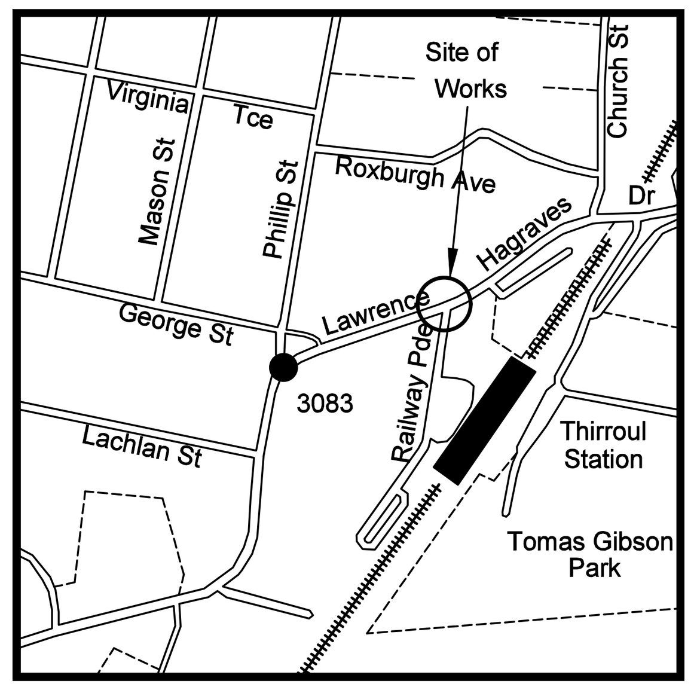
NOTES

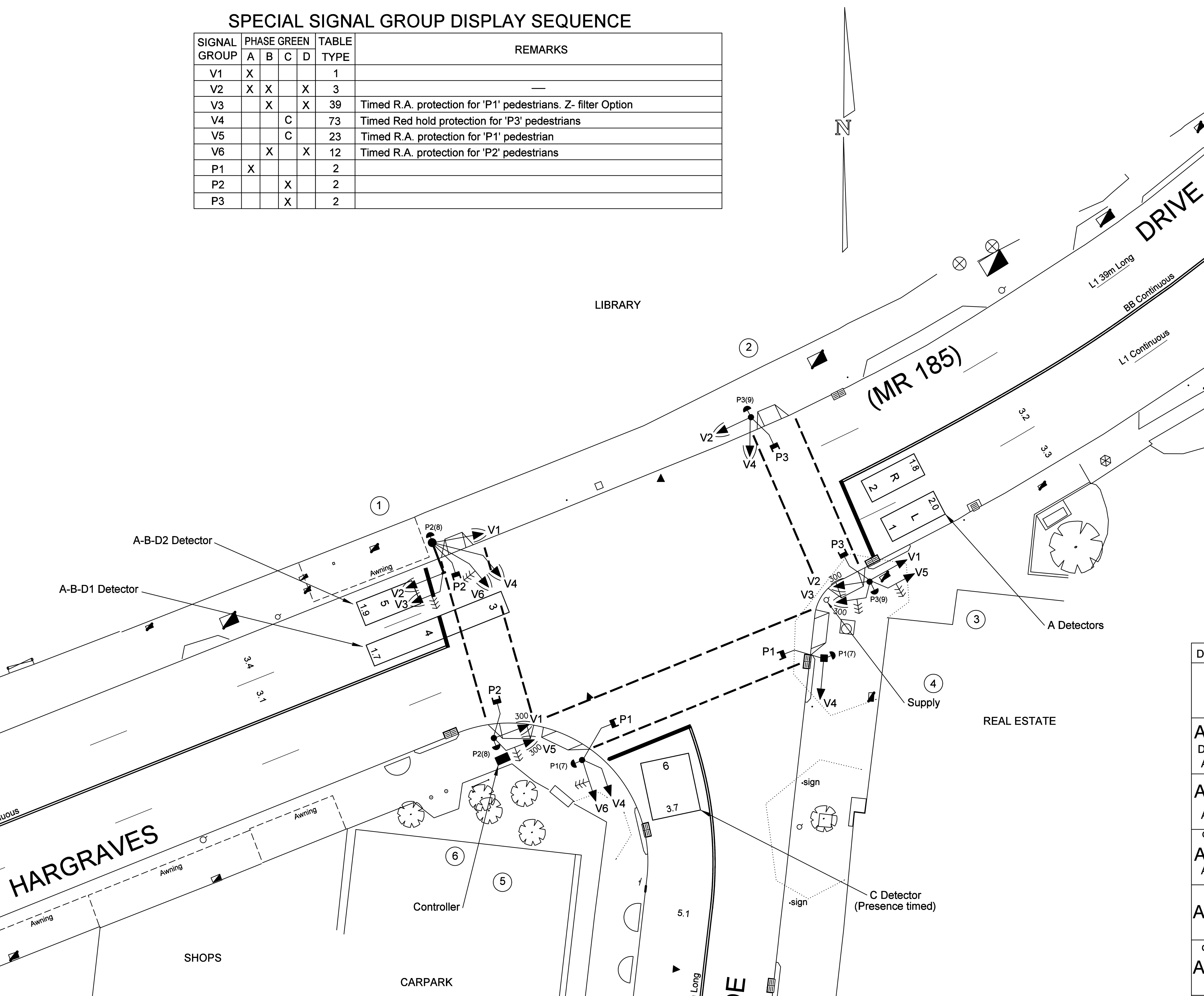
1. This site is SCATS linked.
2. Special stop sign (R1-4) placed on Posts 4 & 5.
3. All push buttons are audio tactile.

SPECIAL SIGNAL GROUP DISPLAY SEQUENCE

SIGNAL GROUP	PHASE GREEN A	B	C	D	TABLE TYPE	REMARKS
V1	X				1	
V2	X	X		X	3	—
V3		X		X	39	Timed R.A. protection for 'P1' pedestrians. Z- filter Option
V4			C		73	Timed Red hold protection for 'P3' pedestrians
V5			C		23	Timed R.A. protection for 'P1' pedestrian
V6		X		X	12	Timed R.A. protection for 'P2' pedestrians
P1	X				2	
P2			X		2	
P3			X		2	

LOCALITY SKETCH



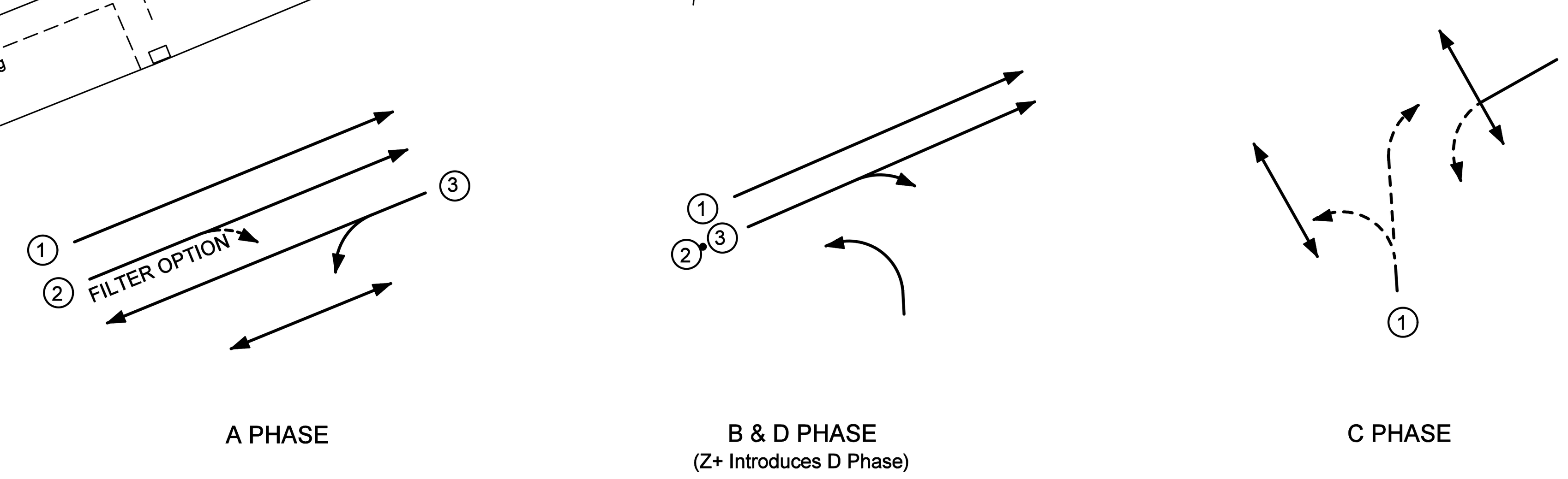


DETECTOR SPECIFICATION

Detector		Specifications			
A	FN	A(L)	A(E3)		
	SG/PS	$\overline{A}$	A		
	DS	—	—		
A-B-D1 Depart. & Approach	FN	B(PR)	D(PR)	B(E3)	D(E3)
	SG/PS	A	A	B	D
	DS	-	Z+	A(NEXT)	A(NEXT)
A-B-D1 Approach	FN	A(L).B(L)	D(L)	A(E2)	
	SG/PS	$\overline{V2}$	$\overline{V2}$	A	
	DS	-	Z+	$\overline{\text{A-B-D1(PR).B(NEXT).D(NEXT)}}$	
cont. A-B-D1 Approach	FN	B(E2)		D(E2)	
	SG/PS	B		D	
	DS	$\overline{\text{A(NEXT).D(NEXT)}}$		$\overline{\text{A(NEXT).B(NEXT)}}$	
A-B-D2	FN	A(L)	A(E1)		B(E1)
	SG/PS	$\overline{V2}$	A		B
	DS	—	$\overline{\text{B(NEXT).D(NEXT)}}$		$\overline{\text{A(NEXT).D(NEXT)}}$
cont. A-B-D2	FN	D(E1)			
	SG/PS	D			
	DS	$\overline{\text{A(NEXT).B(NEXT)}}$			
C	FN	C(PR)	C(E1)		
	SG/PS	$\overline{C}$	C		
	DS	—	—		
P1 P.B.	FN	A(PB)	C(L)		
	SG/PS	$\overline{\text{P1(WALK)}}$	$\overline{\text{A.P1(WALK)}}$		
	DS	—	$\overline{\text{B.C.D}}$		
P2 P.B.	FN	C(PB)	A(L)		
	SG/PS	$\overline{\text{P2(WALK)}}$	$\overline{\text{C.P2(WALK)}}$		
	DS	—	$\overline{\text{A.B.D}}$		
P3 P.B.	FN	C(PB)	A(L)		
	SG/PS	$\overline{\text{P3(WALK)}}$	$\overline{\text{C.P3(WALK)}}$		
	DS	—	$\overline{\text{A.B.D}}$		

POSTS

POST	TYPE	LENGTH	OFFSET	REMARKS
1	5S	-	1.3	EXISTING
2	2	4.1	1.1	EXISTING
3	2	4.1	1.1	EXISTING
4	6	-	1.0	EXISTING
5	2	4.1	1.0	EXISTING
6	2	4.1	1.4	EXISTING



MOVEMENTS

A ORIGINAL ISSUE
B Issue JI ILL 1956 19.01.09 Controller repositioned. Amended signal chart and post chart. WAE 09/09 WSPKHAN

PUBLIC UTILITY LEGEND	
HYDRANT	
STOP VALVE	
GAS VALVE	
SEWER MANHOLE	
TELECOM PIT	
ELECT LIGHT POLE	
POWER POLE	
STAY POLE	
TELEPHONE BOX	
TELECOM PILLAR	

REFERENCE PLANS	
SYMBOLS/ABBS.	VD003-6
STD POSIT	VD001-5
DET SCHED EXP	VD018-10
PRES. DETECT	VC005-17
SSG DIS. SEQ.	VD018-8
SURVEYOR : WOLLONGONG CC	
DATE : 2008	

U.B.D. Ref. MAP 22 F2
I.S.G. CO-ORDS E: 292 385 N: 1 201 186
DESIGNED J BATES
CHECKED
SITE CHECKED J BATES
RECOMMENDED
DATE B-Line Drafting 27/11/08

THESE DRAWINGS HAVE BEEN EXAMINED AND ARE RECOMMENDED FOR APPROVAL
REFER HARD COPY
SIGNATURE
NAME J. HARPER
POSITION MANAGER RS & TS
DATE 4 DEC. 2008

APPROVED
REFER HARD COPY
SIGNATURE
NAME T. McCLURE
POSITION MANAGER RS & TM
DATE 4 DEC. 2008

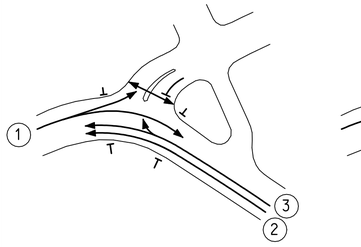
Roads and Traffic Authority,N.S.W

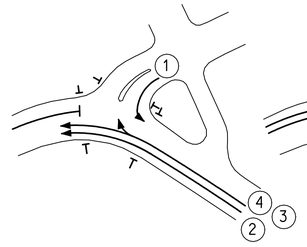
WOLLONGONG CITY COUNCIL AREA
TRAFFIC SIGNALS AT THE INTERSECTION OF
LAWRENCE HARGRAVES DRIVE (MR 185) &
RAILWAY PARADE - THIRROUL

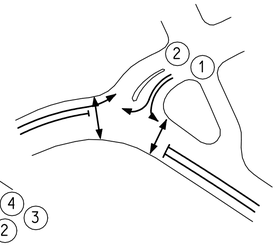
DESIGN LAYOUT TCS No 4285

EXISTING ☒ PROPOSED ☐
CADD FILE: VV4285_1B.dgn
SCALE (1:200)
ISSUE B
FILE 497 TS 545
SUPERSEDES SHEET/ISSUE –
REGN. 0185.497.VV.4285
SHEET 1

DATE IN SERVICE:21.12.94







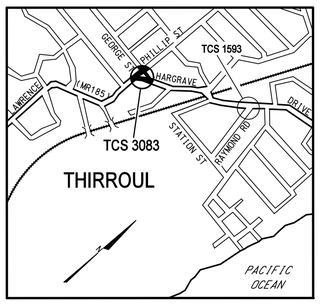
MOVEMENT DIAGRAMS

DETECTOR SPECIFICATION

Detector		Specifications			
A	FN	A(L)	A(E1)		
	SG/PS	$\overline{A}$	A		
	DS	—	—		
A-B1 Depart. & Approach	FN	B(PR)	B(E4)		
	SG/PS	A	B		
	DS	—	A(NEXT)		
A-B1 Approach	FN	A(L).B(L)	A(E3)		B(E3)
	SG/PS	$\overline{A/B}$	A		B
	DS	—	$\overline{A\text{-}B1(PR).B(NEXT)}$		$\overline{A(NEXT)}$
A-B2	FN	A(L)	A(E2)	B(E2)	
	SG/PS	$\overline{A/B}$	A	B	
	DS	—	$\overline{B(NEXT)}$	$\overline{A(NEXT)}$	
B-C	FN	B(PR)	B(E1)	C(E1)	
	SG/PS	$\overline{B.C}$	B	C	
	DS	$\overline{C}$	$\overline{C(NEXT)}$	$\overline{B(NEXT)}$	
C	FN	C(L)	C(E2)		
	SG/PS	$\overline{C}$	C		
	DS	—	—		
A P.B.	FN	A(PB)	C(L)		
	SG/PS	$\overline{A(WALK)}$	A.$\overline{A(WALK)}$		
	DS	—	$\overline{B.C}$		
C P.B.	FN	C(PB)	A(L)		
	SG/PS	$\overline{C(WALK)}$	C.$\overline{C(WALK)}$		
	DS	—	$\overline{A.B}$		

SPECIAL SIGNAL GROUP DISPLAY SEQUENCE

SIGNAL GROUP	TABLE TYPE	REMARKS
B (RT)	5	——
B/C COND (LT)	14	Timed R.A. protection for 'C' pedestrians.
C (LT)	23	——



LOCALITY SKETCH

NOTES

1. Post 4 is a Type 6, Post 5 is a Type 2, 3.2m long.
2. Special regulatory stop signs placed on posts 6 and 7.
3. Audio tactile push buttons provided on posts 1, 2, 3, 4, 5 and 7.
4. Arterial on A phase.

PUBLIC UTILITY LEGEND

HYDRANT	□	ELECTRIC LIGHT POLE	⌀
STOP VALVE	▲	POWER POLE	○
GAS VALVE	#	STAY POLE	⌒
SEWER MANHOLE	⊛	TELEPHONE BOX	⊟
TELECOM PIT	▭	TELECOM PILLAR	◐

DRAWING FILE : /tcs/thirroul/mr185_phillip/vv3083_1h.dgn
SURVEY FILE : /tcs/thirroul/mr185_phillip/svy.inp

DESIGN LAYOUT

A ORIGINAL ISSUE
B Issue JJ.ILL.1086 29.9.94 W.A.E. 21.2.94 S.H.
C Issue JJ.ILL.1144 22.9.95 Provide right turn phase into Phillip St. and complimentary left turn phase from Phillip st. S.H.
D Issue JJILL.1154 19/10/95 Work as Executed 10/4/96 MK 7/96
E Issue JJ.ILL.1345 16.6.98 W.A.E. 26.6.98 PROM Installed on detectors B/C. REJ.
F Issue JJ.ILL.1720 4.03.04 Amend Intersection to include pedestrian crossings on all three road crossing points. W.H. 26.03.04
G Issue JJ.ILL.1740 6.09.04 C Phase pedestrian lanterns & buttons relabelled. Notes amended. Ramp dimensions deleted. W.A.E. 3.12.04 W.H. 14.12.04
H Issue JJ.ILL.1824 10.03.06 Pedestrian Warning Sign added to Post 3. W.A.E. C.B. 24/05/07

REFERENCE PLANS	
Symbols & Abb.	VD003-6
Standard Posit.	VD001-5
Det. Sched. Exp.	VD018-10
Pres. Detectors	VC005-17
SSG Dis. Seq.	VD018-8
Cable Installation	Sheet 2
Wiring Chart	Sheet 3

U.B.D.REF. MAP 3 F12
I.S.G. CO-ORDS E 2 224 E, N 1147 N

S LAPPIN 9/94 DESIGNED
N BURKE 9/94 CHECKED
N BURKE 9/94 PASSED

THESE DRAWINGS HAVE BEEN EXAMINED AND ARE RECOMMENDED FOR APPROVAL
SIGNATURE REFER TO A ISSUE
NAME G. BRISBANE
POSITION TRAFFIC MANAGER
DATE 19/9/94

APPROVED
SIGNATURE REFER TO A ISSUE
NAME N.C. LAMB
POSITION ZONE MANAGER
DATE 29/9/94

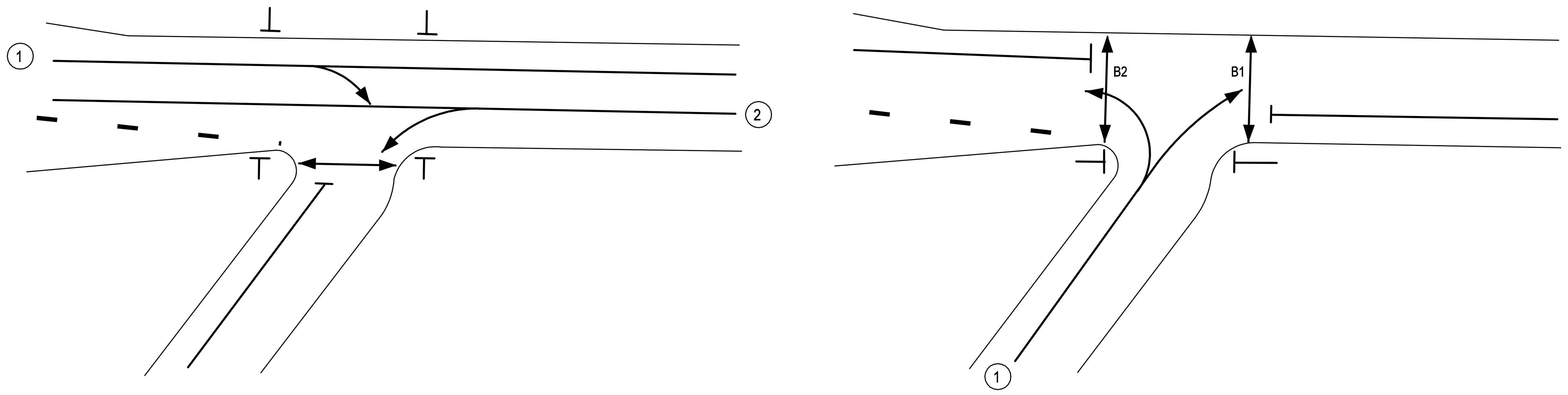
ROADS AND TRAFFIC AUTHORITY OF NSW

CITY OF WOLLONGONG
MR 185 LAWRENCE HARGRAVE DRIVE
AND PHILLIP STREET, THIRROUL

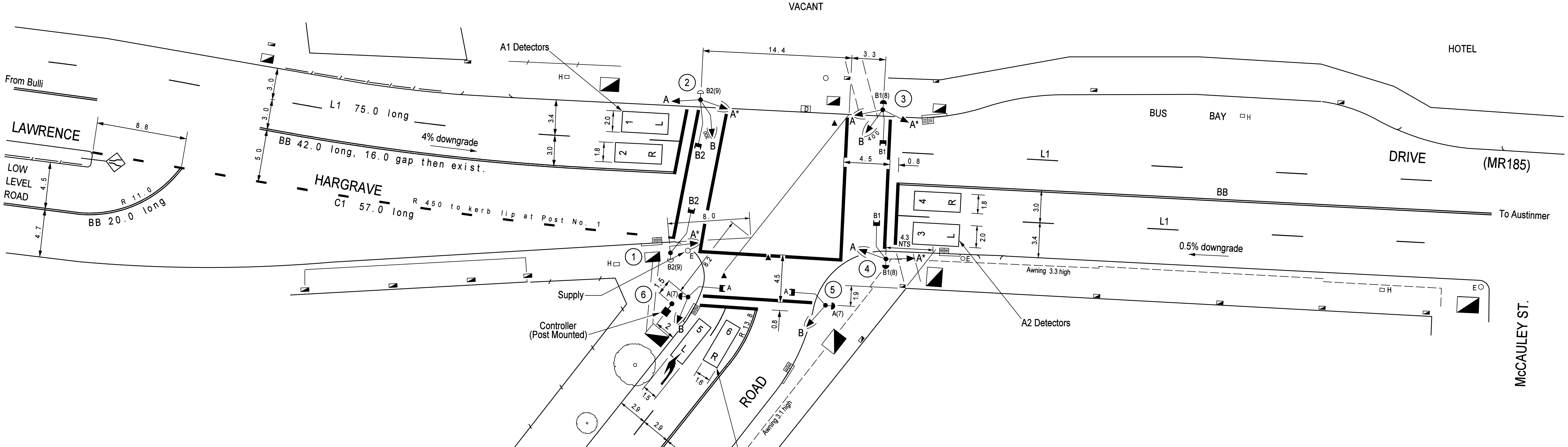
REGION : SOUTHERN REGION
SHEET 1
SCALE 5 0 5 10
ISSUE A B C D E F G H
FILE 497.TS.505
SUPERSEDES SHEET
REGN. 0185.497.VV.3083

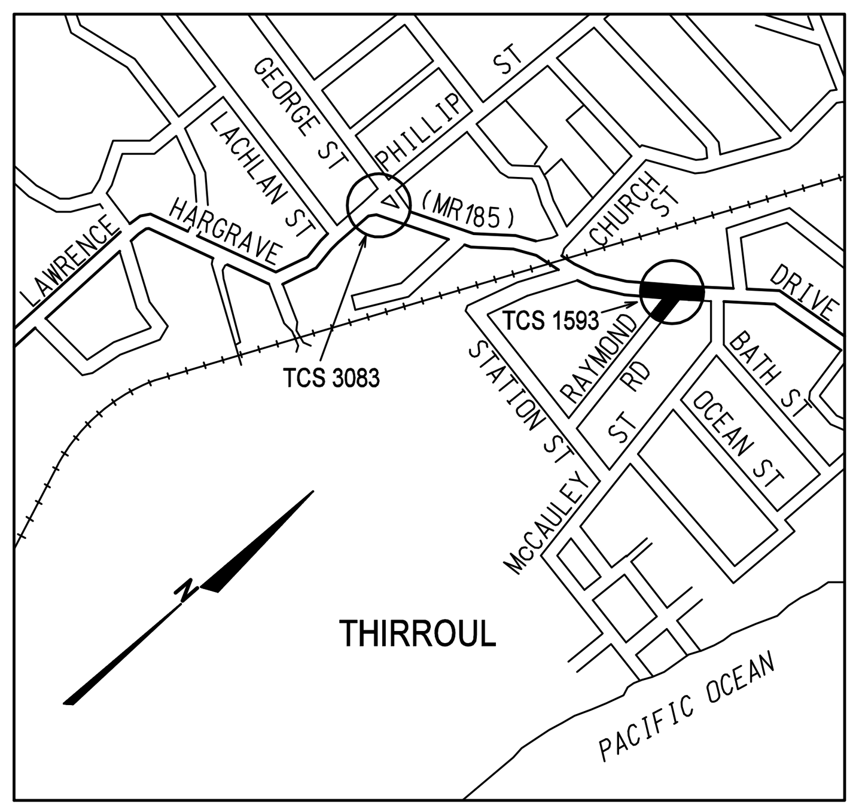
Sheet Type G

Date in Service 23.12.80



MOVEMENT DIAGRAMS





LOCALITY SKETCH
NOT TO SCALE

NOTES

1. Special Post Details :-
   a. Post 4 is Type 1, 4.6m long and placed 0.7 from kerb.
   b. Post 3 is Type 2 and placed 0.6 from kerb.
   c. Post 2 is placed 0.6 from kerb.
   d. Lanterns on Posts 1 & 6 are mounted by offset brackets.
2. Audio Tactile Push Buttons are provided on Posts 3,4,5 & 6.
3. Special Regulatory Stop Sign placed on Post 6.
4. Lanterns denoted by an asterisk are wired to a separate signal group.

PUBLIC UTILITY LEGEND

HYDRANT	□	ELECTRIC LIGHT POLE	⌀
STOP VALVE	▲	POWER POLE	○
GAS VALVE	#	STAY POLE	⌒
SEWER MANHOLE	⊗	TELEPHONE BOX	⊡
TELECOM PIT	▬	TELECOM PILLAR	◐

FILE NAME: /tcs/thirroul/mr185_raymond/vv1593_7d.dgn

SURVEY FILE :

DESIGN LAYOUT

A ORIGINAL ISSUE
JI ILL 1088 18.10.94 Provide Audio Tactile facilities for pedestrian crossings. W.A.E 18.7.95 BIW 3.10.96

B Issue JI ILL1551 14.5.01 W.A.E. 16.6.01 Additional A phase primary lantern post 3, north app. S.H.

C Issue. B2 Pedestrian added, kerb ramp added. A1 Detectors relocated. C.E. 4-3-03

D Issue J.I. ILL 1739 6-09-04 Lantern added to Post 2, controller amended to post mounted type, notes amended. W.A.E. 17-11-04 W.H. 14-12-04

REFERENCE PLANS	
Symbols & Abb.	VD003-6
Standard Posit.	VD001-5
Det. Sched. Exp.	VD018-10
Pres. Detectors	VC005-17
SSG Dis. Seq.	VD018-8

U.B.D.REF. Map 3 G11
I.S.G. CO-ORDS E 292700 N 1201400

G.E. 8/78 DESIGNED
P.B.& J.K. 9/78 CHECKED
F.M.& P.J. 9/78 PASSED

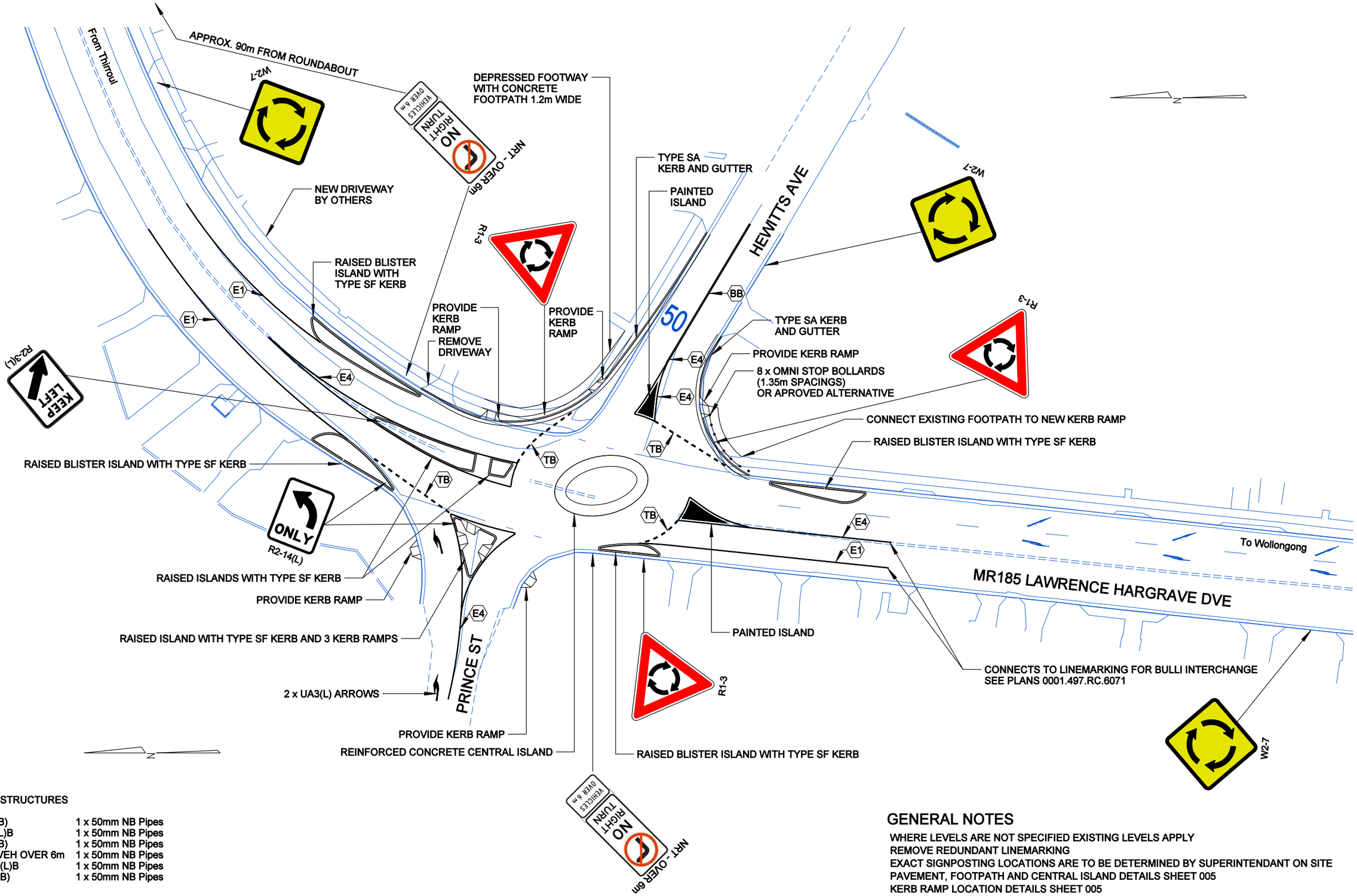
THESE DRAWINGS HAVE BEEN EXAMINED AND ARE RECOMMENDED FOR APPROVAL
SIGNATURE Refer Sheet 1 Issue A
NAME Refer Sheet 1 Issue A
POSITION Divisional Engineer
DATE 18.10.78

APPROVED
SIGNATURE Refer Sheet 1 Issue A
NAME Refer Sheet 1 Issue A
POSITION Engineer-in-Chief
DATE 8.12.78

ROADS AND TRAFFIC AUTHORITY OF NSW

CITY OF WOLLONGONG
MR185 LAWRENCE HARGRAVE DRIVE
AND RAYMOND ROAD, THIRROUL

REGION : SOUTHERN REGION
SHEET 7
SCALE 5 0 5 10
ISSUE A B C D
FILE 497.TS.299
SUPERSEDES SHEET 1
REGN. 0185.497.VV.1593



SIGN STRUCTURES

R1-3(B)	1 x 50mm NB Pipes
R2-3(L)B	1 x 50mm NB Pipes
R2-4(B)	1 x 50mm NB Pipes
NRT-VEH OVER 6m	1 x 50mm NB Pipes
R2-14(L)B	1 x 50mm NB Pipes
W2-7(B)	1 x 50mm NB Pipes

GENERAL NOTES

WHERE LEVELS ARE NOT SPECIFIED EXISTING LEVELS APPLY
REMOVE REDUNDANT LINEMARKING
EXACT SIGNPOSTING LOCATIONS ARE TO BE DETERMINED BY SUPERINTENDANT ON SITE
PAVEMENT, FOOTPATH AND CENTRAL ISLAND DETAILS SHEET 005
KERB RAMP LOCATION DETAILS SHEET 005
ALIGNMENT AND SETOUT DETAILS SHEET 008 TO 015

REFER TO SHEET 023 FOR UTILITY DETAILS

No.	Amendment Description	Initials	Date
A2	SIGNATURE ISSUE	CB	26/05/09
A1	TENDER ISSUE	CB	18/05/09

A3 original | This sheet may be prepared using colour and may be incomplete if copied

SCALES
0 5 10 15 20 25
NOMINAL SCALE RATIO 1:500

Co-ordinate System: MGA 56 | Height Datum: A.H.D.

RTA PREPARED BY ENGINEERING TECHNOLOGY SOUTHERN PROJECT DESIGN

DESIGNED C. BOUWENS
REVIEWED M. KEECH

ROADS AND TRAFFIC AUTHORITY OF NSW

CITY OF WOLLONGONG
MR185 LAWRENCE HARGRAVE DRIVE
ROUNDABOUT AND IMPROVEMENTS AT
HEWITTS AVENUE THIRROUL
DETAIL, PAVEMENT MARKING AND SIGNPOSTING PLAN (HEWITTS NTH)

FILE No.	DRAWING	PRINTED DATE	SHEET No.
1/497.11489	DETAIL HEWITTS NT	26/05/2009	017

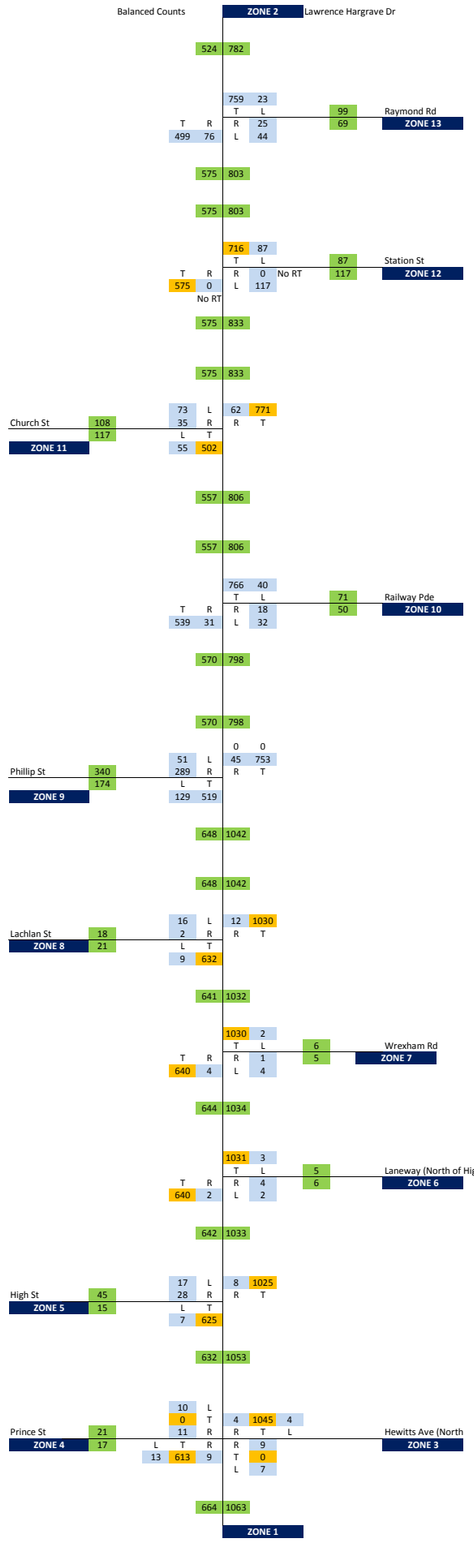
REGISTRATION NUMBER
0185.497.RC.2769

PRODUCED 26/05/2009 AT 10:49:09 AM USER: bouwensc PATH: K:\Design\0185_497_rc_2769\Drawings\DETAIL PLANS\017_DETAIL HEWITTS NTH.dgn General Sheet

Appendix B

Existing AM & PM Traffic Flows and GEHs

2010 AM Peak Existing Traffic Volumes Data



3.30-4.30 Lawrence Hargrave Dr

PM PEAK

ACTUAL COUNTS

763 608

590 18 — T L — 59 — Raymond Rd
T R — R 42 — 78
721 41 — L 36

762 626

T L — 0 — Station St
T R — R 0 — No RT — 127
0 — L 127
No RT

99 L — 84
Church St 112 — 13 R — R T — 106
L T
22

766 673

643 30 — T L — 84 — Railway Pde
T R — R 33 — 91
733 54 — L 58

787 701

839 693

62 L — 107 586
Phillip St 225 — 163 R — R T — 423
L T
316 777

1093 749

26 L — 29
Lachlan St 28 — 2 R — R T — 43
L T
14

14 2

4
T L — 8 — Wrexham Rd
T R — R 1 — 4
4 — L 3

4 3

3
T L — 4 — Laneway (North of High Street)
T R — R 3 — 5
1 — L 2

1 2

12 L — 13
High St 12 R — R T
L T
32

32 12

7 L
T
Prince St 0 R — R 10 T 7 L — Hewitts Ave (North
L T R — R 8
20 14 — T
L 7

34 7

2
T L — Hewitts Ave (South)
R — R 0
0 — L 6

3.30-4.30 Lawrence Hargrave Dr — ZONE 2

BALANCED COUNTS

###	Modified
###	Assumed Through Traffic
###	Actual Counts
###	Mid-Block Volumes

801 653

635 18 — T L — 74 — Raymond Rd
T R — R 42 — 92 — ZONE 13
759 56 — L 50

815 685

815 617

617 0
T L — 0 — Station St
T R — R 0 — No RT — 127 — ZONE 12
815 0 — L 127
No RT

815 744

815 744

89 L — 84 660
Church St 102 — 13 R — R T
ZONE 11 — L T — 106
22 726

748 673

748 673

643 30 — T L — 89 — Railway Pde
T R — R 25 — 83 — ZONE 10
723 59 — L 58

782 701

784 701

52 L — 109 592
Phillip St 215 — 163 R — R T
ZONE 9 — L T — 425
316 732

1048 755

1048 755

26 L — 29 726
Lachlan St 28 — 2 R — R T
ZONE 8 — L T — 43
14 1022

1036 728

724 4
T L — 8 — Wrexham Rd
T R — R 1 — 4 — ZONE 7
1035 4 — L 3

1039 727

724 3
T L — 4 — Laneway (North of High Street)
T R — R 3 — 5 — ZONE 6
1038 1 — L 2

1039 726

12 L — 13 713
High St 24 — 12 R — R T
ZONE 5 — L T — 45
32 1027

1059 725

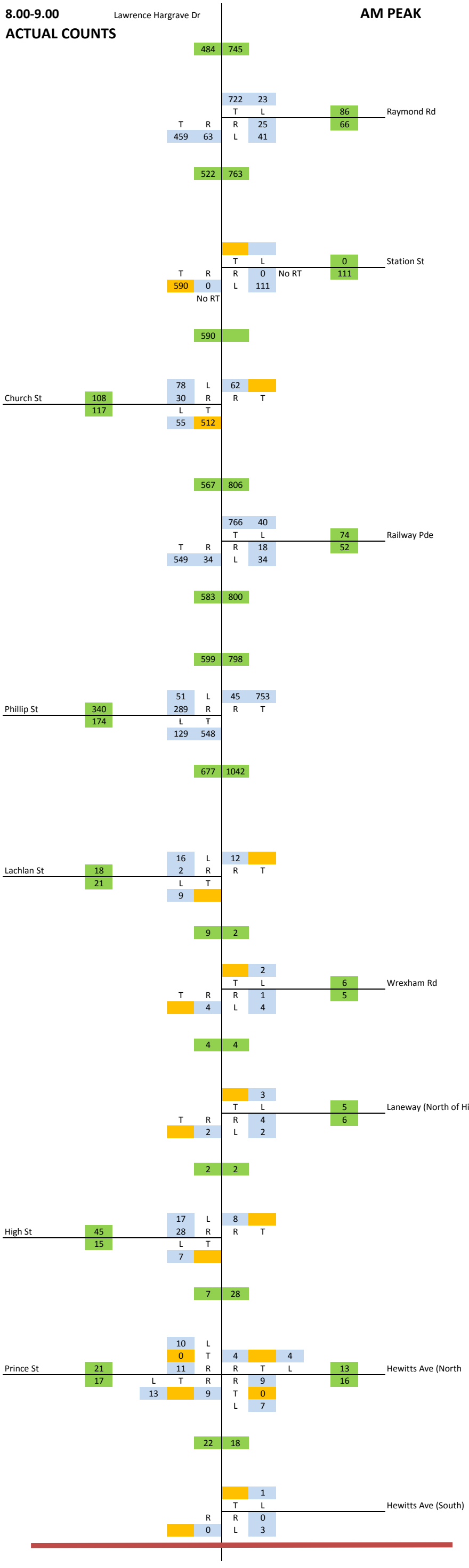
7 L
0 T — 10 708 7
Prince St 7 — 0 R — R T L — 21 — Hewitts Ave (North
ZONE 4 — 30 — L T R — R 8 — 15 — ZONE 3
20 1044 14 — T 0
L 7

1078 715

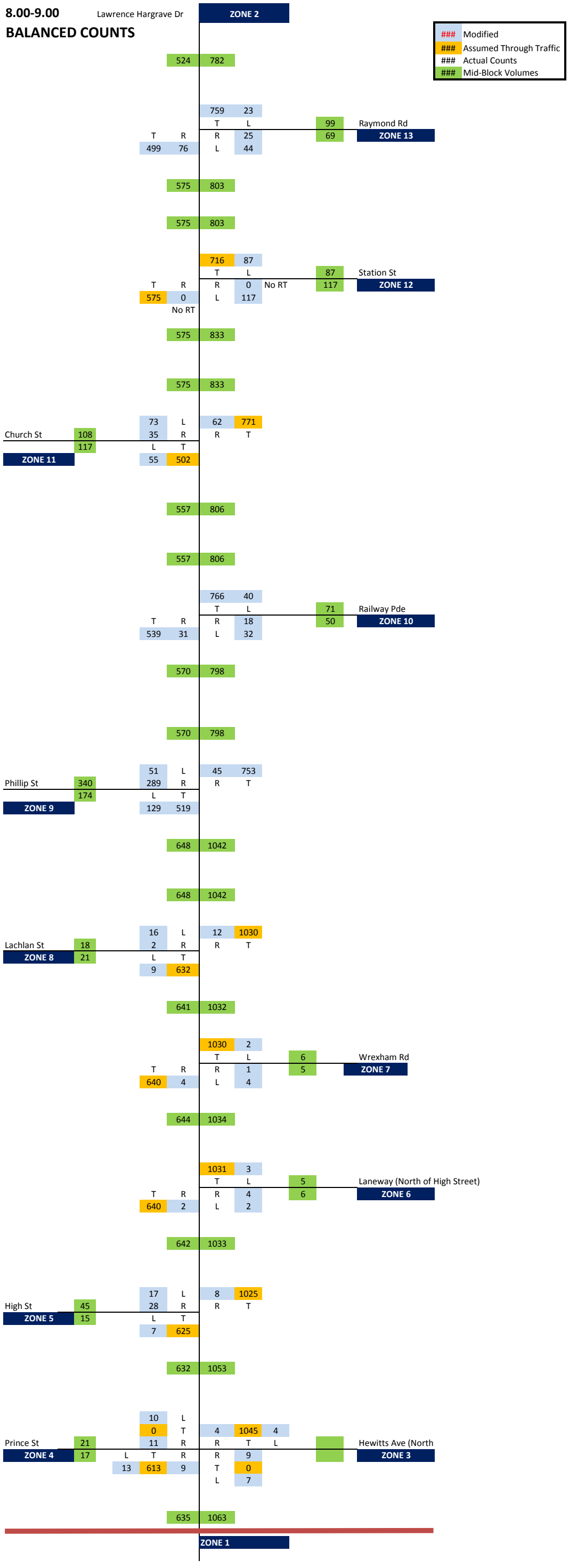
ZONE 1

8.00-9.00 AM PEAK

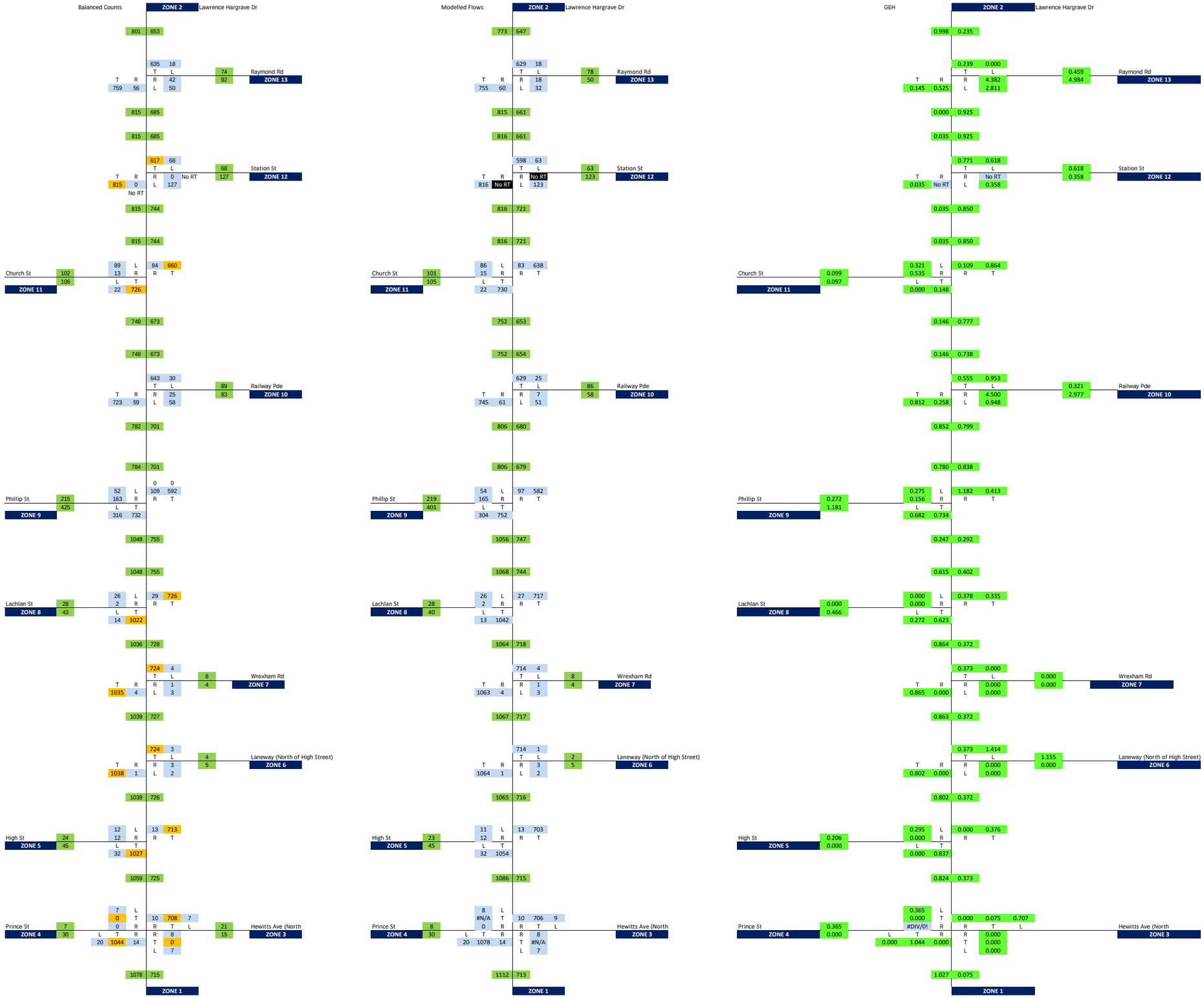
ACTUAL COUNTS



BALANCED COUNTS

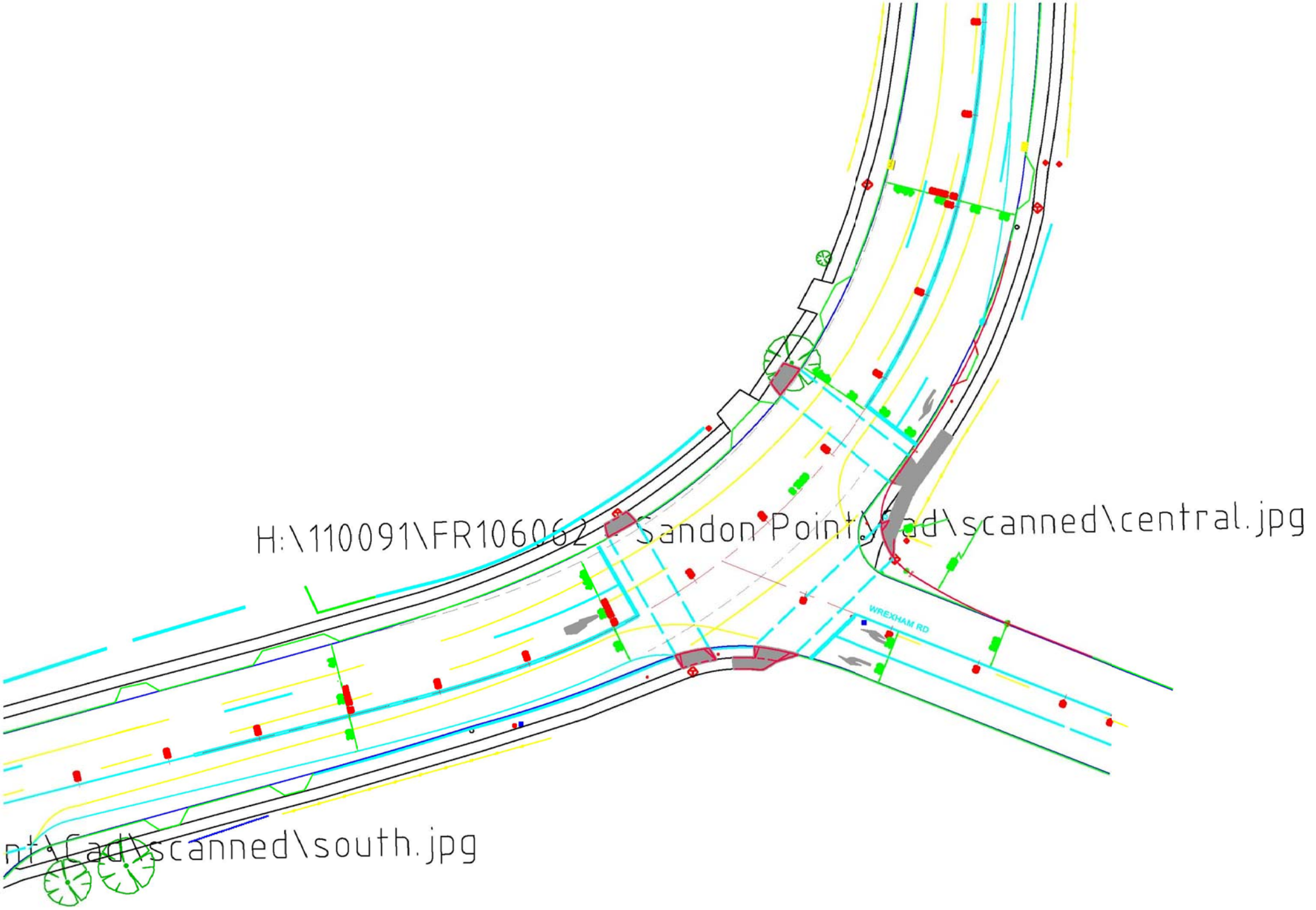


2010 PM Peak Existing Traffic Volumes Data



Appendix C

Proposed Intersection Layout of LHD/Wrexham Road


H:\110091\FR106062 - Sandon Point\Cad\scanned\central.jpg
WREXHAM RD
nt\Cad\scanned\south.jpg

Appendix D

Reference Report from Christopher Hallam & Assoc Pty Ltd

REVIEW OF TRAFFIC ACCESS TO SANDON POINT – INTERSECTION OF LAWRENCE HARGRAVE DRIVE & WREXHAM STREET

4TH DECEMBER 2008

CHRISTOPHER HALLAM & ASSOCIATES PTY LTD
PO BOX 1021,
GLEBE NSW 2037
DX 23908 GLEBE
Telephone: 02 9571 7322
Fax: 02 9571 7323
E-mail: hallamc@bigpond.net.au

JOB:2850

1.0 INTRODUCTION

This report has been prepared in response to a letter from the Roads & Traffic Authority of NSW, to the Department of Planning, dated 28 August 2008, in which additional information was requested.

The Roads & Traffic Authority (RTA) recommended that the access to the Sandon Point area be via Wrexham Road and/or Point Street. The current masterplan for the site proposes use of both of these streets for access.

This report assesses the traffic implications at the Lawrence Hargrave Drive/Wrexham Road intersection. The starting point for this analysis is the report prepared by Christopher Stapleton Consulting Pty Ltd titled *Sandon Point Traffic Review May 2006.* This report also uses traffic modelling that was undertaken for this study.

2.0 DESIGN TRAFFIC FLOWS

INTANAL analysis of the intersection of Lawrence Hargrave Drive and Wrexham Road has previously been undertaken and presented. The starting point for this analysis was the traffic projections undertaken as part of the 2001 TRACKS traffic modelling. These 2001 projections were upgraded to 2006 design traffic flows using growth factors. The latter design flows were used in the INTANAL analysis. These flows are used in the aaSIDRA analysis discussed in Section 3. Table 2.4 of the Christopher Stapleton Consulting report provides a summary of design traffic flows at different locations in the road network.

For the assessment of the Lawrence Hargrave Drive/Wrexham Road intersection, the figures in Table 2.4 of the CSC report, for Lawrence Hargrave Drive north of Wrexham Road provide the starting point. Note that in this Table, the "2001 Assessment Flows" are in fact the 2001 TRACKS flows growthed up to a design year of 2006, as noted under Table 2.4.

For traffic growth projections, we understand that the TRACKS model assumed a morning peak hour growth rate of 3.1% per annum, and an afternoon peak hour growth factor of 3.0% per annum. Assuming compound growth, for +10 years, the AM peak flows would increase by 35.7%, while the PM peak flows would increase by 34.4%.

Excluding the Sandon Point traffic into and out of Wrexham Road, the 2006 and the 2016 two-way peak hour flows on Lawrence Hargrave Drive at Wrexham Road would be:

Lawrence Hargrave Drive – Vehicles/hour (two-way)

Peak	**2006**	**2016**	**(2026)**
AM	1457	1977	(2071)
PM	1427	1918	(2141)

The figures for 2006 are the base "current" flows used in the analysis of the 2006 situation, to which Sandon Point traffic via Wrexham Road is added. For figures for 2016 are the base flows for that year, to which Sandon Point traffic is added. The (2026) figures are from Table 2.4 of the CSC report and are the year 2026 TRACKS traffic projections for Lawrence Hargrave Drive at Wrexham Road, without Sandon Point traffic. It can be seen that these figures are only marginally more than the nominal year 2016 figures, and suggest that perhaps the 3.1% and 3.0% annual traffic growth rates might be high in this location. The minimum assumption we would make is that the "2016" figures could be assumed to apply to 10 years from today – 2018.

3.0 TRAFFIC ANALYSIS RESULTS

Layout and Design Flows

Figure 1 shows an aerial view of the intersection of Lawrence Hargrave Drive and Wrexham Road, with lanes marked up to reflect the installation of traffic signals at this location. The analysis of this intersection has made the following assumptions:

- Northbound: kerb lane used for northbound travel, with centre lane used for a right turn bay, 80 metres long; kerb lane tapers back to centre lane north of the intersection
- Southbound: kerb lane used for left turn traffic, and is 80 metres long; centre lane continues to be used for southbound traffic
- Wrexham Road: left-turn lane out of Wrexham Road 50 metres long; right turn lane is continuous

Figure 2 presents this information diagrammatically, as taken from the aaSIDRA model. Also shown on Figure 2 are the year 2006 design traffic flows, with Sandon Point, with AM peak hour flows, and PM peak hour flows in brackets.

As is further discussed, if the long term traffic projections occur, there will be a higher demand for through movement along Lawrence Hargrave Drive. Peak hour peak direction flows are of the order of 1200 veh/hr in one lane. For the approach to a traffic signal-controlled intersection, additional capacity will be desirable in due course, when flows reach these levels. Figure 3 presents a long-term intersection layout option that utilises the full four lanes of Lawrence Hargrave Drive. This would be appropriate for at least the approaches and departures from this intersection. Lawrence Hargrave Drive could revert to one through lane per direction beyond the influence of the intersection.

SIDRA Analysis

The SIDRA analysis has been undertaken for six scenarios:

- 2006 flows with Figure 2 layout (AM and PM)
- 2016 flows with Figure 2 layout (AM and PM)
- 2016 flows with Figure 3 layout (AM and PM)

The SIDRA files have been separately provided to the RTA. The Movement Summaries are reproduced at the end of this report. Table 3.1 summarises the key outputs.

TABLE 3.1 SIDRA Outputs for Lawrence Hargrave Drive/Wrexham Road

Year	Peak	Layout	Level of service	Avg delay (secs/veh)	Degree of saturation
2006	AM	Fig 2	A	9	0.69
	PM	Fig 2	B	11	0.65
2016(2018)	AM	Fig 2	C	20	0.94
	PM	Fig 2	B	15	0.87
2016(2018)	AM	Fig 3	A	8	0.50
	PM	Fig 3	A	9	0.47

For the base year of 2006 the Figure 2 layout will work very efficiently.

For the design year of 2016 (which is probably later than this, as discussed), the intersection level of service becomes B or C, which are still satisfactory, based on Table 4.2 of the RTA's *Guide to Traffic Generating Developments*, but the degree of saturation of the intersection does increase substantially. This is due to one-way peak hour flows of about 1200 veh/hr in one lane. This is satisfactory mid-block but delays will occur at intersections.

With the Figure 3 layout, these capacity issues dissipate and the level of service reverts to A in both peak periods.

The conclusion is that the Figure 2 layout is appropriate for the short to medium term, and can be implemented. If and when the longer term traffic flow increases occur, the Figure 2 layout can be simply converted to the Figure 3 layout using lane lining and other paintwork. Civil works will not be required. The simple trade-off is on-street parking on Lawrence Hargrave Drive versus through traffic flow efficiency.

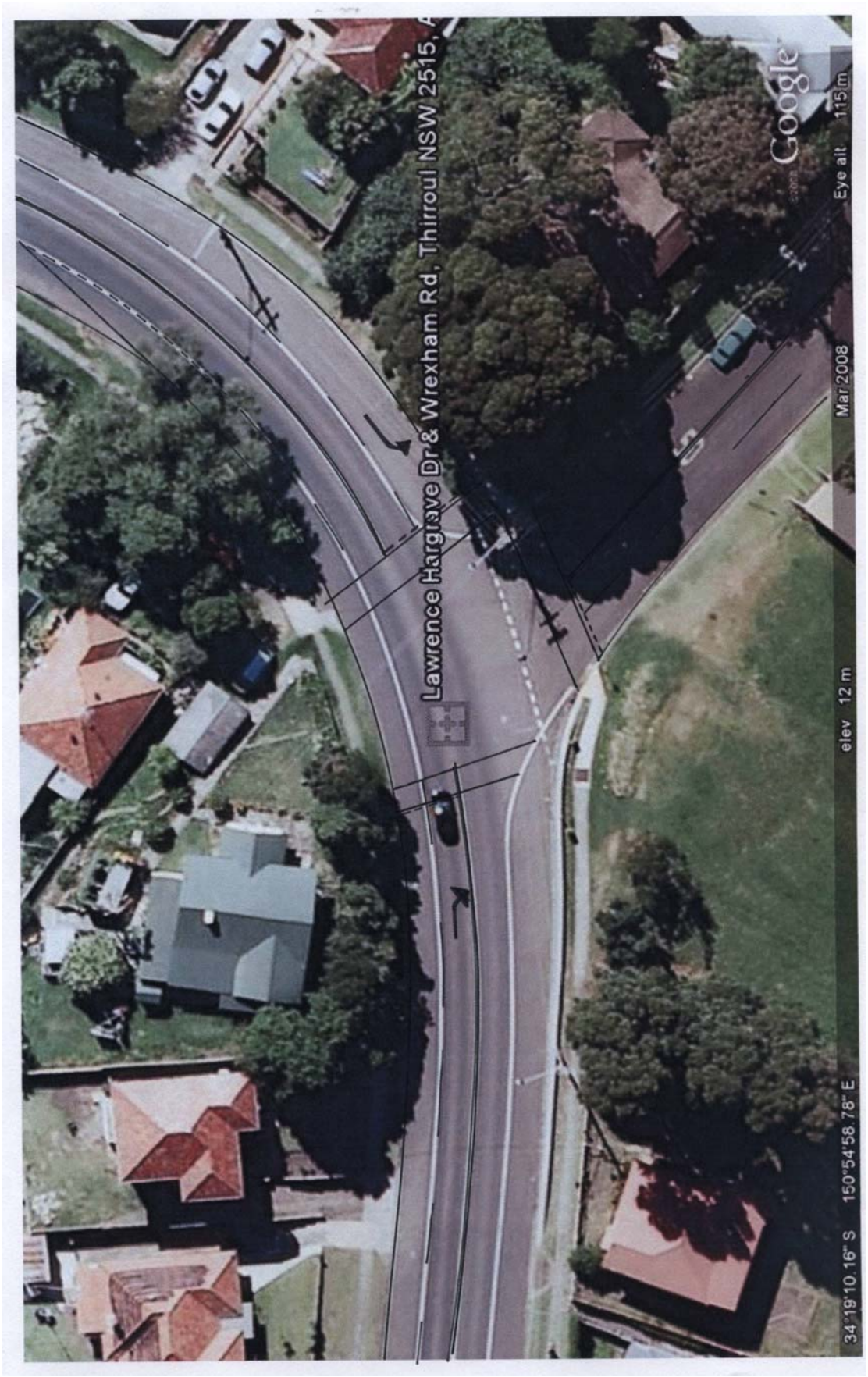
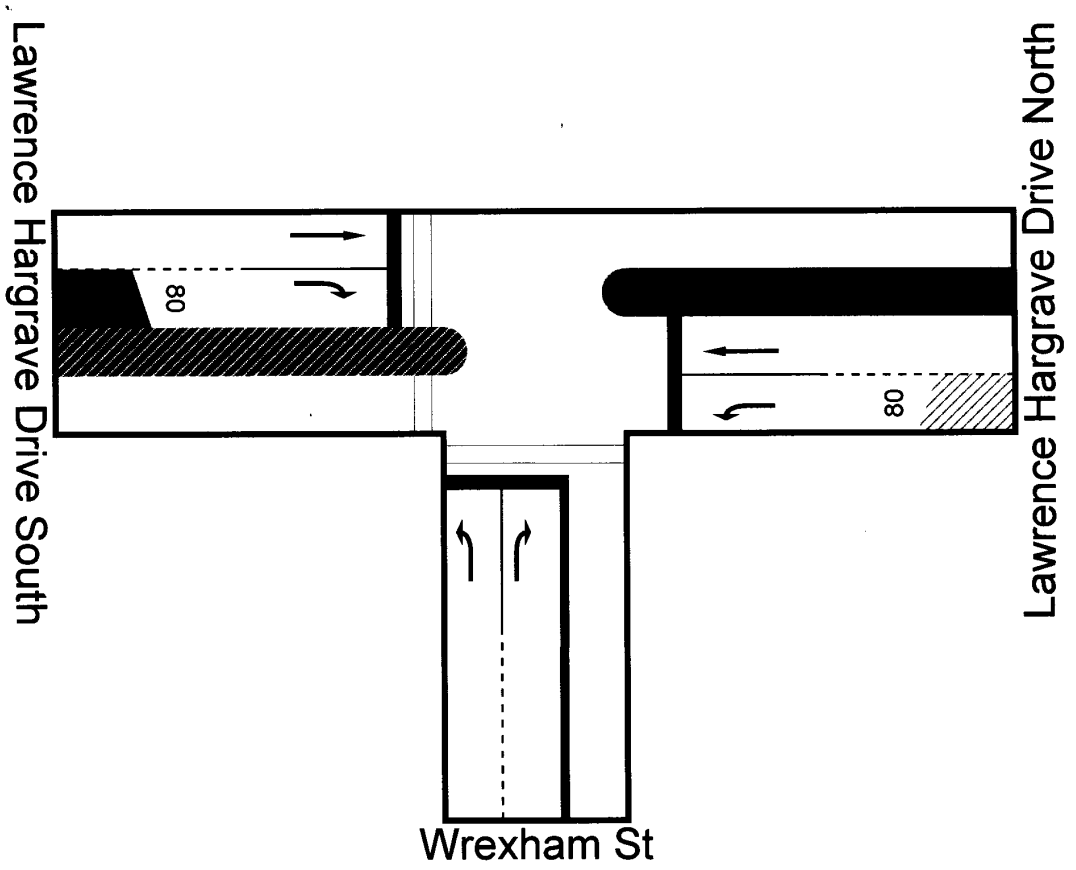


FIGURE 1 SCHEMATIC LAYOUT OF INTERSECTION OF LAWRENCE HARGRAVE DRIVE & WREXHAM STREET



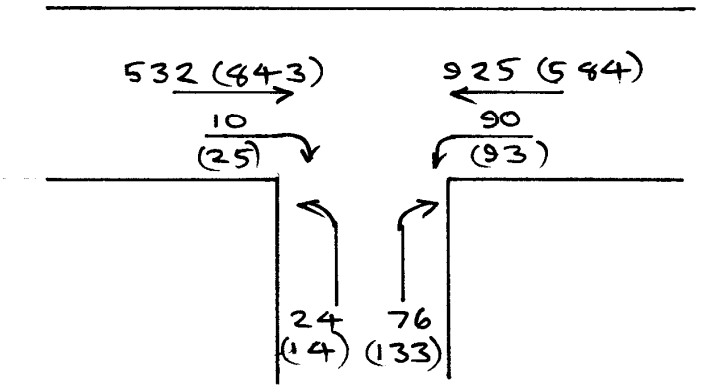


FIGURE 2 INTERSECTION LAYOUT FOR MEDIUM TERM YEAR 2006 PEAK HOUR TRAFFIC FLOWS: AM (PM)

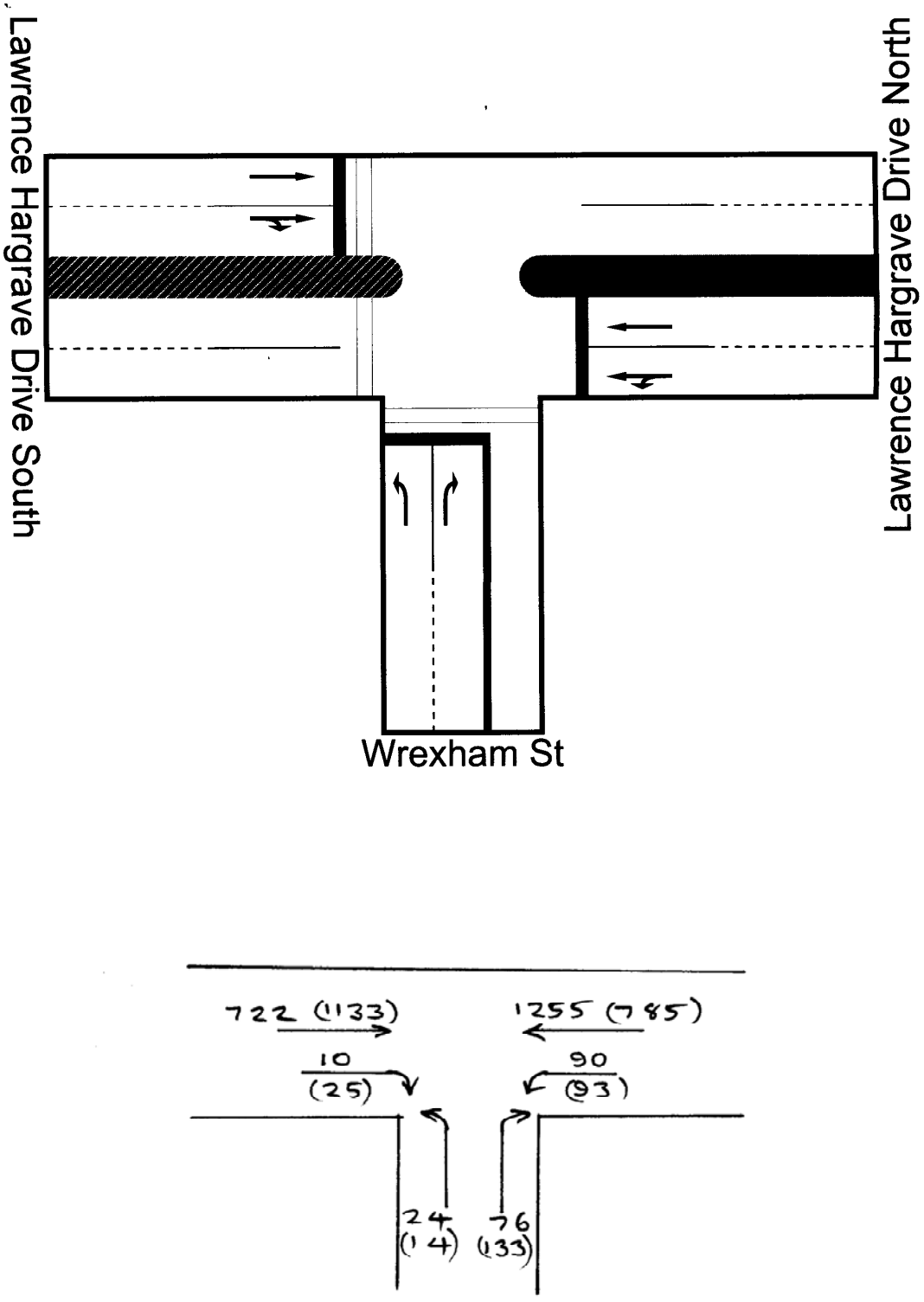


FIGURE 3 INTERSECTION LAYOUT FOR LONG TERM YEAR 2016 (2018) PEAK HOUR TRAFFIC FLOWS: AM (PM)

SIDRA INTERSECTION

Movement Summary

Lawrence Hargrave Drive Wrexham St

2006 AM

Signalised - Actuated isolated **Cycle Time = 95 seconds**

Vehicle Movements

Mov ID	Turn	Dem Flow (veh/h)	%HV	Deg of Satn (v/c)	Aver Delay (sec)	Level of Service	95% Back of Queue (m)	Prop. Queued	Eff. Stop Rate	Aver Speed (km/h)
Wrexham St										
1	L	25	0.0	0.085	45.7	LOS D	9	0.86	0.71	24.7
3	R	80	0.0	0.273	47.4	LOS D	29	0.90	0.76	24.2
Approach		**105**	**0.0**	**0.273**	**47.0**	**LOS D**	**29**	**0.89**	**0.75**	**24.3**
Lawrence Hargrave Drive North										
4	L	95	0.0	0.112	11.2	LOS B	11	0.28	0.69	44.7
5	T	974	3.0	0.690	7.4	LOS A	185	0.57	0.53	49.9
Approach		**1068**	**2.7**	**0.690**	**7.7**	**LOS A**	**185**	**0.55**	**0.55**	**49.4**
Lawrence Hargrave Drive South										
11	T	560	3.0	0.397	5.1	LOS A	81	0.39	0.35	52.6
12	R	11	0.0	0.044	22.9	LOS C	3	0.54	0.70	35.6
Approach		**571**	**3.0**	**0.397**	**5.5**	**LOS A**	**81**	**0.40**	**0.36**	**52.2**
All Vehicles		**1744**	**2.6**	**0.690**	**9.4**	**LOS A**	**185**	**0.52**	**0.50**	**47.3**

Pedestrian Movements

Mov ID	Dem Flow (ped/h)	Aver Delay (sec)	Level of Service	95% Back of Queue (m)	Prop. Queued	Eff. Stop Rate
P1	11	41.7	LOS E	0	0.94	0.94
P7	11	41.7	LOS E	0	0.94	0.94
All Peds	**22**	**41.7**	**LOS E**	**0**	**0.94**	**0.94**

Symbols which may appear in this table:

Following Degree of Saturation
x = 1.00 for Short Lane with resulting Excess Flow
* x = 1.00 due to minimum capacity

Following LOS
- Based on density for continuous movements

SIDRA INTERSECTION

Movement Summary

Lawrence Hargrave Drive Wrexham St

2006PM

Signalised - Actuated isolated **Cycle Time = 98 seconds**

Vehicle Movements

Mov ID	Turn	Dem Flow (veh/h)	%HV	Deg of Satn (v/c)	Aver Delay (sec)	Level of Service	95% Back of Queue (m)	Prop. Queued	Eff. Stop Rate	Aver Speed (km/h)
Wrexham St										
1	L	15	0.0	0.044	43.8	LOS D	5	0.83	0.69	25.2
3	R	140	0.0	0.410	47.5	LOS D	52	0.90	0.79	24.2
Approach		**155**	**0.0**	**0.410**	**47.1**	**LOS D**	**52**	**0.90**	**0.78**	**24.3**
Lawrence Hargrave Drive North										
4	L	98	0.0	0.123	12.0	LOS B	12	0.31	0.69	43.9
5	T	615	2.9	0.449	6.5	LOS A	101	0.44	0.40	50.9
Approach		**712**	**2.5**	**0.449**	**7.2**	**LOS A**	**101**	**0.43**	**0.44**	**49.9**
Lawrence Hargrave Drive South										
11	T	887	3.0	0.650	8.2	LOS A	175	0.57	0.53	48.9
12	R	26	0.0	0.063	17.5	LOS B	5	0.44	0.71	39.3
Approach		**914**	**3.0**	**0.650**	**8.5**	**LOS A**	**175**	**0.57**	**0.53**	**48.6**
All Vehicles		**1781**	**2.5**	**0.650**	**11.4**	**LOS B**	**175**	**0.54**	**0.52**	**45.1**

Pedestrian Movements

Mov ID	Dem Flow (ped/h)	Aver Delay (sec)	Level of Service	95% Back of Queue (m)	Prop. Queued	Eff. Stop Rate
P1	11	43.2	LOS E	0	0.94	0.94
P7	11	43.2	LOS E	0	0.94	0.94
All Peds	**22**	**43.2**	**LOS E**	**0**	**0.94**	**0.94**

Symbols which may appear in this table:

Following Degree of Saturation
x = 1.00 for Short Lane with resulting Excess Flow
* x = 1.00 due to minimum capacity

Following LOS
- Based on density for continuous movements

SIDRA INTERSECTION

Movement Summary

Lawrence Hargrave Drive Wrexham St

2016 AM

Signalised - Actuated isolated **Cycle Time = 95 seconds**

Vehicle Movements

Mov ID	Turn	Dem Flow (veh/h)	%HV	Deg of Satn (v/c)	Aver Delay (sec)	Level of Service	95% Back of Queue (m)	Prop. Queued	Eff. Stop Rate	Aver Speed (km/h)
Wrexham St										
1	L	25	0.0	0.085	45.7	LOS D	9	0.86	0.71	24.7
3	R	80	0.0	0.273	47.4	LOS D	29	0.90	0.76	24.2
Approach		**105**	**0.0**	**0.273**	**47.0**	**LOS D**	**29**	**0.89**	**0.75**	**24.3**
Lawrence Hargrave Drive North										
4	L	95	0.0	0.112	11.2	LOS B	11	0.28	0.69	44.7
5	T	1321	3.0	0.938	26.9	LOS C	474	0.92	1.03	34.5
Approach		**1416**	**2.8**	**0.937**	**25.8**	**LOS C**	**474**	**0.88**	**1.01**	**35.0**
Lawrence Hargrave Drive South										
11	T	760	3.0	0.539	6.0	LOS A	124	0.46	0.43	51.5
12	R	11	0.0	0.102	48.1	LOS D	4	0.86	0.71	24.9
Approach		**771**	**3.0**	**0.539**	**6.6**	**LOS A**	**124**	**0.47**	**0.43**	**50.7**
All Vehicles		**2292**	**2.7**	**0.938**	**20.3**	**LOS C**	**474**	**0.74**	**0.80**	**38.2**

Pedestrian Movements

Mov ID	Dem Flow (ped/h)	Aver Delay (sec)	Level of Service	95% Back of Queue (m)	Prop. Queued	Eff. Stop Rate
P1	11	41.7	LOS E	0	0.94	0.94
P7	11	41.7	LOS E	0	0.94	0.94
All Peds	**22**	**41.7**	**LOS E**	**0**	**0.94**	**0.94**

Symbols which may appear in this table:

Following Degree of Saturation
x = 1.00 for Short Lane with resulting Excess Flow
* x = 1.00 due to minimum capacity

Following LOS
- Based on density for continuous movements

SIDRA INTERSECTION

Movement Summary

Lawrence Hargrave Drive Wrexham St

2016PM

Signalised - Actuated isolated **Cycle Time = 98 seconds**

Vehicle Movements

Mov ID	Turn	Dem Flow (veh/h)	%HV	Deg of Satn (v/c)	Aver Delay (sec)	Level of Service	95% Back of Queue (m)	Prop. Queued	Eff. Stop Rate	Aver Speed (km/h)
Wrexham St										
1	L	15	0.0	0.044	43.8	LOS D	5	0.83	0.69	25.2
3	R	140	0.0	0.410	47.5	LOS D	52	0.90	0.79	24.2
Approach		**155**	**0.0**	**0.410**	**47.1**	**LOS D**	**52**	**0.90**	**0.78**	**24.3**
Lawrence Hargrave Drive North										
4	L	98	0.0	0.123	12.0	LOS B	12	0.31	0.69	43.9
5	T	826	3.0	0.606	7.8	LOS A	156	0.54	0.49	49.4
Approach		**925**	**2.7**	**0.605**	**8.2**	**LOS A**	**156**	**0.51**	**0.51**	**48.8**
Lawrence Hargrave Drive South										
11	T	1193	3.0	0.874	15.6	LOS B	339	0.82	0.82	42.0
12	R	26	0.0	0.085	22.2	LOS C	6	0.53	0.72	36.1
Approach		**1219**	**3.0**	**0.873**	**15.7**	**LOS B**	**339**	**0.81**	**0.81**	**41.9**
All Vehicles		**2299**	**2.7**	**0.874**	**14.8**	**LOS B**	**339**	**0.70**	**0.69**	**42.2**

Pedestrian Movements

Mov ID	Dem Flow (ped/h)	Aver Delay (sec)	Level of Service	95% Back of Queue (m)	Prop. Queued	Eff. Stop Rate
P1	11	43.2	LOS E	0	0.94	0.94
P7	11	43.2	LOS E	0	0.94	0.94
All Peds	**22**	**43.2**	**LOS E**	**0**	**0.94**	**0.94**

Symbols which may appear in this table:

Following Degree of Saturation
x = 1.00 for Short Lane with resulting Excess Flow
* x = 1.00 due to minimum capacity

Following LOS
- Based on density for continuous movements

SIDRA INTERSECTION

Movement Summary

Lawrence Hargrave Drive Wrexham St

2016AM - 4 lanes LHD

Signalised - Actuated isolated **Cycle Time = 95 seconds**

Vehicle Movements

Mov ID	Turn	Dem Flow (veh/h)	%HV	Deg of Satn (v/c)	Aver Delay (sec)	Level of Service	95% Back of Queue (m)	Prop. Queued	Eff. Stop Rate	Aver Speed (km/h)
Wrexham St										
1	L	25	0.0	0.085	45.7	LOS D	9	0.86	0.71	24.7
3	R	80	0.0	0.273	47.4	LOS D	29	0.90	0.76	24.2
Approach		**105**	**0.0**	**0.273**	**47.0**	**LOS D**	**29**	**0.89**	**0.75**	**24.3**
Lawrence Hargrave Drive North										
4	L	95	0.0	0.504	13.2	LOS B	111	0.44	0.76	42.8
5	T	1321	3.0	0.503	5.8	LOS A	112	0.44	0.40	51.8
Approach		**1416**	**2.8**	**0.503**	**6.3**	**LOS A**	**112**	**0.44**	**0.43**	**51.1**
Lawrence Hargrave Drive South										
11	T	760	3.0	0.296	4.8	LOS A	56	0.36	0.32	53.0
12	R	11	0.0	0.296	12.5	LOS B	49	0.36	0.73	43.5
Approach		**771**	**3.0**	**0.296**	**4.9**	**LOS A**	**56**	**0.36**	**0.32**	**52.9**
All Vehicles		**2292**	**2.7**	**0.504**	**7.7**	**LOS A**	**112**	**0.44**	**0.41**	**49.2**

Pedestrian Movements

Mov ID	Dem Flow (ped/h)	Aver Delay (sec)	Level of Service	95% Back of Queue (m)	Prop. Queued	Eff. Stop Rate
P1	11	41.7	LOS E	0	0.94	0.94
P7	11	41.7	LOS E	0	0.94	0.94
All Peds	**22**	**41.7**	**LOS E**	**0**	**0.94**	**0.94**

Symbols which may appear in this table:

Following Degree of Saturation
x = 1.00 for Short Lane with resulting Excess Flow
* x = 1.00 due to minimum capacity

Following LOS
- Based on density for continuous movements

SIDRA INTERSECTION

Movement Summary

Lawrence Hargrave Drive Wrexham St

2016PM - 4 lanes LHD

Signalised - Actuated isolated **Cycle Time = 98 seconds**

Vehicle Movements

Mov ID	Turn	Dem Flow (veh/h)	%HV	Deg of Satn (v/c)	Aver Delay (sec)	Level of Service	95% Back of Queue (m)	Prop. Queued	Eff. Stop Rate	Aver Speed (km/h)
Wrexham St										
1	L	15	0.0	0.044	43.8	LOS D	5	0.83	0.69	25.2
3	R	140	0.0	0.410	47.5	LOS D	52	0.90	0.79	24.2
Approach		**155**	**0.0**	**0.410**	**47.1**	**LOS D**	**52**	**0.90**	**0.78**	**24.3**
Lawrence Hargrave Drive North										
4	L	98	0.0	0.340	13.2	LOS B	70	0.40	0.74	42.8
5	T	826	3.0	0.340	5.8	LOS A	71	0.40	0.35	51.8
Approach		**925**	**2.7**	**0.340**	**6.6**	**LOS A**	**71**	**0.40**	**0.39**	**50.7**
Lawrence Hargrave Drive South										
11	T	1193	3.0	0.472	6.7	LOS A	108	0.46	0.41	50.7
12	R	26	0.0	0.472	14.1	LOS B	98	0.46	0.76	42.0
Approach		**1219**	**3.0**	**0.472**	**6.8**	**LOS A**	**108**	**0.46**	**0.42**	**50.5**
All Vehicles		**2299**	**2.7**	**0.472**	**9.4**	**LOS A**	**108**	**0.46**	**0.43**	**47.1**

Pedestrian Movements

Mov ID	Dem Flow (ped/h)	Aver Delay (sec)	Level of Service	95% Back of Queue (m)	Prop. Queued	Eff. Stop Rate
P1	11	43.2	LOS E	0	0.94	0.94
P7	11	43.2	LOS E	0	0.94	0.94
All Peds	**22**	**43.2**	**LOS E**	**0**	**0.94**	**0.94**

Symbols which may appear in this table:

Following Degree of Saturation
x = 1.00 for Short Lane with resulting Excess Flow
* x = 1.00 due to minimum capacity

Following LOS
- Based on density for continuous movements

Appendix E

Intersection Upgrade for LHD/Phillips St (S5c)

5 0 5 10 15 20 METRES
SCALE 1 : 200 @ A1 SCALE 1 : 400 @ A3

CUT BACK AND LENGTHEN ISLAND TO MIN 8m

REMOVE EXISTING LINEMARKING ON APPROACH AND REINSTALL AS SHOWN

RELOCATE SIGNAL POST AND PRAM RAMPS AS SHOWN

REALIGN KERB AND CHANNEL AS SHOWN

REMOVE EXISTING TURN ARROW LINEMARKING

PHILLIP STREET

RELOCATE SIGNALS HARDWARE AND PRAM RAMP

CUT BACK ISLAND TO INCREASE TRAVEL LANE WIDTH

BUSES AND TAXIS ONLY (ONE WAY)

REMOVE AND REINSTATE LINEMARKING AS SHOWN

PROVIDE NEW LINEMARKING AS SHOWN

REALIGN KERB AND CHANNEL TO INCREASE TRAVEL LANE WIDTH

LAWRENCE HARGRAVE DRIVE

LAWRENCE HARGRAVE DRIVE

NEW KERB AND CHANNEL
NEW KERB ONLY
NEW LINEMARKING
NEW PRAM RAMP
NEW SIGNAL POLE LOCATION
EXISTING KERB AND CHANNEL, KERB ONLY
EXISTING LINEMARKING
EXISTING FOOTPATH
EXISTING PLANTER BOX
NEW PRAM RAMP
EXISTING SIGNAL POLE

REV	DATE	REVISIONS	DRN	CHK
A	08/07/2010	ISSUE FOR DISCUSSION	KH	AL

ARCHITECT:

	PREPARED	CHECKED
DESIGNED:	KH	AL
DRAWN:	KH	

APPROVED: PROJECT DIRECTOR DATE

REVIEWED: PROJECT MANAGER DATE

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CLIENT STOCKLAND PTY LTD

1ST-LINE-TEXT
LAWRENCE HARGRAVE DRIVE/
PHILLIP STREET CONCEPTUAL
REALIGNMENT WORKS

DRAWING STATUS: PRELIMINARY

DRAWING NUMBER: FR106062-001

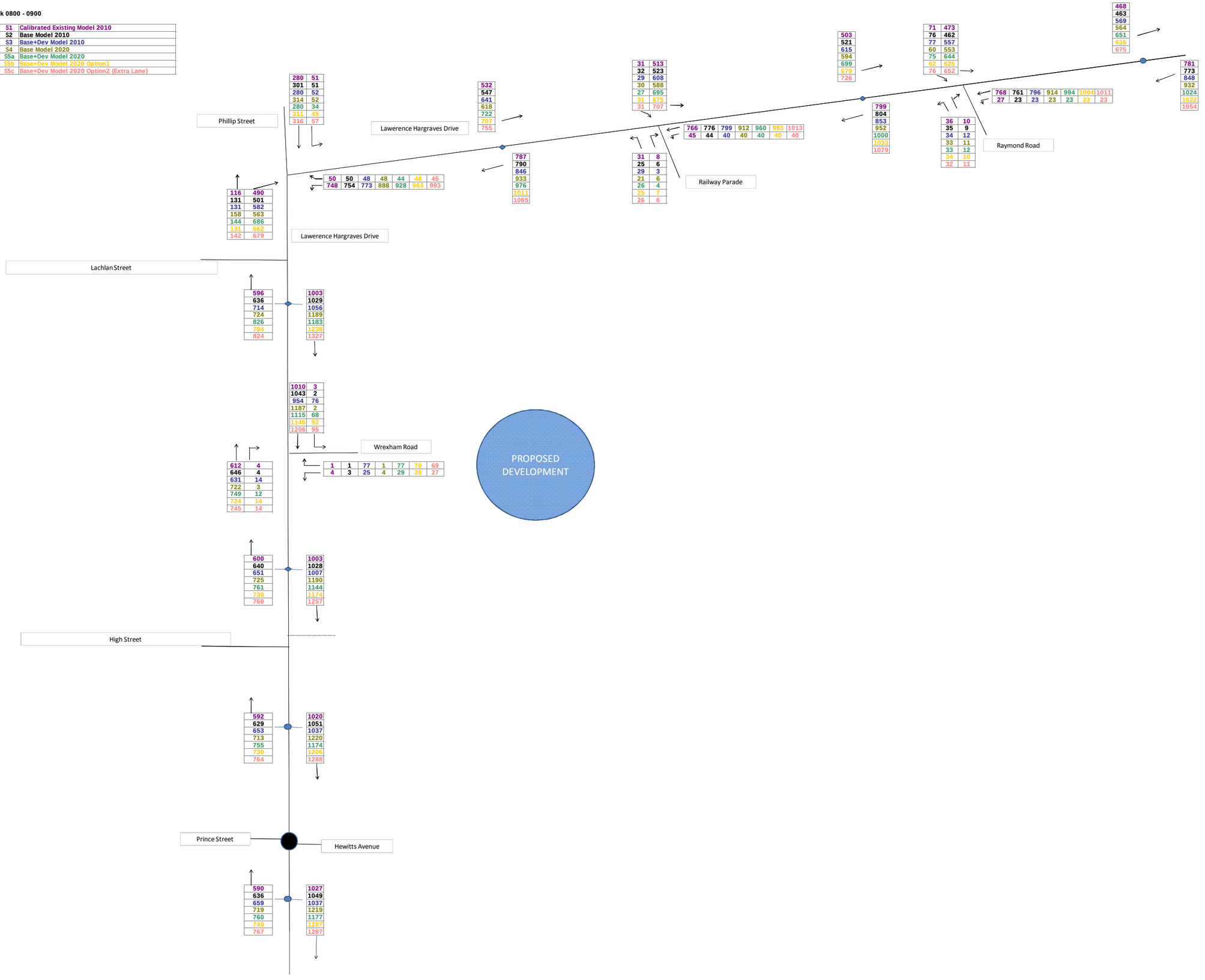
REV: A

Appendix F

Full Network Volumes

AM Peak 0800 - 0900

####	S1	Calibrated Existing Model 2010
####	S2	Base Model 2010
####	S3	Base+Dev Model 2010
####	S4	Base Model 2020
####	S5a	Base+Dev Model 2020
####	S5b	Base+Dev Model 2020 Option1
####	S5c	Base+Dev Model 2020 Option2 (Extra Lane)



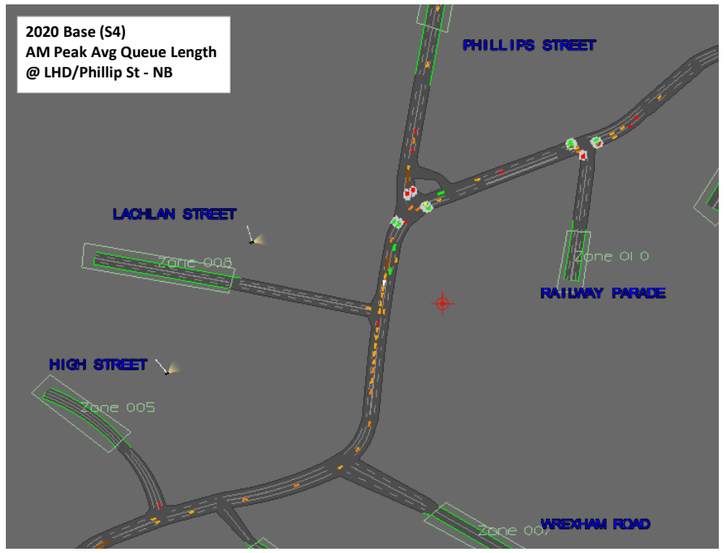
PM Peak 1530 - 1630

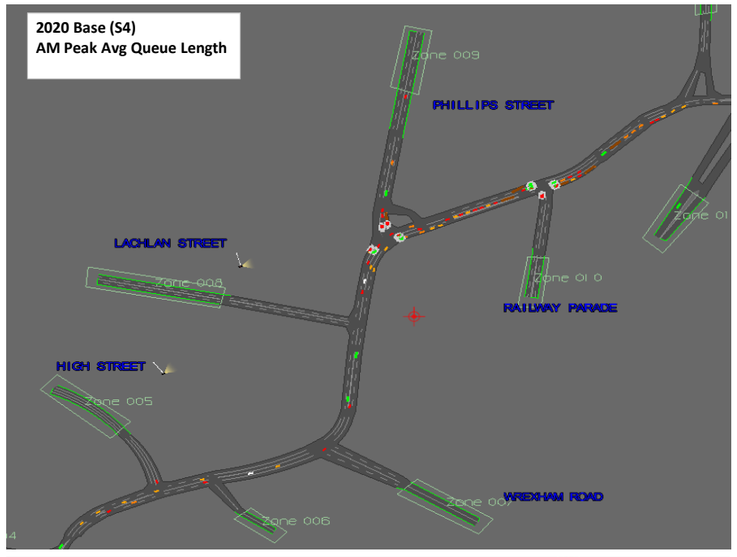
8888	S1	Calibrated Existing Model 2010
8888	S2	Base Model 2010
8888	S3	Base+Dev Model 2010
8888	S4	Base Model 2020
8888	S5a	Base+Dev Model 2020
8888	S5b	Base+Dev Model 2020 Option1
8888	S5c	Base+Dev Model 2020 Option2 (Extra Lane)

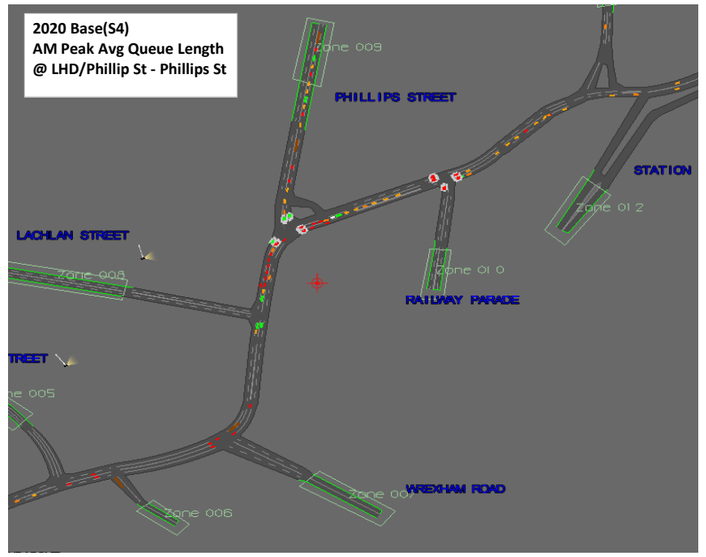
Appendix G

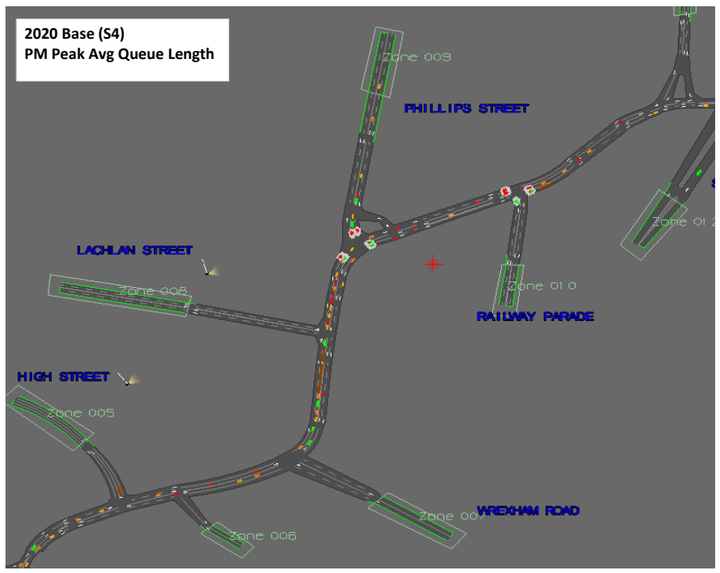
Queue Lengths Screenshots

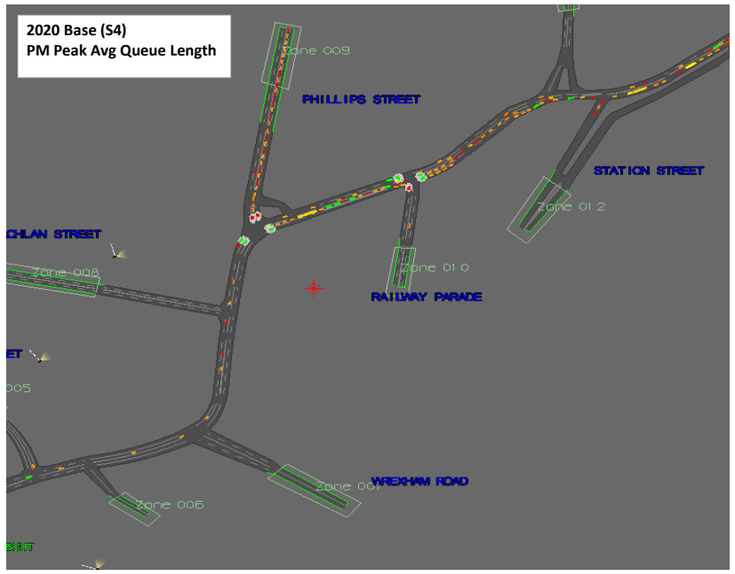
2020 Base Models Queue Lengths Screenshots

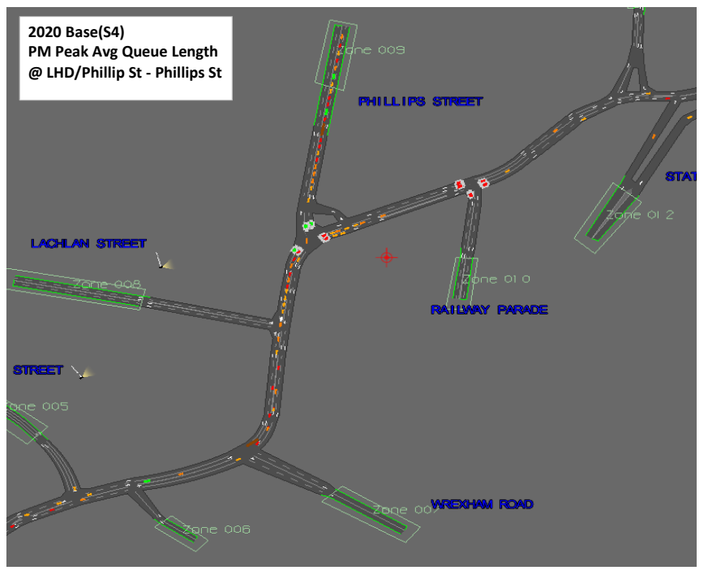




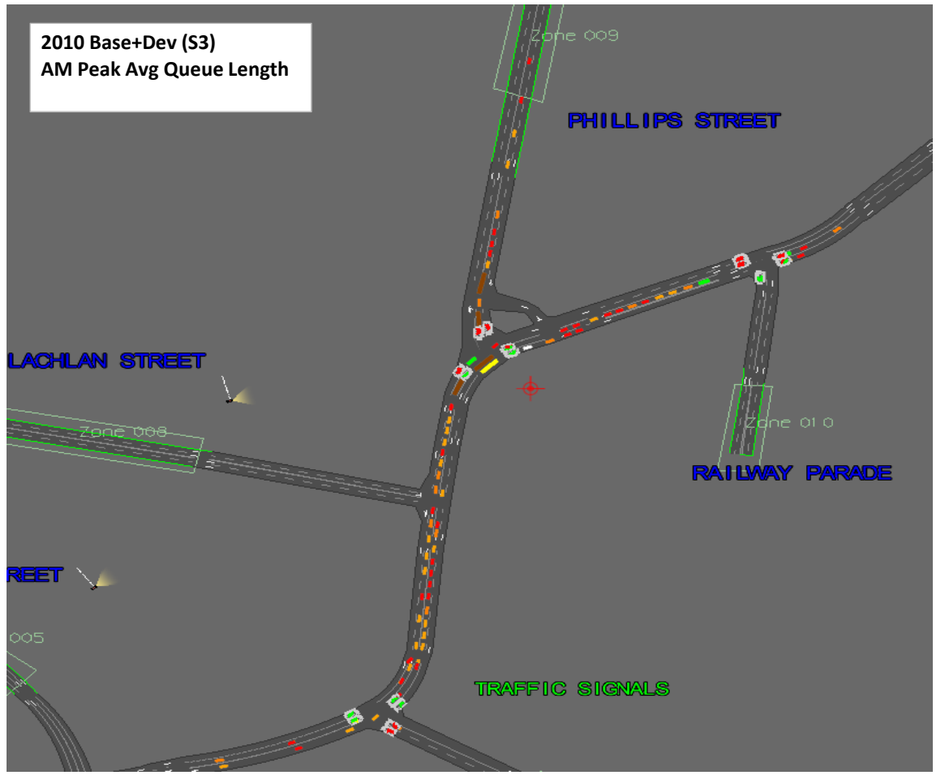


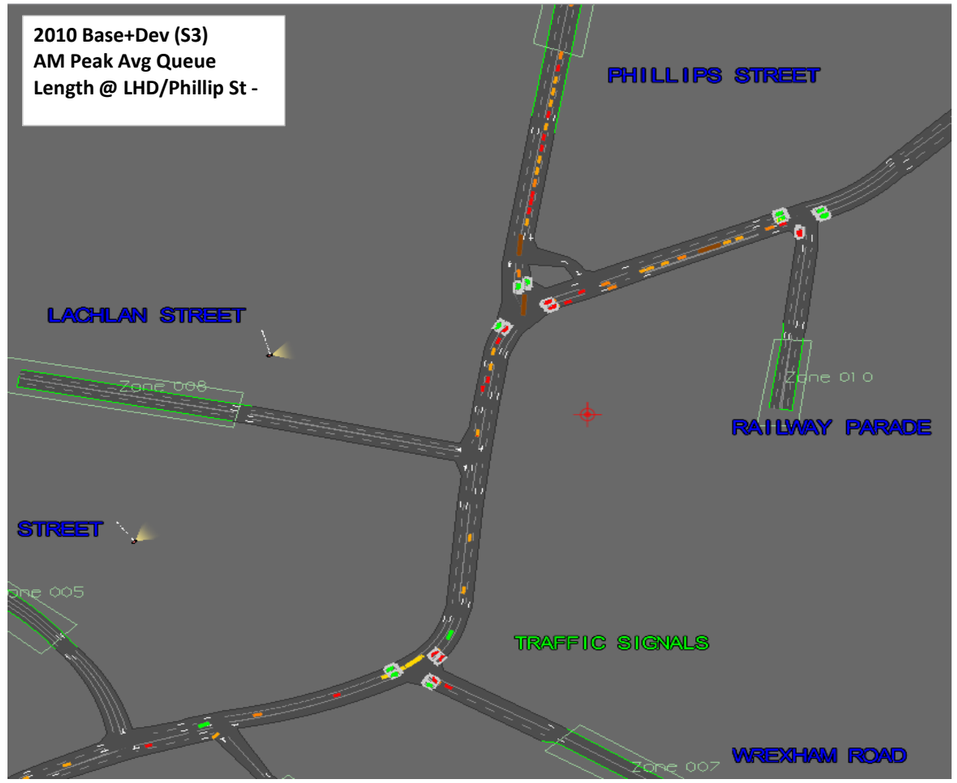


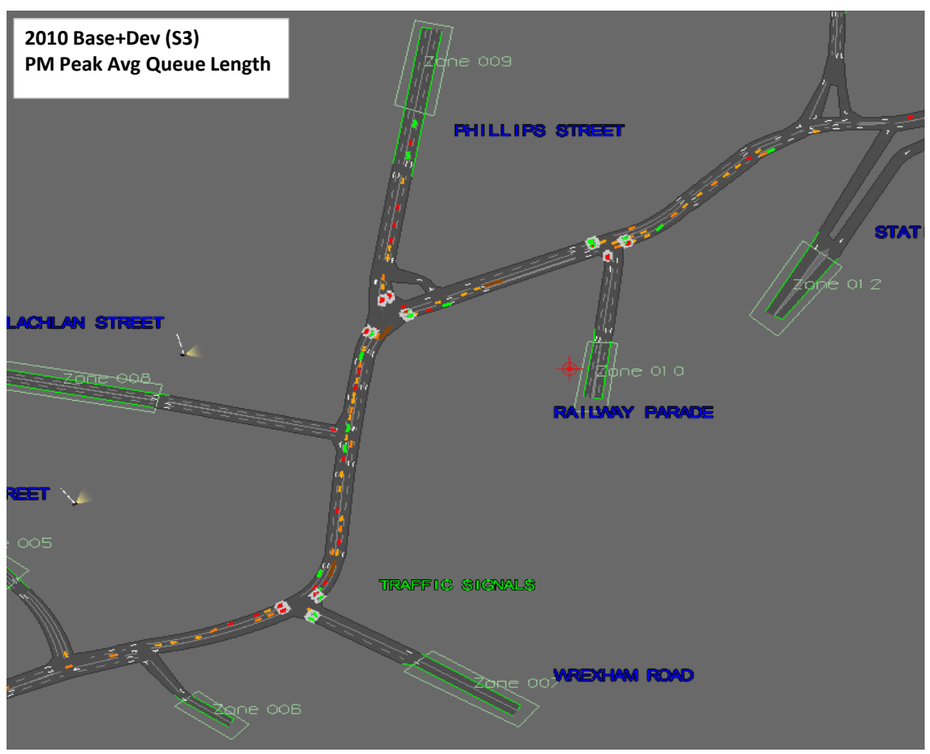


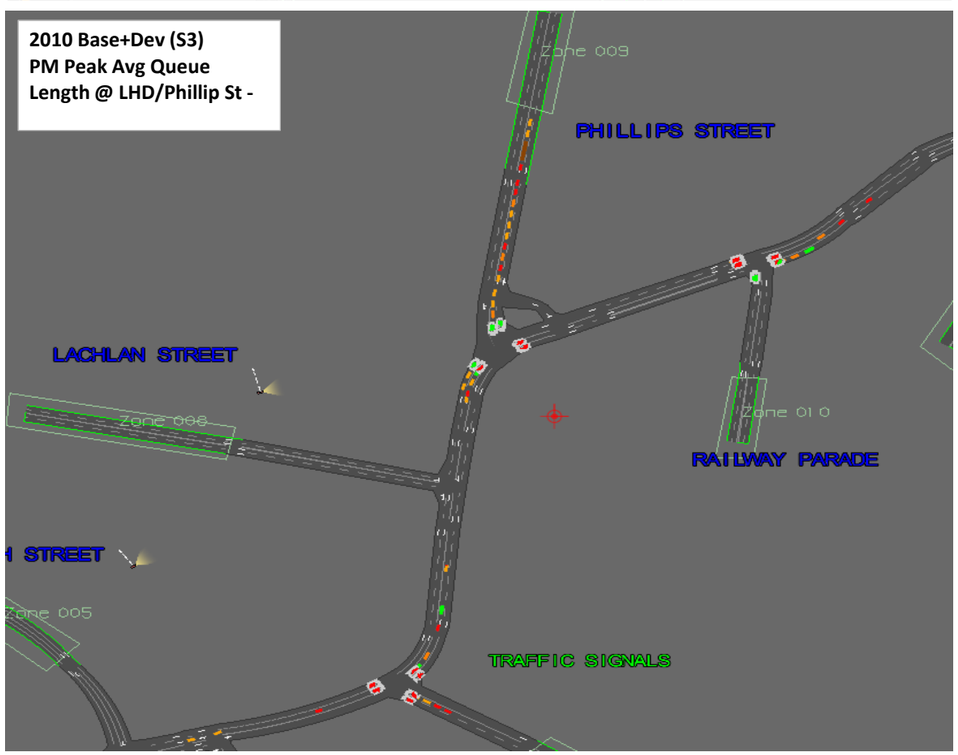


2010 Base+Dev Models Queue Lengths Screenshots

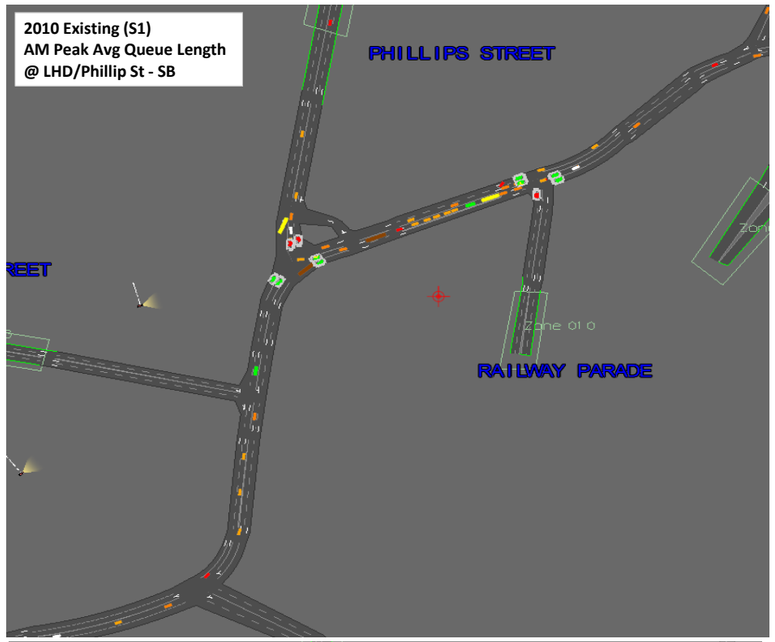


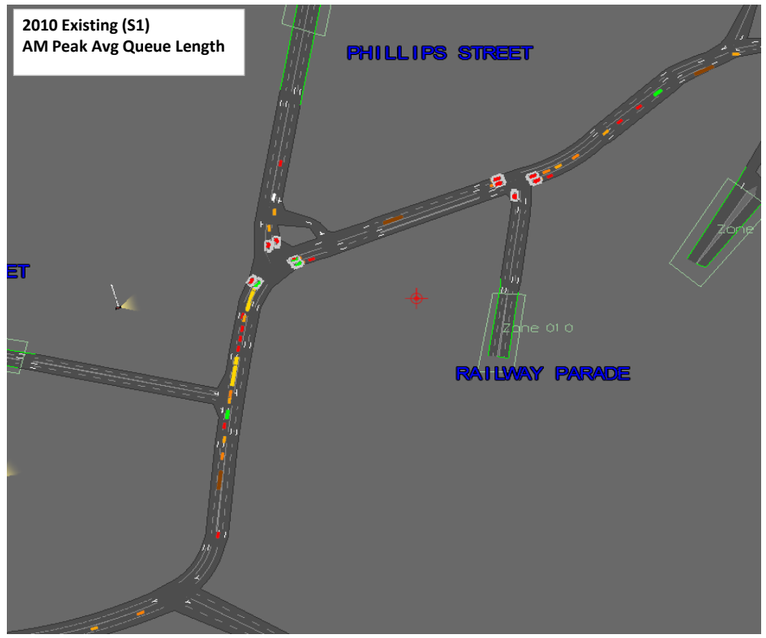


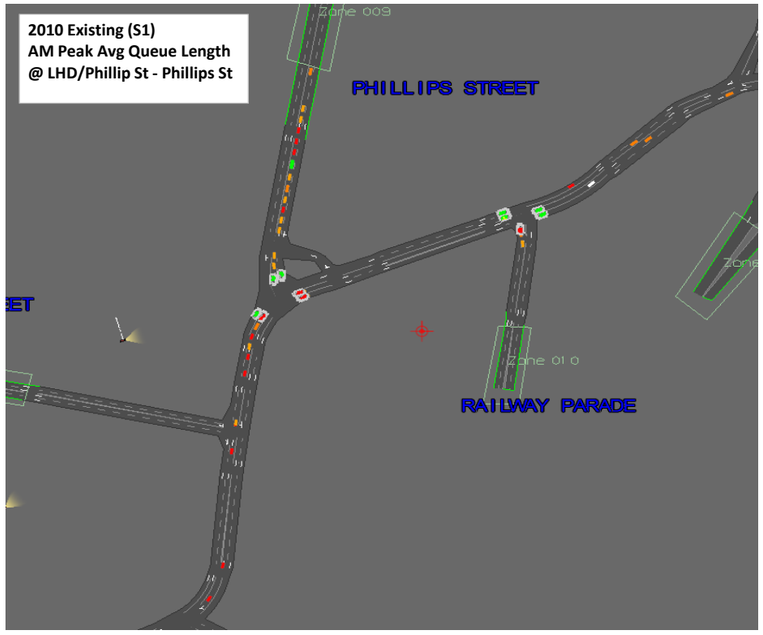


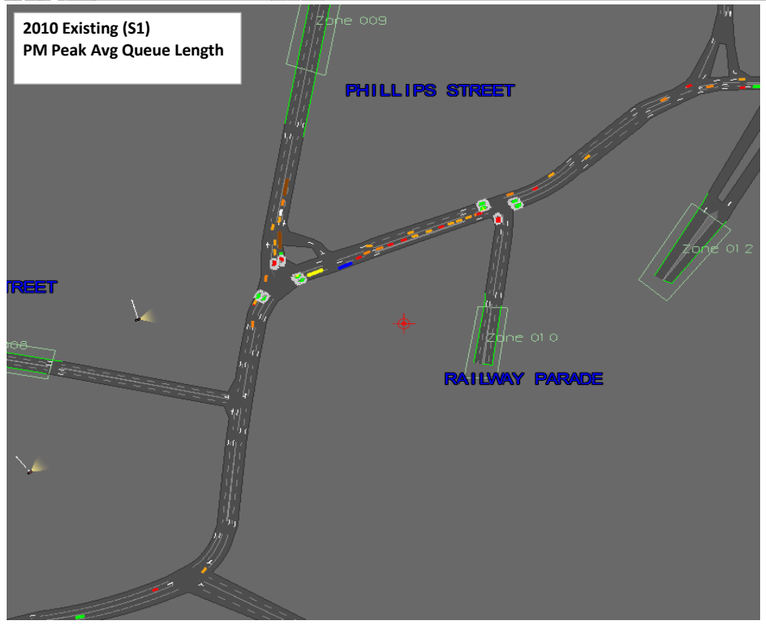


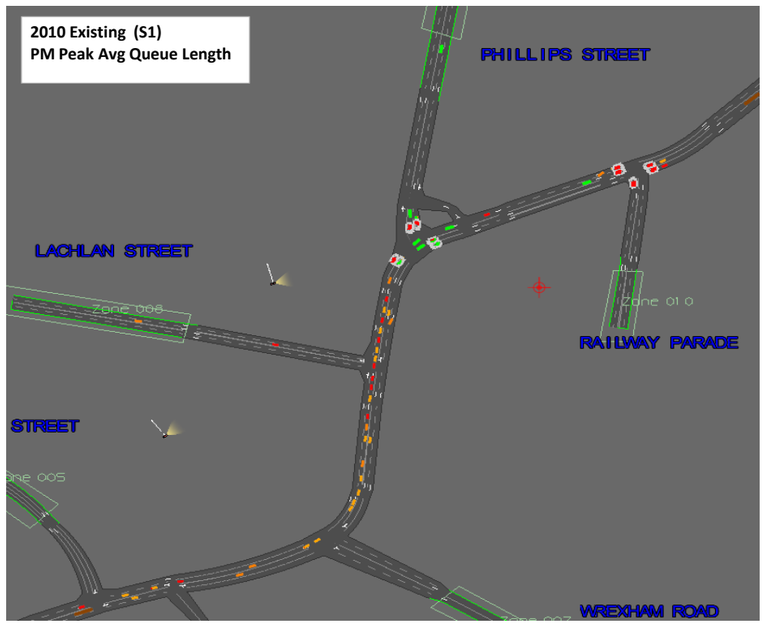
2010 Existing Models Queue Lengths Screenshots

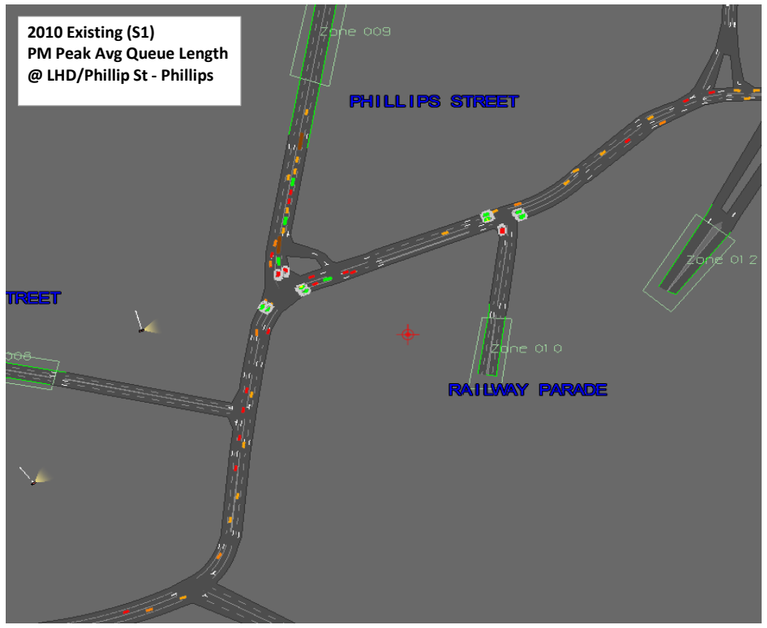












2020 Base+Dev Models Queue Lengths Screenshots