ANALYSIS OF THE ANU'S TRAFFIC NETWORK

ENGN 2226: 2016 PORTFOLIO

Australian National University

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EXECUTIVE SUMMARY

It is essential to have an integrated transport network that can allow community members to travel from their homes to their destinations and back again efficiently, enjoyably, safely and easily on a day to day basis. This report looks at using established practices combined with a focus on Research Methods and System Perspectives from the ENGN 2226 course to answer the research question developed in Appendix E: Crafting a Research Question.

What areas of the ANU are most likely to experience issues and what can be done to manage these issues safely and efficiently?

In Canberra, Roads ACT manages the network and utilise a Traffic Warrant System (TWS) to objectively assess locations and prioritise remedial treatments. The TWS takes into account traffic volume, speed, crash history, volume of heavy vehicles and land use (Veitch Lister Consulting, 2014).

As the Road Network in question is within the ANU Commonwealth lease boundary it is outside the jurisdiction of the Territory authority (Roads ACT), the University is responsible for the management and maintenance of the road network and associated infrastructure such as footpaths (ANU Sustainability Office, 2013).

Legislatively, driving and parking on campus is handled under:

- Australian Road Rules
- ACT Road Transport (Safety and Management) Regulations
- ANU Parking and Traffic Statute (No. 2) 2007 (ANU Sustainability Office, 2013)

For the purpose of this report traffic volumes and movements are considered the focus due to being unable to receive all the data in the timeframe necessary to follow the general guidelines of a local area traffic management program. Some qualitative observations are utilised to still incorporate some of the other factors that Roads ACT consider important but without this data these recommendations generally focus more on how this lack of information can be addressed and where the problem appears to be occurring.

The study area that was identified focuses on the ANU campus but does exclude some small intersections from the analysis where the side streets are considered minor. There was still a total of 25 intersections included in the final model. The analysis included the use of an Austroads endorsed tool Sidra Intersection 5.0. This tool was used to determine potential areas where issues may appear in the future.

ENGN 2226 tools were used at several stages of this project including:

- Establishing the validity and high leverage of this project.
- Planning the project and ensuring that completion was on time and professional. Allowing better utilisation of the peer reviews due to a relatively finished portfolio.
- Ensuring the project was targeted and had a solid outcome in the form of strong recommendations.
- Extending the model to car park sliding gates, safety aspects and exploring the social and cultural perspectives
- Evaluating the economics of the solution using the concept of lifecycle costs and the payback period

It was identified that there were several concerns with the ANU network that were found either quantitatively through the model or qualitatively through field observations. These are indicated below with a summary of the recommended action below each concern.

- **Underutilisation of the South side of the ANU Road Network due to uneven demand**
  There should be a plan to attempt to balance demand on the road network by building future developments on the south side of campus. This should be the topic of another large report and could be incorporated into the universities master plan. Care should be taken that is well integrated with the rest of campus as large distances for travel are not desirable.

- **Speeding on Daley Road**
  While on site several vehicles appeared to be exceeding the 40 km/h speed limit significantly. The ANU should have data on 85th percentile speeds located around campus and an analysis of this data would allow an educated recommendation to be made regarding traffic calming devices that could be effective at decreasing excessive and unsafe speeds.

- **Large Traffic presence in shared area on the West side of Union Court.**
  The shared zone at the bottom of Union court could become dangerous as the university continues to expand. Union court is about to be redeveloped and therefore it is the perfect time to make this road a local access road only by closing off the access to the car park in front of the new chemistry building. This would still allow delivery trucks to deliver to the cafes and other shops in union court but would lead to a decline in the number of vehicles and would make this shared zone safer. Further modelling can be done using a program called Commuter and this is a way to justify and inform this decision for future work.

- **Crash occurred at the Intersection of Daley Road and North Road on the 26/09/2016**
  One car crash was observed while recording data on the unusual Daley Road and North Road T – Intersection. One crash is not enough to indicate a problem but the ANU should be keeping a record of the crash history which would include Road User Movement (RUM) codes. These RUM codes indicate the type of crash that has occurred and therefore a repeating RUM code can indicate a structural flaw with the intersection. For example, it is common for a vehicle heading straight to be hit on the right side could indicate a poor sightline. This analysis would allow intersections to be assessed more closely for problems like sightlines etc.

- **Large Traffic Volumes on small access roads (Kingsley Street and Hutton Street) that cater as a primary access for pedestrians and cyclists.**
  Cars appear to be utilising Hutton Street and Kingsley Street to cut the corner across the ANU campus and access the large arterial road Barry Drive. This is a significant problem and is heavily explored in this report as this leads to large volumes passing through small streets not designed to handle them. Kingsley Street also acts as a major entrance for pedestrians and cyclists and therefore high traffic volumes leads to a high risk environment.

  This report explores two options to push traffic onto Marcus Clarke Street which is a major arterial street and through modelling indicates that the solution can both increase safety as well as efficiency due to a more efficient light phasing being possible. The option decided upon through an economic analysis is to implement 4 speed cushions and 2 raised pedestrian crossings to encourage vehicles to slow down or take the other route.

For future work it is recommended that:

- A more detailed analysis of the ANU bus network is undertaken.
- A temporal parking analysis is undertaken to predict periods of the day that the university experiences surges in traffic volumes.
- Incorporating traffic generated by future developments like the new halls of residences into the model.
- Use of a program like Commuter to model shared zones and comparison to industry standards for shared zones.
- Reduction in sampling errors by increasing the data collected.
- A crash analysis on the history of crashes to identify structural problems.
- Traffic speed analysis to identify high speed areas.
- Community consultation to determine potential issues and ensure community support.

Overall this project identifies several key aspects that should be focused on as well as identifying several potential issues. The major recommendation focuses on how the university can create a massive efficiency gain resulting in reductions in the cost of time, petrol and a reduction in the carbon dioxide produced on the road network while also increasing the safety of the ANU community.

TABLE 1: SUMMARY OF SYSTEMS TECHNIQUE'S USED

Technique Name	Section of Occurrence***	
Rule of Thumbs		
Fermi Estimation	1.2	Motivation for Analysis
Parkinson's Law	1.3	Aim
Hofstadter's Law	1.3	Aim
Occam's Razor	2.13	SIDRA Intersection
Jevon Paradox	1.1	The Importance of Traffic Engineering
Impact of a System	1.1	The Importance of Traffic Engineering
Research Methods		
Crafting a Research Question	1.3	Aim
Quantitative and Qualitative Methodologies	2.0	Modelling and Analysis
Error Types	2.2.3	Error Types
Research Ethics	2.1.1	Scope of Analysis
Data Organisation	2.1.1	Scope of Analysis
Descriptive Statistics	2.2.4	Other Aspects and Influences
Confidence Intervals	2.2.4	Other Aspects and Influences
Hypothesis Testing-populations	2.2.4	Other Aspects and Influences
System Perspectives		
Social and Cultural Perspectives	1.1	The Importance of Traffic Engineering
Safety and Risk Perspectives	1.3	Aim
Sankey Diagram	1.1	The Importance of Traffic Engineering
Planning Approaches	1.3	Aim
Queuing Perspectives	2.2.4	Other Aspects and Influences
Anthropometric Perspectives	1.3	Aim
Life Cycle Costing	2.3	Discussion and Recommendations
Payback Period	2.3	Discussion and Recommendations
Energy-Mass Balance	1.2	Motivation for Analysis

*** Many of these tools have been explored in detail in an appendix section with only the final insights stemming from each tool present in the body of the report.

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1.0 INTRODUCTION

1.1 The Importance of Traffic Engineering

Convenient and safe transport is critical to the functioning of society and it is often something we take for granted. Traffic systems or traffic networks are a vital aspect to providing the ability to travel to work, university and other locations and as such are utilised by everyone. Traffic engineering focuses on ensuring that the road network runs both efficiently and safely (Austroads, 2016b). As the number of users on our roads and as we move to autonomous vehicles the ability to model and understand traffic flows will become even more important.

The ACT Government created a 2031 plan called Transport for Canberra which outlines the governments goals for the ACT region (ACT Government, 2012). They state six primary principles which explain the importance of planning the future of transport.

1. It is safe for people to travel.
2. Makes Active Travel easier and therefore encourage a larger percentage of the population to walk and/or bike instead of driving.
3. Provides sustainable options that also reduce transport emissions.
4. Is accessible to everyone no matter their place or if they have a disability.
5. Is efficient and cost effective for the government, businesses and the general community.
6. Integrates with land use planning to help activate primary real estate locations.

FIGURE 1: TRANSPORT CANBERRA PRINCIPLES FOR DESIGN (ACT GOVERNMENT, 2012)

It is important to state that this project analyses a smaller subsection of what is considered transport due to time constraints. This report will focus on vehicles but it is also important to also analyse and consider other forms of transport like bikes and walking. Active travel is a goal of both the ACT government and the ANU and it will be shown that the percentage of the population that active travels to University is a higher percentage than is seen in most other urban environments.

The alternatives to the road network will be considered when making recommendations such as adding carparks and better roads. Making driving easier could lead to an increase in people travelling to university by car and this could make it unsafe, increase traffic emissions, harder to park (accessibility and efficiency) and decrease the number of university staff and students that utilise Active Travel. These are not outcomes that are desirable and therefore such a straight forward solution such as increasing the number of lanes and increasing the number of car parks is likely to have serious flaws when considering Jevon's Paradox. A more detailed discussion of this effect and how it can lead to larger environmental impacts can be found in Appendix D: Jevon's Paradox and The Impact of the System.

There are other negative aspects such as an increase in the concrete footprint of the ANU, reduction in the available land for research buildings, student accommodation, green space and other facilities that provide vast benefits to the ANU community and might be a better and more efficient use of land then a larger transport network.

In particular, the ANU have a sustainable transport management plan that indicate how the university population commutes to university. This has been adapted into a Sankey Diagram so as to conceptualize and view the flows of commuters into the ANU in Figure 2: Sankey Diagram of Traffic Flows. The data for the flows comes from the ANU report that is cited in the caption of the picture.

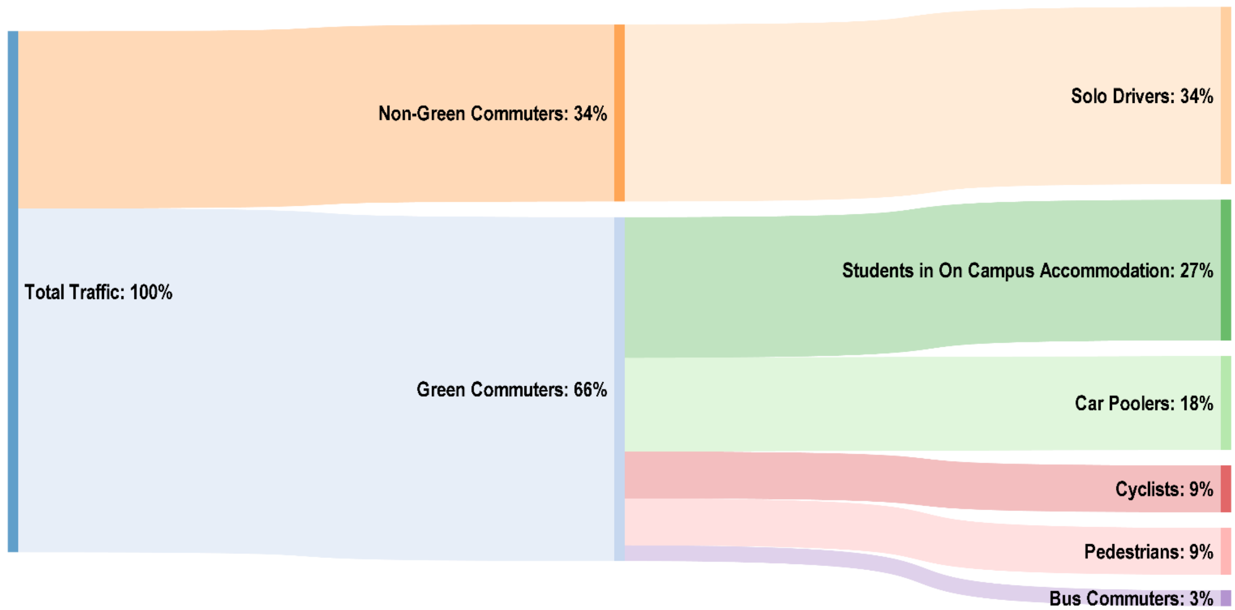

FIGURE 2: SANKEY DIAGRAM OF TRAFFIC FLOWS (ANU GREEN, 2009)

The ANU data shows that the number of people utilising car transport is significantly less than the US average of about 85.8% (McKenzie, 2015) and the ABC data of about 71% (ABC News, 2014). This could be due to a lack of parking or it can be because at university the culture is quite different than the general population. Many sources indicate that younger people are less likely to own cars and this appears to be reflected in the Sankey diagram by the reduced driving numbers and increases in the alternative methods of transport (Mullins et al., 1995, Kerr et al., 2010).

Many university students also move out together and live in a share house and therefore carpooling to university might be more common than what is usually expected in the broader society.

The ANU has stated two goals for transport in the future:

I. Creating a pedestrian and bicycle orientated campus (Campus Master Plan 2030) (Australian National University, 2012)

II. Reducing the number of people commuting to the ANU as sole occupants of a vehicle to 20%. (Environmental Management Plan 2009-2015) (ANU Green, 2009)

It is important to consider social and cultural perspectives especially when it comes to the ANU where there is a variety of different cultures from across the world who are used to a different way and this will also influence which method they feel comfortable commuting by. The ANU is attempting to force a cultural shift in the direction of the Active Travel. According to the sustainability report they are hoping to encourage 14% of solo drivers to become a Green Commuter (ANU Green, 2009). This would lead to a total of 80% green commuters. This is a big ask but will be helped greatly by the addition of two confirmed new on campus residential colleges which is why it is also necessary to be careful of the percentages in the Sankey diagram.

Austroads is the primary organisation in charge of $200 billion worth of roads representing the largest community asset in Australia and New Zealand (Austroads, 2016a). As the organisation is in charge of many of the transport and traffic agencies in Australia they are considered the primary source for industry practices and standards and therefore are heavily leveraged in this report. Some states have their own standards that supersede certain sections of the Austroads' guidelines but the ACT is not one of these states (Austroads, 2016a).

1.2 Motivation for Analysis

This report will focus on an analysis of the ANU traffic network in order to determine potential issues that could arise in the near future and also to suggest potential fixes to these issues. A map of the study is shown in Figure 3: Study Area (Austroads, 2016b).

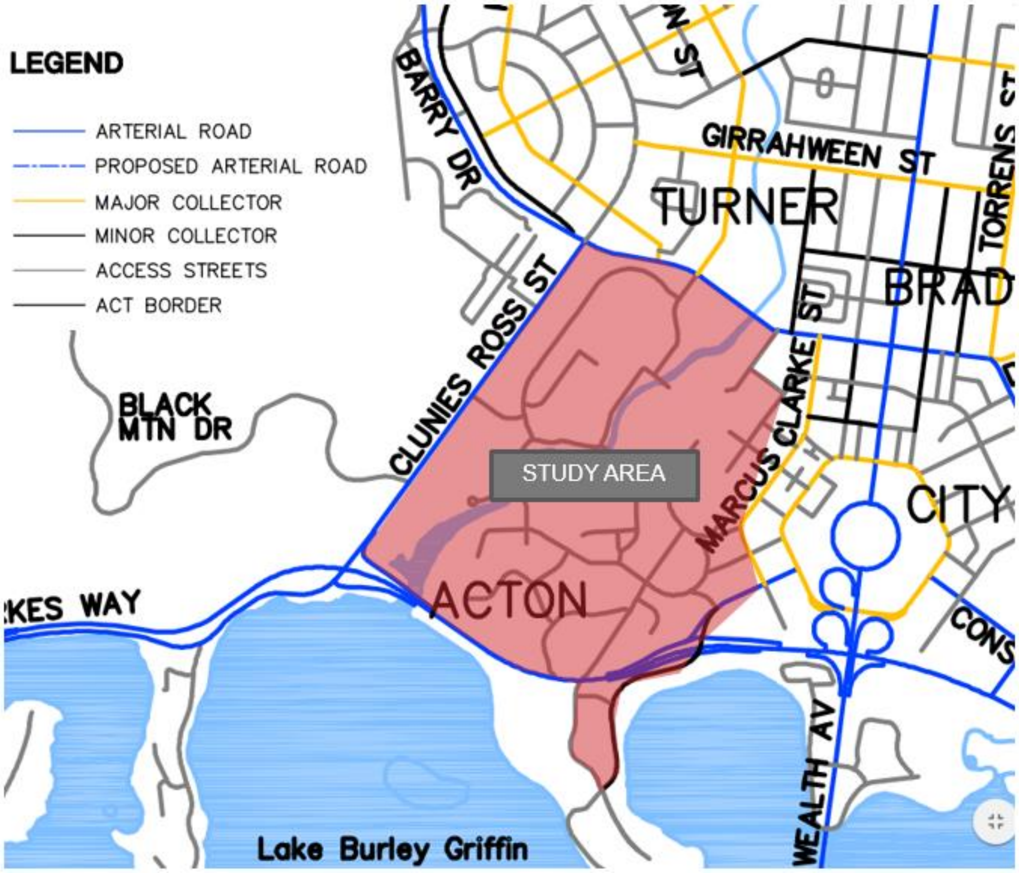

FIGURE 3: STUDY AREA (AUSTROADS, 2016B)

It is expected that demand for the ANU traffic system will increase in the future especially as there are 3 confirmed developments of residential colleges in the near future. These residential colleges have approximately 1300 beds and only one 300-person residence is being demolished which is a dramatic increase in on-campus population (Macdonald, 2016).

To confirm the high leverage that this analysis exhibits a fermi estimation calculated in Appendix A: Fermi Estimation was used. This estimation is rough but indicates that there are almost 10,000 cars on the ANU network between 7am to 7pm on an average day.

The other rule of thumb used at this stage of the project was the use of Parkinson's Law which describes the phenomena of a project scope's increasing to meet the time available before the deadline. This is very similar to scope creep which can result in a cost overrun and an overall messy project. It is very hard to manage this increase in scope in particular as it usually goes hand in hand with managing client's expectations. It is very easy to keep doing small requests to keep clients satisfied but this begins to add up. A plan was established regarding where data will be coming from as well as what the project hoped to achieve. Additions to this plan will be considered carefully as sometimes an increasing scope is necessary and useful to the success of the project. The plan developed in order to be able to carefully manage both time and scope creep is located in Appendix B: Parkinson's, Hofstadter's Law and Project Planning. This plan also indicated that collecting data was on the critical path and would have the potential to hold up the project. This retrospectively proved to be correct.

It is possible to analyse the leverage by adopting an energy mass balance approach. This energy mass approach focuses on where energy in the system is being utilised and lost (National Framework for Energy Efficiency, 2010). The figure below analyses the inputs and outputs of energy associated with the process of driving.

In Figure 4: Energy Mass Balance for Driving Operation (National Framework for Energy Efficiency, 2010) increasing the efficiency of the driving network can have an effect on the:

- Energy Lost due to idling (Energy, 2015)
- Energy Lost due to decelerating
- Energy Lost due to braking
- Energy Lost due to ancillaries

The application of these two rules of thumbs and the formulation of a project plan indicated that this project was feasible for the goal fitting the time constraints, usefulness and relevance to the ENGN 2226 Systems Analysis course and tools. The energy mass balance indicates where quantifiable savings can be found for use in a life cycle analysis and payback period analysis later in this report.

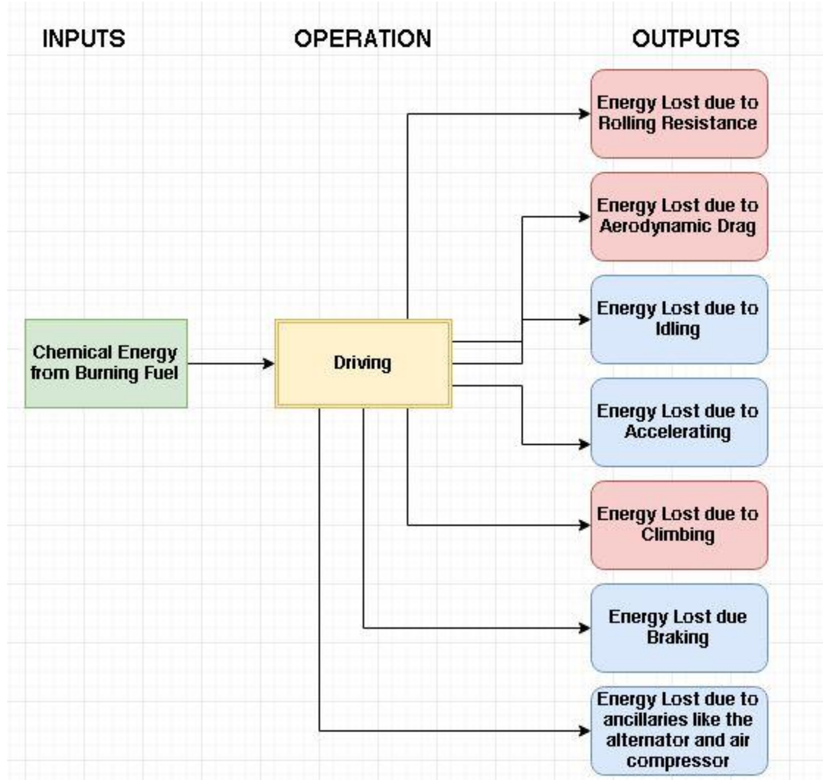

FIGURE 4: ENERGY MASS BALANCE FOR DRIVING OPERATION (NATIONAL FRAMEWORK FOR ENERGY EFFICIENCY, 2010)

1.3 Aim

To decide on an aim for this report it was important to establish a targeted and well defined research question and this is completed in Appendix E: Crafting a Research Question and the final question is shown below.

What areas of the ANU are most likely to experience issues and what can be done to manage these issues safely and efficiently?

This analysis will first identify current behavior on the ANU traffic system before using this data to predict driver behavior and areas that could experience issues in the future and could be experiencing issues currently. Recommendation will then be made and these could include the addition of additional roads, lights, roundabouts, stop and give way signs and other traffic devices.

It is important to note that there are two focuses for this analysis and they often are negatively correlated with each other. The two aspects are safety and efficiency. The goal might be to increase speeds in order to decrease time spent driving but this may result in more crashes or a rise in the severity of crashes and the trade off is hard to manage and quantify. Safety is hard to analyse in this report as it was not possible to get crash data in order to analyse structural problems that may cause crashes on the ANU campus. Analysis will instead focus more quantitaively on efficiency but will take a qualitive evidence based approach to incorporate possible safety issues into the analysis.

When road design is being considered it is important to consider what speed the road will be designed for and if the design speed will be the same as the posted speed limit. The design speed is used to determine minimum values for design aspects such as horizontal curve radius and sight distance.

This concept of a design speed was first considered in 1936 and the exact definition has been redefined over the past 80 years (Transportation, 2009a). The choice of the design speed is an excellent example of where an anthropometric perspectives approach can provide some insight. Drivers drive at different speeds and with different levels of proficiency. There are several tradeoffs to be considered and the use of anthropometric perspectives allows road designers to better understand the tradeoffs.

A road that can handle a higher design speed is generally costlier but this higher speed can also lead to increased mobility and this may result in an increase in the number of crashes. Currently the regulation states that the design speed should be 10km/h above the posted speed limit (Transportation, 2009b). To simplify analysis, the speed limit on all campus roads will be 40km/h and major arterials will have a speed limit of 60km/h. The actual driver speeds will be represented by a normal distribution with 95% of drivers travelling less than the design speed of the road which is 10km/h above the speed limit. This assumption could only be removed by also measuring speeds of the cars themselves.

A focus on taffic calming devices is utilised in this study as the ANU is a high pedestrian area and the local roads do not focus on efficiency. Only one road in the study area is considered as having a large focus on efficiency and that is Barry Drive that serves as an arterial pathway to Belconnen and services large traffic volumes. Traffic calming devices and reliance on physical barriers or pschological cues to slow local traffic is the method that the ANU currently uses to control traffic on campus and recommendations will focus on keeping the feel and design consistent. A breakdown of common examples of traffic calming devices can be found in Appendix P: Road Treatments.

These are alternatives that can act on a road system without increasing the demand that is placed on the system. These additions are more likely to stop cars from travelling across the campus unnecessarily by reducing the speed at which cars can travel through and therefor will increase the safety on campus.

As discussed earlier there is a focus on safety for a local area traffic management project and therefore a focus on indicating the types of problems and ways that they can be mitigated and controlled through a risk analysis is conducted in Appendix H: Safety & Risk Perspectives. The analysis focuses on the Fatal Five factors that lead to dangerous crashes and finds that three of them apply directly to this project. The analysis then focuses on using the hierarchy of risk to find ways to eliminate or mitigate the exposure to risk. This then informs elements like the field observations. For example, dangerous driving (speeding, etc) is indicated as a factor and therefore field observations include observations that people appear to be travelling well above the posted speed limit in certain areas and it is then possible to mitigate this through engineering controls in the form of traffic calming devices.

An element that has not been considered is the resilance of the road network (Berdica and Mattsson, 2007). This refers to how well the road network can handle nearby changes and/or accidents that occur. A great example of this is the the Barton Highway where crashes this year resulted in the Northbound lane being temporarily closed forcing heavy vehicles onto to small side streets ,not designed for them, as a detour (Mishra, 2016).

2.0 MODELLING AND ANALYSIS

2.1 Methodology

2.1.1 SCOPE OF ANALYSIS

The scope for this analysis was 25 major intersections within the ANU and a qualitative analysis of other potential issues that could be seen on the ANU campus while on site. Intersections that were not considered major were not modelled and they were generally connected to a non-through road which had no obvious reason such as a carpark to be generating traffic. The cars were indicated as a simple tally and no information was taken to identify the occupants of the car or other elements like number plates. This means that the data cannot be tied back to identify an individual's movements as this would be a breach of ethics as it would remove the individual's right to privacy regarding their movements. Appendix G: Research Ethics focuses on ensuring that the data is anonymous and also that the ANU code of research conduct is satisfied.

It is also recommended that a survey be undertaken as future work in order to answer several questions and ensure that the community is involved in a consultation process that ensures that issues are identified on the road network that they use every day. This survey will also have to carefully adhere with the ANU Code of Research Conduct which is covered in Appendix G: Research Ethics. It is important to note that the code of ethics regarding to collaboration have been adhered to. Betty Xiong has been acknowledged in 5.0 Acknowledgements for helping to collect the traffic count data used in this report. It was possible to complete counts at a much faster rate due to this help but this help is not enough to demonstrate authorship and therefore she has been acknowledged.

An excel spreadsheet was created to organise the data and steps were taken to keep the raw data (pen and paper on site) and the data was entered into the excel workbook that was arranged as mentioned in Appendix F: Data Organisation. Organising the data and keeping the hard copies ensures that the paper trail is there and this indicates that correct research methods were followed and that the data was not fabricated and this is another goal of research ethics.

The data that was collected and recorded in this method was of a quantitative method but it was also important to note down any other observations in order to incorporate elements like bad sightlines, confusing intersections, speeding and other observations that could explain potential issues. These observations are analysed qualitatively and recommendations generally involve finding ways to quantify or back up these field observations.

There were two other types of analysis originally planned for this report and this was a crash analysis and an 85th percentile speed analysis. The crash analysis could identify 'hot spots' on campus as well as the type of crash that occurred. This would allow the identification of intersections that had structural problems and the 85th percentile speed could indicate where speeding is present. These were not incorporated in the analysis as the data collection was a path on the critical path of this project and therefore it was necessary to stop collecting data from the ANU in order to finish this project on time. The project planning for this report relies on Parkinson's law, Hofstadter's law and S04: Project Planning. The plan for this project is developed and presented in Appendix B: Parkinson's, Hofstadter's Law and Project Planning.

Figure 5: Map of the Study Area indicates the intersections where 10-minute traffic counts were undertaken at. While there are other intersections they are considered to be more minor and therefore not necessary to include in the analysis. These counts are the basis of the SIDRA model developed in this report and therefore were incredibly important to the analysis.

FIGURE 5: MAP OF THE STUDY AREA

2.1.2 DATA INPUTS

Traffic counts were conducted for a total of 10 minutes at each of these intersections shown in Figure 5: Map of the Study Area and these count values were then extrapolated to give hourly values that were utilised in the model. It is generally known that the AM peak (8:00-9:30) is the busiest time of road for most traffic networks as the PM peak is generally split into work and school leavers separately (Peter Damen, 2014, Sellick Consultants PTY LTD, 2015). In the case of the ANU it is likely that traffic is a little more sporadic and less affected by the end of the school day. Therefore, counts were conducted between 8:00 am to 9:30 am or 5:00 pm to 6:30 pm to begin with. It was quickly discovered that the AM peak was busier at the initial 5 intersections analysed and due to time constraints only an AM model was developed. A PM model should be developed in the future as the direction of travel for traffic is different.

Some traffic was gathered from a traffic impact assessment that the university had completed for their student accommodation 5 (Sellick Consultants PTY LTD, 2015). A traffic impact assessment is required by the ACT government whenever a large project has an expected effect on the surrounding traffic network and aims to stop large projects from generating large volumes of traffic onto roads that are unable to cope with the loading.

From these reports data was found that illustrated the flow of cars in the Burgmann car park and this combined with a traffic count at the nearby intersection was utilised to form a base line analysis for car parks. Counts were completed regarding the number of spaces each car park on campus contains. These counts were not done at peak hour but were instead focused on finding the total volume of the car park and then the data from the Burgmann car park was used as a baseline. More data was collected from the Burgmann car park for use in a queuing analysis by timing the service times of cars leaving the Burgmann car park and then using descriptive statistics. This is discussed later in this report.

2.13 SIDRA INTERSECTION

The SIDRA intersection software is used by the industry to model, design and evaluate intersections. It can be used for all types of intersections. The version used for this report was a 1-month free trial of SIDRA 5. The big difference between this version of SIDRA and later versions of SIDRA is the lack of network analysis (SIDRA Intersection 7, 2016). Network analysis allows backlog at one intersection to affect traffic at the another intersection if sufficiently close together.

SIDRA is able to use the regulations of the particular country and state that the analysis is completed in and the program has been endorsed by Austroads and the Association of Australian State, Territory and Federal Road and Transport Authorities. In particular Appendix Q: New South Wales Guidelines for Sidra Analysis contains defaults that are expected to be used unless proven otherwise in the state of NSW. The demographic might be more risk taking and therefore accept smaller gaps which effects the model. The SIDRA model once created is able to determine level of services across each intersection and these are defined in the Austroads Level of Service (LOS) definitions.

Level of service		Threshold ratio of volume to capacity		
		Motorway	Arterial	Local
A	Drivers may travel at desired speed, and manoeuvre freely, experiencing no delay due to other traffic	0.50	0.40	0.35
B	Drivers will incur occasional minor delays and restrictions to manoeuvre due to other traffic	0.65	0.60	0.50
C	Drivers will experience interrupted travel, with minor delays and stops, but with network operating efficiently providing predictable travel times	0.85	0.75	0.65
D	Drivers will experience occasional major delays, with variable travel times due to conflicting traffic and volumes approaching capacity	1.00	0.90	0.80
E	Drivers will experience frequent major delays, with volumes at or exceeding capacity for short periods, unpredictable travel times	1.15	1.05	0.95
F	Drivers will experience severe congestion and delays, with volumes exceeding capacity for long periods, strong influence on route choice			

FIGURE 6: AUSTROADS LEVEL OF SERVICE (LOS) DEFINITIONS (ROADS & MARITIME, 2015)

The minimum level of service required for a development to be approved is LOS C.

2.14 ASSUMPTIONS OF ANALYSIS

The first assumption is that cyclists have been ignored in the modelling as they add a high degree of complexity when analyzing their reaction with vehicles sharing the same road. There are also many paths around the ANU and therefore cyclists may not need to mingle with the cars in most places. A more detailed analysis can be seen in the following ANU report which focuses on cyclists and pedestrians. Cyclists will be considered in recommendations however as traffic calming mechanisms such as road narrowing can lead to increased conflict between road users if not considered carefully.

Pedestrians have a standard percentage based off traffic flows as a default in SIDRA. SIDRA works out an optimal phasing sequence for the lights and uses this to determine when the lights change and pedestrians cross. There are a large number of students travelling the campus on foot and a more sophisticated program like Commuter would be needed to model areas such as the shared area to the North-West of Union court. These areas will be considered however when mentioning potential issues and possible improvements to the network but the analysis will be qualitative.

There are also many underlying assumptions included in a SIDRA model that relate to items such as how long something takes to move, that everyone is travelling at the speed limit and what gap a driver finds acceptable. For these the NSW standards are followed which are indicated in Figure 46: Guidelines for SIDRA Analysis (Roads & Maritime, 2015).

A lot of this is customizable as it can be argued that city drivers will accept a smaller gap then rural drivers. For the case of this analysis these variables were left constant as they are preset to what are considered average values. They government does allow custom values but a case must be given which can used with items like retirement homes where the gap acceptance might need to be larger than the average (Austroads, 2016b).

2.2 Outcomes

2.2.1 FIELD OBSERVATIONS

While counting cars it was important to keep an eye on possible problems or factors that were inherent to the study site. This could include items such as poor sight lines, congestion and illegal parking or other activities.

In particular, locations that were marked with interest during the study and the reasoning are recorded in Table 2: Field Observations.

TABLE 2: FIELD OBSERVATIONS

Location	Reasoning	Addressed in Recommendations
Daley Road	A large number of cars were noticed to be travelling at speeds well above the posted speed limit.	Yes
Union Court/ North Street	There is a shared zone at the intersection of University Avenue and North Road. There was a large number and pedestrians utilising this area and while shared zones are not considered in this study it should be considered as possible further work to ensure the safety of the community.	Yes
Kingsley Street	Local Access Street but appears to have high levels of traffic moving from Hutton to Kingsley and during the time of the count being taken the entire length of Hutton was inundated with Traffic.	Yes
South End of Campus (Past Law School)	It was noticed that there was a dramatic difference in the number of pedestrians and the number of vehicles at intersections.	Yes
Daley Road /North Road Intersection	It was observed while on site on the 26/09/2016 there was a car crash at this intersection. One car crash does not indicate a pattern but in the absence of crash history data this intersection will be noted.	No

2.2.2 RESULTS

A detailed results section can be found in Appendix L: SIDRA Analysis of Existing Network which conatians the output of the SIDRA model for the existing network. The model identified two intersections of interest both signalized and located on Barry Drive. Overall the existing ANU Road Network had minimal problems when modelled.

2.2.3 ERROR TYPES

In order to understand the errors that could be involved in this analysis it is important to understand the sources and limitations of the data that is used as an input for this project.

Data Inputs:

- **Traffic Counts**
- **Data from the ANU for some intersections**
- **Data from the ANU for the Burgmann Car Park.**

TABLE 3: TYPES OF ERRORS IN THE DATA

Sampling Error	Non-Sampling Error				
	Coverage Error	Non-Response Error	Response Error	Interviewer Error	Processing Error
Counts were taken for 10 minutes during 5:00 pm to 6:30 pm and 8:00 am to 9:30 am. This creates a sampling error as the traffic recorded over this time is not necessarily an accurate representation of the ANU population.	The car park analysis was only performed on the Burgmann car park and this will result in some coverage error.			This error is likely to occur as counts on busy streets can be hard to complete accurately. This can lead to small errors in volumes recorded due to cars being missed.	The data was then entered into excel and it is possible that the entering of this data created errors due to Human Errors. All paper copies were scanned and filed away in the same folder for record keeping purposes.

Methods that could be used in the future to reduce these errors are:

- **Collect Sydney Coordinated Traffic Data (SCATS):** This is a system that is being used to allow traffic lights to detect queues and change their phasing to optimise efficiency and safety during busy periods by measuring the number of cars that pass through each lane via the change in inductance. It is possible to pay a processing fee and get data for the number of cars that have passed through an intersection in a period of time. This would only be applicable to signalized intersections which as can be seen in Appendix N: Location of Signalised intersections are only found on the edges of the university.

- **Collect traffic counts from all car parks**: Rather than extrapolating from the known data a more time intensive but accurate approach would be to collect data at all car parks. This would reduce the error due to coverage error.

- **Utilise automated counting mechanisms**: Automated systems can be utilised to perform the counts by setting up a camera at each intersection. This would allow counting at the same time and to ensure that no cars are missed. This would reduce Interviewer Error and sampling error.

- **Reduce Data Input Error:** Having multiple different people input the data and then combine their data sets could reduce the processing error further. Currently not all counts were performed by the same person and this is reflected in the section 5.0 Acknowledgments. This is a time intensive and resource intensive way to decrease the error and it might be possible to use the automated counting mechanisms and a data output from them to both avoid error and decrease the time and resources that the project requires.

2.2.4 OTHER ASPECTS AND INFLUENCES

While the SIDRA analysis is an incredibly helpful analytical tool there are limitations and aspects of the problem that need to be considered outside the model. In particular SIDRA does not handle queuing at boom gates and other parking control systems. Public transport is another aspect that should be focused on.

Car Parking:

It was noticed that for the Sellick's Traffic Impact and Parking Report the ANU has provided data that appears to be inconsistent (Sellick Consultants PTY LTD, 2015). A signed letter from the ANU located in Appendix O: Carpark Analysis of this report indicates that 257 car spaces were sold out of their 482 Dickson Precinct (Burgmann) Parking Station. However, their utilization of this car park appears to be stable at approximately 80 long term parked cars and the number of cars never gets close to the 257 that were supposedly sold out. This could indicate a significant misread in the data that should be corrected for further analysis to ensure the validity of this research.

A survey was conducted of the Burgmann carpark and 30 cars were counted recording the time it took the gate mechanism to service each of these cars. The start and final counting times were noted and this allows a total time to be calculated. It is possible to utilise descriptive statistics to develop an average utilisation rate and the cars were assumed to be arriving linearly across the time the study was undertaken. Using some basic statistics, it was also possible to determine the maximum number of cars that can arrive and leave in an hour and with the addition of the second access this easily complies with Austroad's standards for car parks (Austroads, 2016b).

The ANU needs to ensure that cars pulling off the road to access car parks are not queuing across the street as this can lead to serious safety and efficiency problems if the cars block the road. The way this can be done is via a hypothesis test (this study utilised a 5% significance level) on the data by establishing the chance that there will be a particular number of cars in the queue. In this case the null hypothesis is that there will be 2 cars queued at any time. It is found that the chance of this is approximately 3.2% and therefore the null hypothesis can be rejected and we know that it is unlikely that 2 cars will be queued at any one time. Repeating another hypothesis test it can be seen that the probability of one car queuing is 16.0% and therefore the ANU should provide at least 1 car space of queuing area for these car parks. It is important to note that the cars do not arrive linearly but instead had a peak period and then dwindled. Further studies are likely to find that the cars leaving the car parks are normally distributed as the central limit theorem will begin to apply.

SIDRA relies on the principle of queuing theory but on a much more detailed level due to the complexity of the intersections that form part of the road network. SIDRA however does not support the analysis of gates and other queuing mechanisms which is why this analysis was conducted and is useful to this analysis.

This analysis should be furthered by looking at the confidence intervals calculated in Appendix O: Carpark Analysis in order to determine a range that the result may reside in as taking the average could lead to some error in this analysis and it might be better to provide for the highest service time found due to the addition of one car space not comprising of a relatively high cost compared to many other alternative recommendations. No analysis has been conducted regarding potentially faster methods of granting access to car parks like number plate recognition.

Public Transport:

It has been mentioned multiple times that due to the social demographic of the university public transport is more heavily utilised in the university community then in the general community. In Appendix J: Public Transport Routes it can be seen that during the week 29 bus services run through some part of the ANU and as these buses often run multiple times per hour during peak time this is a very high level of service provided by ACTION. This supports the claim made earlier regarding the differing demographic. Further analysis can focus on where these buses are stopping as in many locations they are forced to block traffic when stopping.

2.3 Discussion and Recommendations

In this study possible concerns were identified through field observations and traffic modelling via the SIDRA intersection program. 5 concerns were identified and four of these are discussed in Table 4: Recommended

Remediation to concerns. The fifth was the North Road and Daley Road intersection as there was an observed car crash at that intersection. It is an unusually structured intersection and is expected to be a major vehicular access to the ANU campus. As crash data was unable to be retrieved from the ANU within the timeframe of this project it is hard to identify any structural problems with this intersection and the modelling indicates that while busy it is handling well under the traffic volumes.

TABLE 4: RECOMMENDED REMEDIATION TO CONCERNS

Location	Concern	Recommended Remediation	Expected Outcome/Future Work
South End of Campus	Low traffic numbers and underutilisation of roads.	Currently union court is the epicenter of campus but careful planning to ensure that ANU's land is used efficiently. More buildings could be located on that side of campus without creating problems with the road network. This is a large task to compete comprehensibly and can easily be another report in itself but it might be possible to utilise on campus buses to enable students to leave their cars on the outside of the campus.	Further work on identifying ways to spread the traffic load on campus as evenly as possible to increase the utilisation of roads on the south side of campus.
Kingsley and Hutton Street	An appearance of cars cutting the corner to get onto Barry Drive by going through Hutton Street and Kingsley Street which are both considered local access roads. This area is also a pedestrian and bike access to the ANU and it can be seen in Appendix R: ANU Pedestrian Counts that this area facilitates the largest recorded number of pedestrians and cyclists entering the ANU.	Utilisation of traffic calming measures to encourage cars to go slowly or move onto the major arterial Marcus Clarke Street and then onto Barry Drive rather than cutting through the smaller streets. Details of viable options are compared via a lifecycle and payback period analysis in Appendix I: Life-cycle Costing and the Payback Period. This appendix indicates that option C which is to implement 4 speed cushions and 2 raised pedestrian crossings appears to be have the highest benefit to cost ratio and therefore is most efficient economic solution. There are other elements that are costs and benefits to the solution that need to be considered to increase the robustness of the analysis and these are identified in the appendix as well.	Increased safety of other road users like pedestrians and cyclists. In this case efficiency can be increased due to a more efficient phasing of lighting on the intersection of Barry Drive and Kingsley. A life-cycle costing and payback period analysis shows us that the recommended option C will cost approximately $22,000 but is expected to bring in benefits of approximately $40,500 p.a. This leads to a 6 or 7-month payback period. It is important to realise that this is a preliminary analysis that indicates the option is viable and to indicate accurate costs and benefits further work can be conducted. This is detailed in Appendix I: Life-cycle Costing and the Payback Period
Daley Road	There appears to be speeding occurring on Daley Road past the colleges. The chicanes there indicate that this might have been a problem in the past that the university has attempted to address.	Find data on the 85th percentile speeds through this section of the road network to confirm the issue. After that focus on possible traffic calming devices to encourage through physical and mental barriers a reduced speed. In particular the residential colleges lead to large numbers of students crossing the road so a focus on pedestrian safety is likely to be beneficial to the college.	Verify the issue so that the problem can be explored in more detail and solutions can be explored. Solutions will likely involve the implementation of devices from Appendix P: Road Treatments. Possible solutions then should be costed and analysed extensively to determine the most effective path forward.
Union Court Shared Area	Shared zone areas can be areas of conflict as you have pedestrians and cyclists crossing the	The recommendation would be to promote traffic to stick to the outside of the university. Currently this is already done to a large extent with the car parks located around the edge of the campus. However, students entering from	Only local traffic moving through the shared zone. Increased Pedestrian and cyclist safety.

	road and often in a chaotic manner.	Barry onto North to get to the Chemistry car park on university avenue are the exception. If the North Road is closed off from this car park it would promote these same users to travel via Daley Road.	Increased traffic on Daley which is expected to be able to handle the extra capacity from the SIDRA modelling. The extra traffic on Daley and then on Clunies Ross Street is expected to be a small percentage increase for these major arterial roads.

3.0 CONCLUSION

This report focused on the ANU traffic network and attempted to identify problems with the network and remediation works that could be undertaken to increase the efficiency and safety of vehicular travel on the ANU campus. To do this it was important to consider the social and cultural perspectives that emerge with dealing with only the segment of the population that attend and work at the ANU. This perspective led to an understanding that the university population is more likely to engage in a forms of travel such as walking, riding or catching public transport to the campus. This meant that it was important to identify and incorporate cyclists and pedestrians into the analysis in order to achieve the best results for all stakeholders.

A SIDRA Intersection model was then developed to simulate the complex interplay between traffic trying to enter and exit 25 different intersections on campus. Pedestrian counts that were completed by the ANU were formulated into the model at these intersections. Other data was found by individual counts at different intersections held other 10 minutes and then used to find hourly volumes.

There were many potential errors in the data but the largest was expected to be due to sampling data. Multiple ways to reduce this error have been suggested but the best and most effective would be to procure the ANU data. The ANU holds three commuter audits a year where they conduct these counts for a total of 90 minutes each over the peak periods. This would be more accurate and the addition of previous data would allow some comparison to check for irregularities in the data. This is an area where descriptive statistics and hypothesis testing could be further used.

The SIDRA model identified that the ANU network is operating well and has few problems with most intersections operating at a Level of Service of A which is the highest possible. Two intersections were identified as interesting and both of these were signalized intersections on Barry Drive. The Barry Drive and North Road intersection appears to be caused by high volumes heading to Belconnen in the AM peak. An idea would be to try to minimise the number of cars taking this intersection but due to the locations of car parks on Daley Road and this exit being the most relevant to these car parks it is unlikely that a major change is possible from the ANU side without relocating these major car parks.

The Barry Drive and Kingsley Intersection was also identified as still operating at what is considered an above satisfactory level but was identified due to slightly lower performance than around the rest of the university and therefore is expected to be a potential future problem area. This area is also the primary entrance of cyclists and pedestrians according to the ANU's surveys found in Appendix R: ANU Pedestrian Counts. It was identified that cars appear to be cutting the corner of campus to get onto Barry Drive and this is undesirable as these are local access streets with high pedestrian and cyclist activity. It would be preferred for traffic to move along the arterial Marcus Clarke Street which is built to handle much higher volumes than Hutton Street and Kingsley Street. This is a major recommendation area that this report has honed in on.

Three options were presented for this area and a cost benefit analysis was performed on the options which identified option C (combination of speed humps and raised pedestrian crossings) as being the most cost effective and economical option. There were substantial savings that came from being able to push traffic onto the arterials and therefore change the traffic light phasing to minimise the stopping and starting associated with changing phases to allow traffic from multiple directions keep travelling. These savings were large and the project costed at approximately $22,000 had a payback period of 6 to 7 months under the current assumptions. These assumptions are still too low level to start a project. There are three elements that need to be investigated further now that Option C has been identified as a viable traffic management option. These elements are a focus on the effect of the additional demand on Marcus Clarke Street, the costs associated with the construction causing down time and also what percentage of cars currently cutting the corner can be convinced to utilise the arterial.

A large amount of time was spent on site during the lifespan of this project and it was important to note down field observations that could be qualitatively discussed and through future work could be possibly quantified. An example is that it was observed on the North Road and Daley Road intersection there was car crash during the study period. This could be due to the unusual structure of that intersection or due to problems caused by sightlines at this intersection. It is recommended that a crash analysis is conducted focusing on Road User Movement (RUM) codes that occur often. RUM codes indicate the type of crash so if you have the same type of crash often then this could indicate a structural problem with the intersection. Structural problems can then be addressed through remediation.

SIDRA Intersection models rely heavily on queuing analysis but have not been designed to incorporate car park devices like boom gates and other security devices. This is important to consider as it can create a bottle neck and a larger than expected queue due to the longer service times. This analysis analyses the Burgmann car park which is one of the largest car parks on campus and finds that there is less than a 5% chance that 2 cars will be queued at any one time. This means that providing space for 1 car to queue is sufficient under a 95% significance level. This was built as an interactive excel spreadsheet and therefore it is very easy to increase the significance level but it is unlikely that more than 2 spaces will need to be provided at any one time.

4.0 FURTHER WORK

The modelling and conclusions presented in this report have been derived logically from an analysis of available information. To provide the best solution to the community of ANU there are multiple steps that can be undertaken in the future to ensure delivery of the best solution possible by extending the model and the considerations analysed.

4.1 A Detailed Analysis of the ANU Bus Network

According to Tripadvisor the Canberra bus network is one of the best in Australia and low income sections of society (including Students) demonstrate higher utilization of this system then the average member of Canberra (TripAdvisor, 2016). The Sankey Diagram in Figure 2: Sankey Diagram of Traffic Flows (ANU Green, 2009) demonstrates this higher usage by members of the ANU community.

Buses also have a large effect at bus stops where they may stop for a significant time to unload, reload and sort out problems that passengers may be having with their MyWay card. With a large number of buses stopping and starting effort should be taken to ensure they have space to queue (aka three buses arriving at the same time) and that this does not cause other road users to act recklessly. To solve this an application of queuing theory could be applied in conjunction with the frequency of buses which can be found on ACTION's website. Appendix J: Public Transport Routes contains a map of the weekday and weekend bus services that ACTION offers in the ANU's campus.

4.2 Temporal Parking Analysis

It is possible to conduct a temporal parking analysis of parking, as mixed use facilities like the campus often have different sectors that require parking at different times of the day. An example of this is a work place versus residential, the workplace will not utilise a large number of spaces at night but will have a peak parking demand during the workday and residences are the opposite. The ANU has a large number of people living on campus and a large number of people working here. This would be easy to apply if students could be considered a representative population as there are standard rates set by Austroads as to what percentage parking is required at what time. However, the student body is likely to have fewer members leave the university to attend work than the average and therefore a more extensive study would be required.

4.3 Future Developments

Future developments like the new halls of residences and the general increase in the universities population will have an effect on this network and the locations and size of these buildings should be considered carefully. It is necessary for a traffic impact assessment to be performed on these buildings but inconsistencies found during the creation of this report regarding car parking numbers and predicted traffic generation of the new Fenner Hall lead to doubt in the current plans. A further analysis could consist of identifying future proposed developments and using their traffic generation numbers in the Sidra model to determine a future model. This could allow the identification any potential deterioration in the road conditions before this occurs.

4.4 Shared Use Zones

The university has a high number of pedestrians due to a large on campus population and this can lead to some dangerous and chaotic shared zones that should be managed carefully. In future expertise with Commuter or a similar program would have to be developed in order to allow these shared zones to be modelled and monitored accurately.

4.5 Reduction in the Sampling Error

Counts were undertaken for a total of 10 minutes each over the AM peak (8:00 am to 9:30 am). This could lead to large sampling errors especially as traffic will not be constant over this period but instead will undergo a peak and in particular with a large number of cars the resulting distribution is expected to be normally distributed. Increasing the data available would allow inconsistencies to be seen and then explored and would help ensure the quality of the data and therefore the insights derived.

4.6 Crash Analysis

An extension of the technical analysis beyond what has been presented in this report would be to gather crash history data. This data is usually broken down into RUM codes which indicate the type of crash. If over a particular period, a crash code has a high frequency than it could indicate that there is a structural problem with that intersection.

There is a large amount of detail on this in the Austroads guidelines and through collecting many measurements they provide indicative crash rates dependent on elements such as radius of curvature, gradient, design speed, distance off road to hazard and volumes of traffic. This can be used to conduct an economic analysis on erecting possible barriers around the object such as wire fences or W beams. These barriers have a lower severity index displayed in the Austroads guide and therefore a lower cost but span a longer length and a closer to the road so have a higher likelihood of being hit.

4.7 Traffic Speed Analysis

It is possible to request a printout of data from TAMS that has recorded 85th percentile speeds as well as traffic volumes for most of the ACT. The ANU however is crown lands and therefore the ANU is expected to collect and manage this data. The traffic volume data could be used to supplement the count data collected across the course of this study. The 85th percentile speeds could indicate areas where excessive speeds are recorded and this could indicate areas where traffic calming devices could be useful. The maximum speed limit on campus is 40 km/h.

4.8 Community Consultation

It is expected that a consultation process could capture community concerns about volume, speed, noise, on-street parking and sightlines. The community is able to contact the ANU, Roads ACT and Government Ministers and it might be possible to get this information as it would be invaluable to ensuring the community concerns are met.

A consultation process is outlined in the International Association of Public Participation (IAP2) and the recommendation is to work directly with the public throughout the process to ensure that their concerns and aspirations for improvement are understood and considered.

This is where the ability to craft a targeted and well-designed survey could be incorporated into this project. It is recommended that community consultation follows three stages:

1. Step 1: Establish the study area and establish any known issues.
2. Step 2: Once issues are established it is necessary to identify possible solutions to these problems. Feedback can be provided on the possible solutions.

3. Step 3: Inform the community what has been recommended and the more concrete building plans like possible staging of development to fit within budget. This would allow the community to see that the issues with the highest benefit to cost ratio are getting prioritised.

5.0 ACKNOWLEDGEMENTS

This research was supported by Betty Xiong who was vital in her help collecting traffic counts from around the ANU. There were a large number of counts necessary to obtain the data needed for the model and addition of a second person both made the experience more enjoyable and faster.

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7.0 APPENDIXES

Appendix A: Fermi Estimation

It was useful to complete a fermi estimation of the volume of traffic at the ANU. This is important as a low number of cars would make this project less useful as there is less likely to be problems that need to be addressed now and in the near future. A high number of cars would justify that this project should go ahead. First we must state our assumptions:

- There are 20, 000 students at the ANU.
- Students who live on college have no need to add to the ANU road network.
- There are 4,000 staff at the ANU.
- All staff and students visit the university using their car once during the day.
- United States census data predicts that approximately 86% of people travel by car to work. Students are more likely to catch public transport and therefore it is assumed that only 40% of off-campus students travel by car to university McKenzie (2015).
- Fenner is assumed to be off-campus.
- On campus students – 4650
    - 2000 Unilodge,
    - 500 B&G,
    - 400 Bruce, Burgmann, Toad, Johns, Ursula,
    - 150 Graduate House

Now that we have made some assumptions we can calculate an estimated peak load for the network.

$$\text{Total Number of Cars} = (\#Students - \#Oncampus_{Students}) \times 40\% + \#Staff \times 80\%$$

$$\text{Total Number of Cars} = (20{,}000 - 4650) \times 40\% + 4000 \times 80\%$$

$$\text{Total Number of Cars} = 9{,}200 \text{ cars per day}$$

The assumptions are generally reasonably conservative and therefore there does appear to be a use for a traffic analysis of the ANU.

Appendix B: Parkinson's, Hofstadter's Law and Project Planning

The steps needed to complete a traffic analysis of the ANU network are:

Task
Project Initialization - Create a scope - Create a plan to avoid time blowouts and scope creep - Overestimate the amount of time taken due to Hofstadter's Law - Identify relevant and useful Research Method topics and System Perspective Topics
Collect Data - Car Parking Counts (Manually) - Intersection traffic counts for later SIDRA Modelling - Identification of public transport that move through the ANU
Analyse Data - Create and utilise a Sidra model of traffic at the ANU. - Identify future problem areas
Finalize the report - Create a report focusing on conclusions drawn from the analysis utilised in the last point. - Future work - Limitations to the analysis
Submit Draft for TC-4
Incorporate feedback and finalise the report.

ENGN 2226 Plan

Period Highlight: 12

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Determine a Project	1	1	1	1	9%
Research Topic	1	3	1	3	9%
Create a Scope	2	1	2	1	18%
Identify Relevant and Useful Research Methods and System Perspectives	2	3	2	3	18%
Create a Plan (Gantt Chart)	3	1	3	1	27%
Car Park Counts Manually	4	3	4	3	36%
Intersection Counts	4	3	4	5	36%
Identification of Public Transport Routes	4	1	4	1	36%
Skeleton of Research Portfolio	4	2	4	3	36%
Approach the ANU for Additional Data	4	1	4	5	36%
Create a Sidra Model	7	1	6	1	64%
Apply Model to determine potential issues	8	1	9	1	73%
Decide on Recommendations	9	1	9	1	82%
Finish the Draft Portfolio	9	1	9	1	82%
Peer Review	10	1	10	1	91%
1 Week to incorporate Feedback	11	1	11	1	100%

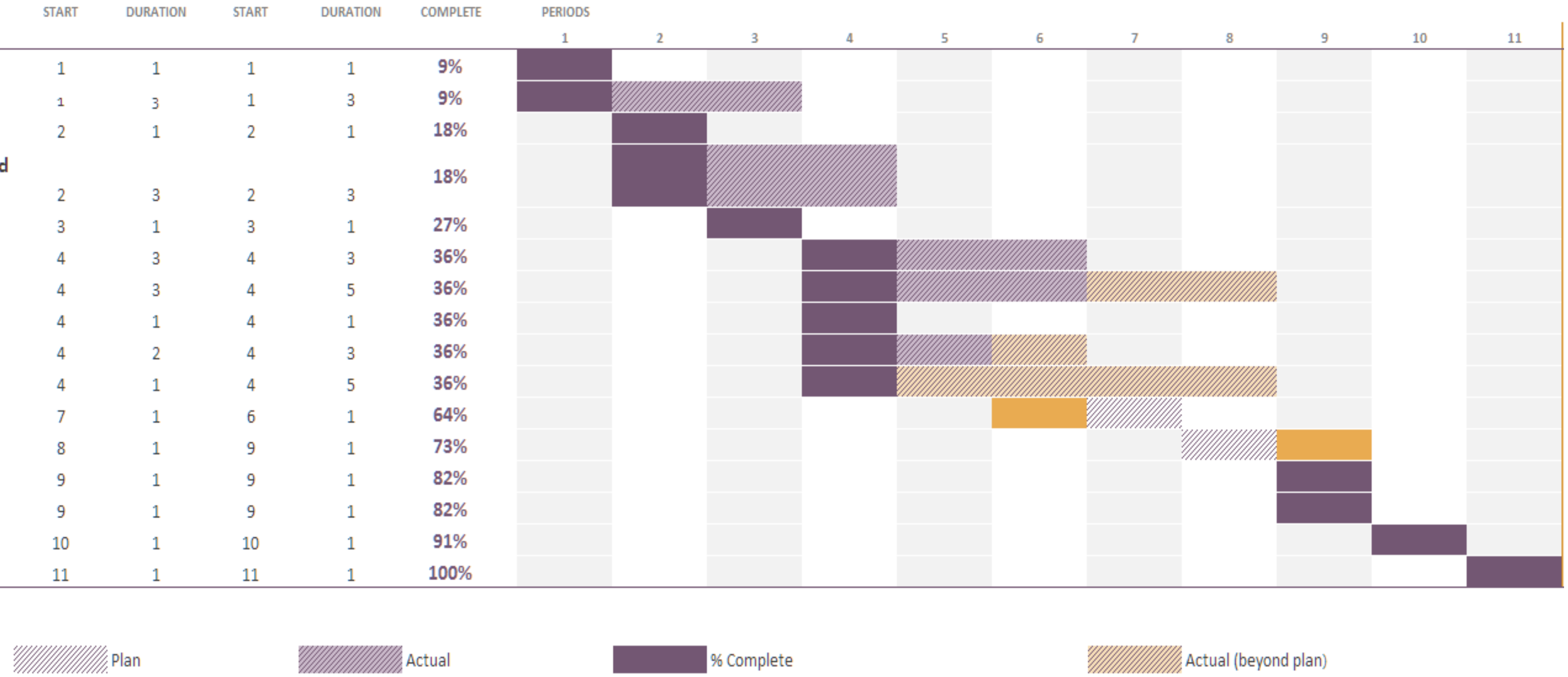

FIGURE 7: GANTT CHART FOR THIS PROJECT

Appendix C: SIDRA Analysis and Occalm's Razor

Occalm's razor bias thought processes towards the simplest explanation. Simple explanations generally rely on the fewest assumptions and have the advantage that they are usually easier to communicate which is vital element to be considered when undertaking projects. Keeping the idea and assumptions as simple as possible are even more important when engaging with projects like traffic analysis as it is often important to engage in community engagement. The community that utilises the roads are often the end user and therefore are often a major stakeholder in these projects.

Some assumptions that were made for the purpose of this project would be simplifier in a full scale traffic analysis and it is explained in the further work section of the report exactly how these assumptions could be removed through further work. Assumptions that are made in this project are listed below:

1. Traffic Data taken across multiple term days for different intersections would yield similar volumes if taken on another non-event day.

2. Car Park temporal profiles were determined from the survey but this could be refined to remove the assumption that the survey sample represent the entire population of ANU road users.

3. There are large number of estimations and assumptions utilised by traffic analysis program SIDRA. This program is utilised by the industry currently and is used in the generation of traffic impact assessments on a regular basis (links to reports that SIDRA has been used in). A full list of assumptions that have been justified can be found in the SIDRA model user guide (link).
   a. These assumptions are assumed to be as accurate as possible for a traffic analysis due to the scrutineering that this program has been put through due to its high utilization in the industry.

4. Heavy Vehicles are excluded from the analysis.

This proposed method has fewer assumptions then every other possible method brainstormed especially when looking in detail at the assumptions underlying the SIDRA software. For example, it is important to factor in the hesitation of the drivers and what constitutes an acceptable gap for drivers entering a busy street. The software has been based off a large statistical sample which has presented an average based off a large number of measurements. In order to make your own assumption you would have to measure all sites in the investigation and even then it would be time consuming to get large data sizes.

If you were to only measure a few intersections you would need to consider the difference between the intersections such as gradient, sightlines and demographics.

Appendix D: Jevon's Paradox and The Impact of the System

A primary consideration of the Local Area Traffic Management is to reduce delays saving both time as well reducing the emissions that the cars produce. These can play off in a complex manner due to Jevon's paradox. Currently a large percentage of the university car pools, uses public transport, cycles or walks to the campus.

If the traffic network was improved by items such as additional parks, more lanes, etc it could lead to a classic example of Jevon's paradox. This is the case where making something more efficient has actually increased the usage of the technology or improvement until it is as it was or even more worse off than it had been when the technology had been introduced.

In this case improving the traffic system could lead to a larger number of the university population driving to the campus and could lead to larger delays and more emissions. Therefor this solution may not always be the best solution despite increasing efficiency and it might be better to step away from travel and find ways to discourage driving and instead encourage forms of travel like Active Travel.

Appendix E: Crafting a Research Question

It is important to create a targeted research question carefully as the choice of question has enormous impacts on the scope of your analysis. To do this a researcher must choose a theme, focus, topic and then a question to ensure the research is targeted at what is most important and does not end up becoming unruly.

In the case of this report the process was:

Theme: Transport Networks

Topic: ANU Traffic Network

Focus: Expected problems and concerns

Research Question:

What areas of the ANU are most likely to experience issues what can be done to manage this safely and efficiently?

Appendix E: Quantitative and Qualitative Methodologies

Approaches are generally split into either quantitative or qualitative and are both incredibly useful in different situations (Creswall, 2003). It is quite common for the process used to be a mixture of the two. Quantitative analysis is usually more useful when the research question posed is a closed ended question while qualitative is generally more useful for open ended questions.

The project of completing a traffic analysis of the ANU is primarily a quantitative one but becomes a mixed approach due to qualitative predictions regarding traffic behaviors. Hard data can be found in the form of:

- SCATS intersection data from controlled intersections
- Census data to determine work travel routes
- Car park counts
- Intersection traffic counts

This data will be useful in a quantitative analysis but has several limitations and assumptions that need to be made. Common assumptions that will need to be qualitatively discussed are that the AM peak (8:30-9:30) is the busiest point of the day. This is usually busier than the PM peak and is split into the time that school ends and the time that the work day finishes. In the case of the ANU these assumptions may not hold as university times are much more flexible but it will too time consuming to take traffic counts at multiple times throughout all the intersections of the ANU.

In order to reduce the time insensitivity of this project some qualitative assumptions are made. An example of a qualitative assumption that is made for this project is that all car parks behave in a similar way to Burgmann's car park. The data that the ANU have provided is only for that car park but some assumptions could lead to a close approximation quickly rather than multiple traffic counts to still not have 100% accuracy.

The primary type of analysis for the traffic analysis will be quantitative but many of the of underlying assumptions will be argued and decided on qualitatively. This being said both will be relied on heavily for this project.

Appendix F: Data Organisation

There is a large amount of data present in this project and therefore it is of vital importance that is ordered and kept track of to ensure transparency, readability and to prevent loss of information. There are multiple different data inputs to this project and therefore how they will be handled will be explained below:

- The vast majority of data for this task were the AM and the PM peak intersection counts. These were performed at each intersection for 10 minutes and the time, number of cars, approaching direction and direction of departure were all recorded.

  To ensure that the data could be ordered in a logical way a template table was drawn up for each intersection prior to commencing traffic counts. These tables were arranged to each be one sheet of a large workbook which contained every intersection and each sheet was given a different name depending on the streets involved to act as a unique key.

  Once the count was completed the hard copies were scanned and then entered into the excel tables were the header was colour coded Red to indicate manual traffic counts.

- Data was also received from some ANU reports. This data was also included in the same excel workbook as the manual counts but had a header that was colour coded blue

- Assumptions were made to allow the car park traffic to be predicted based off data from the ANU regarding their Burgmann car park. Data that was found from this assumption is located in the same excel workbook but is indicated by a green header.

All of this is explained on an introduction page of the excel spreadsheet that goes through the data collected and explains the layout of the database.

Appendix G: Research Ethics

Research ethics focuses on ensuring that research is conducted in an ethical and safe method (Resnik, 2015). Doing this ensures the safety of all partakers and the legitimacy of the research activities being undertaken. There are many codes that have been written by both the government and usually the ANU (Government, 2007, Australian National University, 2014).

Research ethics is incredibly important to consider and to complete a traffic analysis it is necessary to study the behaviors of the participants involved. It is also important to note that the university has several regulations that you must adhere to legally protect not just yourself and the participants of the research but also the university.

The ANU has a code of research conduct which sets out the responsibilities of ANU researchers to conduct research responsibly and ethically.

Research will be carefully conducted to ensure the validity of the research and the safety of all participants both physically and emotionally. Data collected that indicates behavior such as intersection and car park counts will be taken anonymously. It will not be possible to identify the participants in the research or to track individual cars between intersections.

Appendix H: Safety & Risk Perspectives

This report focuses on the problem from as a Local Area Traffic Management (LATM) point of view. This can be done as the ANU is quite similar in its design to a normal suburb with major arterials outlining the edges and then major and minor collectors permeating into the ANU campus. There are also smaller roads that act as small access roads within the boundary of the campus.

LATM is practiced in both Australia and New Zealand and is focused on the planning and management of road space inside a local area. It aims to implement measures that can lead to safer and more livable streets. There are five fatal factors outlined by the Queensland Government as being the primary causes of fatal crashes (Queensland Government, 2016). These are written below and the factors that are most relevant to this LATM project are bolded:

- **Distraction and Inattention**
- Drink and Drug Driving
- **Dangerous Driving (Speeding, etc)**
- Fatigue
- **Failure to wear a seat belt.**

Three factors were identified and focused on. The hazard had been identified, associated risk was identified and the likelihood of a crash occurring was considered unlikely. Using a risk matrix, it was found that the overall level of risk was medium and a list of preventative methods were brainstormed using the hierarchy of risk.

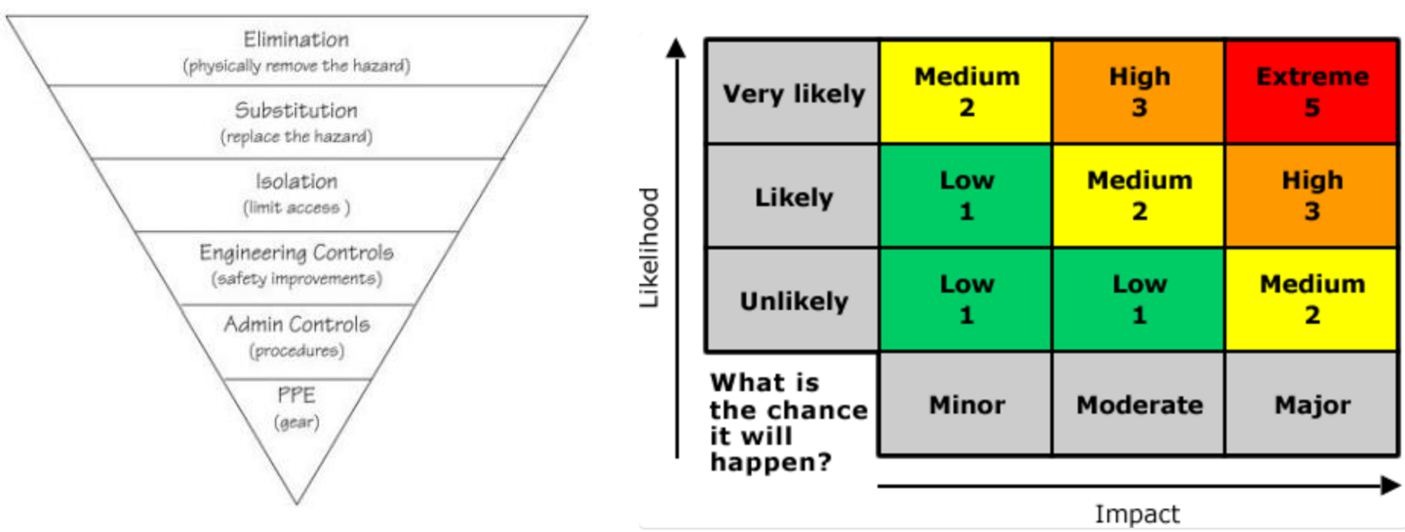

FIGURE 8: SAFETY AND RISK PERSPECTIVES: HIERACHY OF RISK AND RISK ASSESSMENT

TABLE 5: SAFETY AND RISK ASSESSMENT AND CONTROLS

Hazard	Associated Risk	Risk Assessment	Control of Risk
1. Distraction and Inattention **2. Dangerous Driving** **3. Failure to Wear a Seat Belt**	Crash (Property Damage, Injury, Death)	Medium (Unlikely, Major)	Without a ban on traffic there will always be some risk due to traffic but numbers may be possible to **eliminate/reduce** by encouraging **substitution** to other modes of travel. This could be done by increasing the accessibility of public transport, number of bike storage facilities and an increase of on-campus accommodation. The ANU may also be able to **eliminate** distractions such as mobile devices by working closely with police and imposing a fine for these activities. The big arterial roads like Barry Drive are possible to **isolate** by building buildings in locations that allow users to not have to cross busy intersections. An **engineering control** can be the addition of hands free mobile technology which reduce3s the distraction these devices can cause. As well as the introduction of safety features into the car. An **administrative control** that the ANU can implement is the rationing of parking spaces to limit demand for the ANU road system. Drivers should always wear a seat belt and cyclists who also share the network must wear helmets. This **Personal Protective Equipment** can limit the severity of a crash.

Appendix I: Life-cycle Costing and the Payback Period

A life cycle costing and payback period analysis was undertaken on the proposed options for the Kingsley Street and Hutton Street. The three options proposed are to do nothing which produces net benefits and net costs of zero and is the base position, to install traffic lights at the intersection of Childers's and Hutton or to install 4 speed cushions and two raised pedestrian crossings along Kingsley Street and Hutton Street.

To analyse this costs for different road networks were investigated and tabulated in Appendix P: Road Treatments. This allowed us to find the costs for the different methods. It was also found that Austroads assesses projects on a 20-year period as this is how long they expect most of these treatments to last.

The methods chosen do not include items that include landscaping and therefore there are no landscaping costs but the planting and management of trees in the median are incredibly important.

The benefits are summarized as savings in time, savings in fuel and reduction carbon dioxide. These are provided by the SIDRA Intersection program but perusal of the guide indicates that it relies on average time that cars are stopped, average wage, etc. There are many industry tested assumptions being utilised in this analysis by the SIDRA Intersection program. These savings are then all converted to a dollars per year amount by considering the average fuel price (Orima Research, 2016) and the price that the carbon tax was going to impose (Patrick Luckow, 2015).

TABLE 6: FUEL AND CARBON PRICE

Item	Price
Fuel	115.2 cents/L
Carbon Dioxide	23 $/tonne

Option A- Base Case:

This is the case where nothing changes from the current design. This leads to net benefits of zero as there are no costs but no additional benefits.

TABLE 7: COSTS AND BENEFITS ASSOCIATED WITH OPTION A

Benefits	Costs
0	0
Net Benefit over next year	0

Option B- Traffic Lights:

In this case lights are installed on the Childers Street and Hutton Street intersection to encourage cars to travel straight and then up onto the major arterial Marcus Clarke Street. It is assumed that 50% of the traffic that currently cuts through onto Barry Drive is encouraged to go via Marcus Clarke Street. This allows the traffic lights to have a new phase programmed into it which requires less switching and therefore increases the efficiency of the intersection. It also increases the safety of Kingsley street which acts as the largest pedestrian and cyclist access to the university according to the data supplied by the ANU in Appendix R: ANU Pedestrian Counts.

TABLE 8: COSTS AND BENEFITS ASSOCIATED WITH OPTION B

Benefits	Costs
Savings in Time:	Between $15,000 and $60,000

$531,387\ \$/yr - 496,146\ \$/yr = 35\,241\ \$/yr$	
Savings in Fuel: $74,167\ L - 69,485L = 4682\ L/yr$ $4682\ L/yr \times 1.152\ \$/L = \$5\,394\ \$/yr$	
Reduction in Carbon Dioxide Emitted: $185,416\ kg/yr - 173,712\ kg/yr = 11.704\ tonnes/yr$ $11.704\ tonnes/yr \times 23\ \$/tonnes = 270\$/year$	
Net Benefit over next year	Between $19095 to $25905
Net Benefit over next two years	Between $21,180 to $66,810.

It is important to note that the simulation will be slightly worse in real life as lights were not modelled due to the difficulty of determining the correct phasing. Simpler terms it is easy for a car to cause unnecessary queues when used on a single lane road. With the analysis above it appears to be definitely paid back after two years. This is still high level but does appear to show benefits to the proposed plan.

Option C-Traffic Calming Measures (4 speed cushions and 2 raised pedestrian crossings):

The next option focus on the use of multiple different traffic calming devices to naturally encourage flows onto Marcus Clarke which is better equipped to handle the high volumes. There is no detailed sketch up but the recommendation is to utilise 4 speed cushions and 2 raised pedestrian crossings. The same assumption as used with the traffic light option is applied regarding 50% of the unnecessary traffic is encouraged to change their behavior.

TABLE 9: COSTS AND BENEFITS ASSOCIATED WITH OPTION C

Benefits	**Costs**
Savings in Time: $531,387\ \$/yr - 496,146\ \$/yr = 35\,241\ \$/yr$	4 Speed Humps - $2,000 each
Savings in Fuel: $74,167\ L - 69,485L = 4682\ L/yr$ $4682\ L/yr \times 1.152\ \$/L = \$5\,394\ \$/yr$	2 Raised Pedestrian Crossing - $7,000 each
Reduction in Carbon Dioxide Emitted: $185,416\ kg/yr - 173,712\ kg/yr = 11.704\ tonnes/yr$ $11.704\ tonnes/yr \times 23\ \$/tonnes = 270\$/year$	
Net Benefit over next year	$18,905

From this analysis the 4 speed cushions and 2 raised traffic islands had the highest net benefit value. It is important to note that there were several assumptions that should be explored further due to their effects on increasing the expected costs. It is expected that driver behavior may be hard to change and therefore 50% of drivers may not switch their behaviors. The other element to analyse is whether the increased traffic joining Marcus Clarke causes any problems with the phasing as this could lead to increase in the waiting time and therefore costs at that intersection. This could be addressed through the addition of a slip lane or extra lane on Marcus Clarke Street but these would be further costs. Another element that could add further to the cost is the cost of the shutdown that is necessary for construction.

From this analysis option C appears to hold a large benefit and therefore is worth exploring further. It is possible to calculate a payback period for this option which can be seen in the graph below. The payback period analysis indicates that it will take approximately 6 to 7 months to recoup the costs.

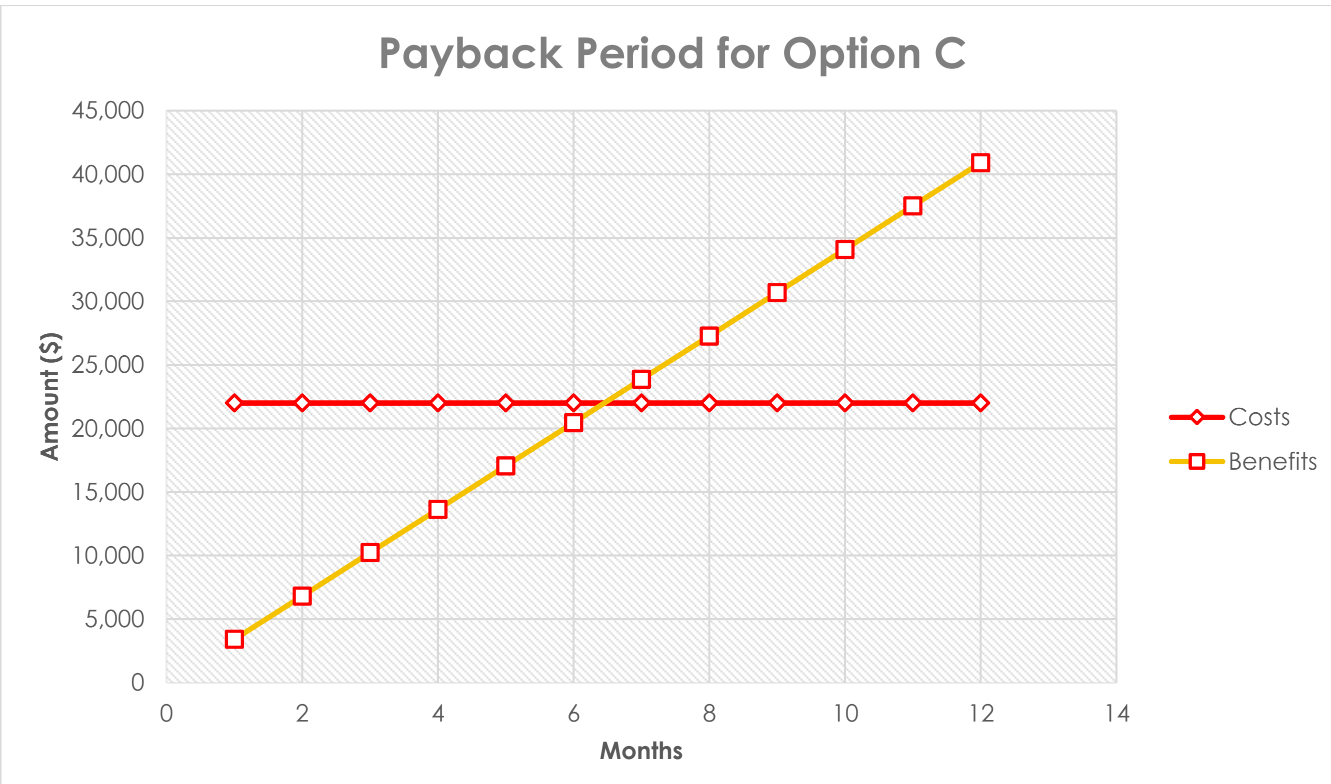

FIGURE 9: PAYBACK PERIOD FOR OPTION C

Appendix J: Public Transport Routes

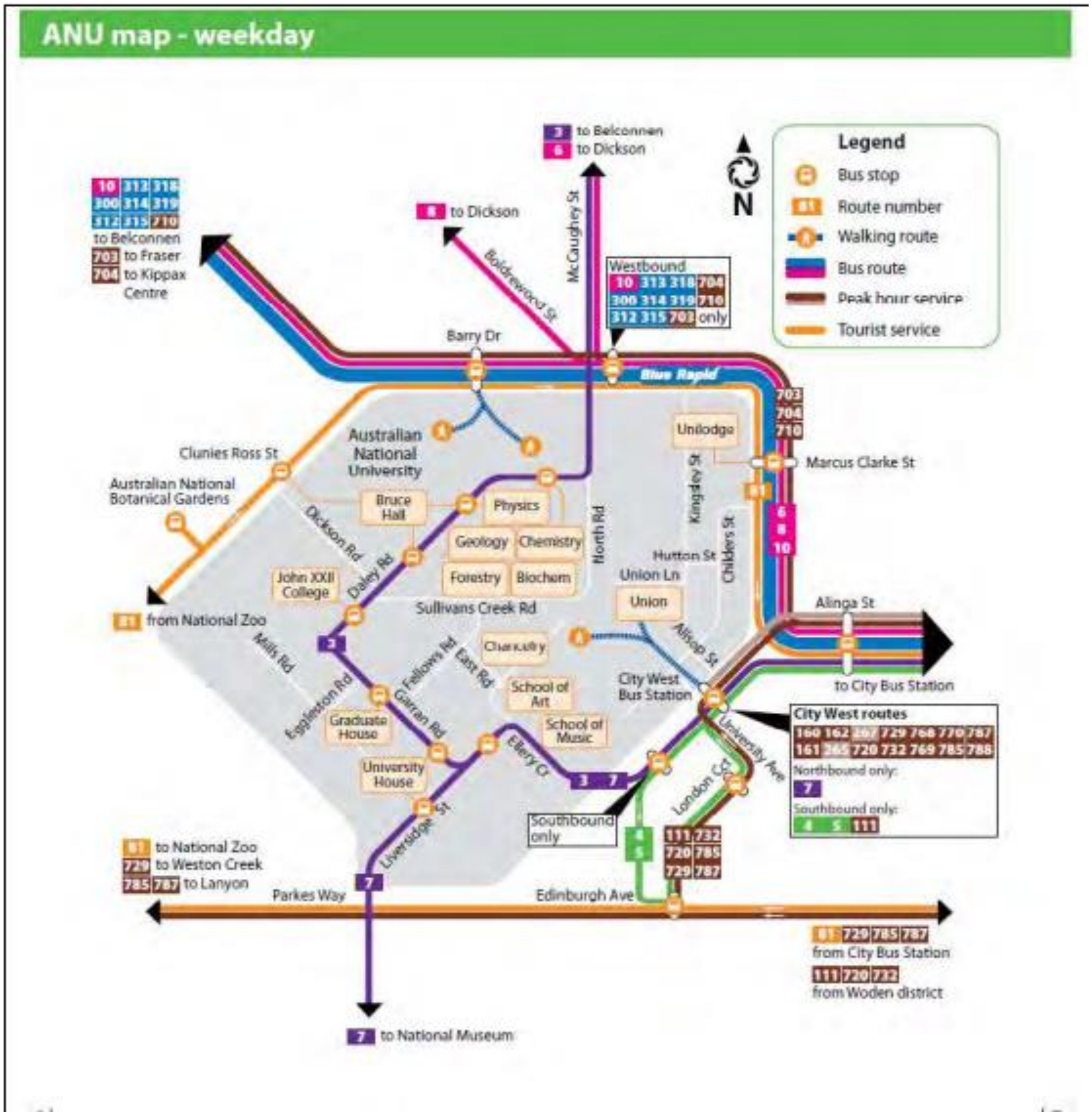

FIGURE 10: WEEKDAY ACTION BUS ROUTES

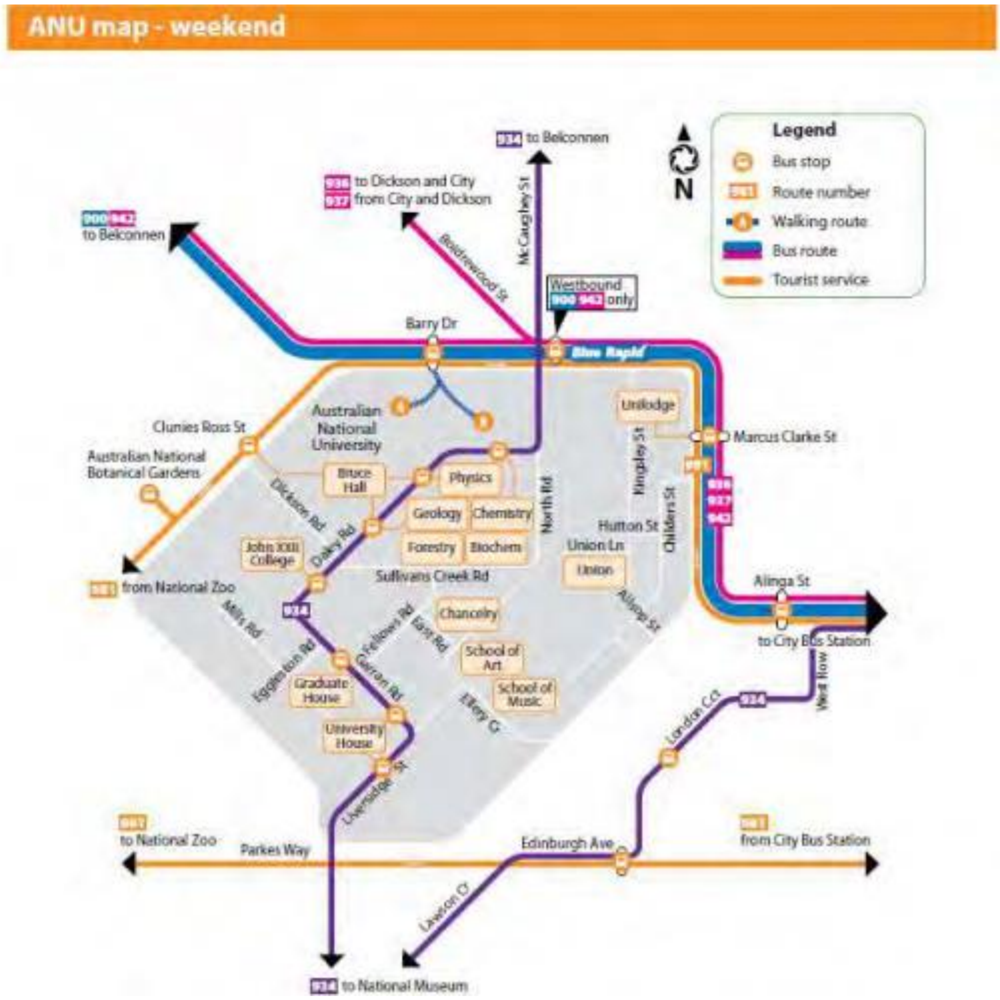

FIGURE 11: ACTION WEEKEND BUS SERVICE

Appendix K: Active Travel

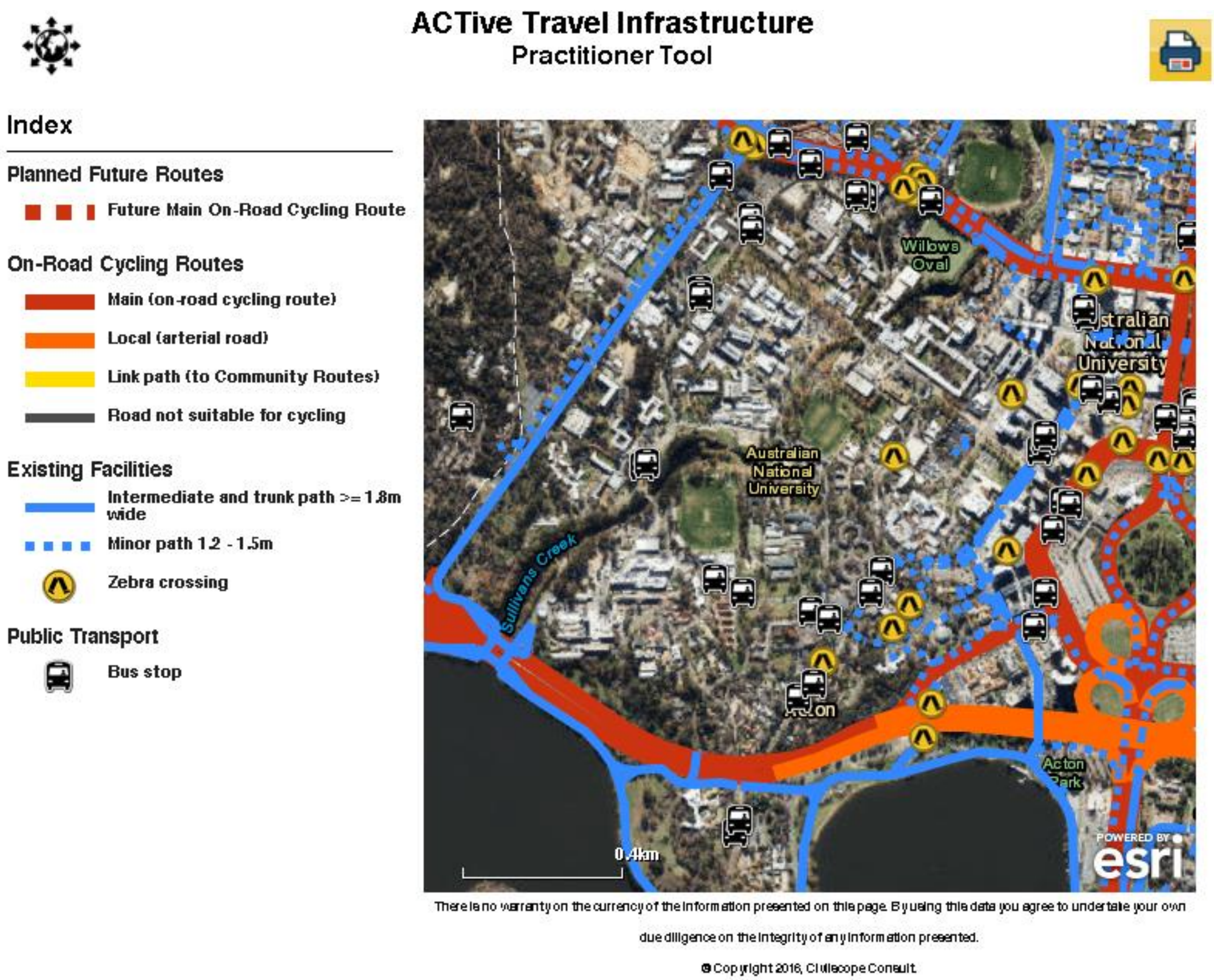

FIGURE 12: LOCATIONS OF SIGNIFANCE (CROSSINGS, MAIN ROADS, BUS STOPS, PATHS) (ACT GOVERNMENT, 2016)

Appendix L: SIDRA Analysis of Existing Network

Unlicensed Trial Version

LANE SUMMARY

Site: Barry Drive/ Daley Road

2016-AM
Signals - Fixed Time Cycle Time = 150 seconds (Practical Cycle Time)

Lane Use and Performance

	Demand Flows L veh/h	Demand Flows T veh/h	Demand Flows R veh/h	Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Lane Length m	SL Type	Cap. Adj. %	Prob. Block. %
South: Daley Road																
Lane 1	82	0	0	82	0.0	607	0.135	100	9.4	LOS A	1.3	9.3	65	–	0.0	0.0
Lane 2	0	57	0	57	0.0	416	0.137	100	51.0	LOS D	4.7	32.6	85	–	0.0	0.0
Lane 3	0	0	76	76	0.0	169	0.448	100	75.1	LOS F	6.9	48.4	75	Turn Bay	0.0	0.0
Approach	82	57	76	215	0.0		0.448		43.6	LOS D	6.9	48.4				
East: Barry Drive- East																
Lane 1	309	0	0	309	0.0	939	0.329	100	10.0	LOS A	5.2	36.1	335	–	0.0	0.0
Lane 2	0	409	0	409	0.0	1378	0.297	90[5]	8.5	LOS A	12.4	86.7	335	–	0.0	0.0
Lane 3	0	409	0	409	0.0	1378	0.297	90[5]	8.5	LOS A	12.4	86.7	335	–	0.0	0.0
Lane 4	0	409	0	409	0.0	1378	0.297	90[5]	8.5	LOS A	12.4	86.7	335	–	0.0	0.0
Lane 5	0	0	69	69	0.0	271	0.256	100	21.2	LOS B	3.3	23.1	90	Turn Bay	0.0	0.0
Approach	309	1227	69	1606	0.0		0.329		9.4	LOS A	12.4	86.7				
North: McCaughey Street																
Lane 1	88	221	158	467	0.0	424	1.103	100	175.2	LOS F	55.5	388.7	70	–	0.0	100.0
Approach	88	221	158	467	0.0		1.103		175.2	LOS F	55.5	388.7				
West: Barry Drive-West																
Lane 1	76	328	0	404	0.0	1365	0.296	100	10.1	LOS A	12.3	85.8	135	–	0.0	0.0
Lane 2	0	408	0	408	0.0	1378	0.296	100	8.5	LOS A	12.3	86.4	135	–	0.0	0.0
Lane 3	0	408	0	408	0.0	1378	0.296	100	8.5	LOS A	12.3	86.4	135	–	0.0	0.0
Lane 4	0	0	309	309	0.0	268	1.153	100	247.9	LOS F	51.6	361.2	75	–	0.0	100.0
Approach	76	1143	309	1528	0.0		1.153		57.4	LOS E	51.6	361.2				
Intersection				3817	0.0		1.153		50.8	LOS D	55.5	388.7				

Level of Service (Aver. Int. Delay): LOS D. Based on average delay for all lanes. LOS Method: Delay (RTA NSW).
Level of Service (Worst Lane): LOS F. LOS Method for individual lanes: Delay (RTA NSW).
Approach LOS values are based on average delay for all lanes.

5 Lane underutilisation determined by program

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SIDRA INTERSECTION

FIGURE 13: SIDRA OUTPUT FOR INTERSECTION (BARRY/DALEY/MCCAUGHERY)

Intersection Performance - Annual Values

Performance Measure	Vehicles	Pedestrians	Persons
Demand Flows (Total)	1,832,084 veh/y	101,760 ped/y	2,300,261 pers/y
Delay	25,870 veh-h/y	1,095 ped-h/y	32,139 pers-h/y
Effective Stops	1,172,735 veh/y	66,653 ped/y	1,473,935 pers/y
Travel Distance	1,113,212 veh-km/y	4,406 ped-km/y	1,340,260 pers-km/y
Travel Time	45,009 veh-h/y	2,037 ped-h/y	56,047 pers-h/y
Cost	1,295,824 $/y	39,107 $/y	1,334,931 $/y
Fuel Consumption	141,635 L/y		
Carbon Dioxide	354,087 kg/y		
Hydrocarbons	634 kg/y		
Carbon Monoxide	20,221 kg/y		
NOx	676 kg/y		

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SIDRA INTERSECTION

FIGURE 14: INTERSECTION PERFORMANCE MEASURES (BARRY/ MCCAUGHERY/DALEY)

Unlicensed Trial Version

LANE SUMMARY

Site: Daley Rd - North Rd

2016- AM
Stop (Two-Way)

Lane Use and Performance

	Demand Flows L veh/h	T veh/h	R veh/h	Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Lane Length m	SL Type	Cap. Adj. %	Prob. Block. %
East: Daley East																
Lane 1	0	265	543	808	0.0	1887	0.429	100	5.6	LOS A	0.0	0.0	82	–	0.0	0.0
Approach	0	265	543	808	0.0		0.429		5.6	LOS A	0.0	0.0				
North: Daley North																
Lane 1	133	0	120	253	0.0	1857	0.136	100	8.3	LOS A	0.0	0.0	100	–	0.0	0.0
Approach	133	0	120	253	0.0		0.136		8.3	LOS A	0.0	0.0				
West: North Road																
Lane 1	32	95	0	126	0.0	680	0.186	100	13.4	LOS A	1.0	6.8	200	–	0.0	0.0
Approach	32	95	0	126	0.0		0.186		13.4	LOS A	1.0	6.8				
Intersection				1187	0.0		0.429		7.0	NA	1.0	6.8				

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Lane): LOS A. LOS Method for individual lanes: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any lane.

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SIDRA INTERSECTION

FIGURE 15: SIDRA OUTPUT FOR INTERSECTION (DALEY/NORTH)

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LANE SUMMARY

Site: Daley-Linnaeus

2016-AM
Giveway / Yield (Two-Way)

Lane Use and Performance

	Demand Flows L veh/h	Demand Flows T veh/h	Demand Flows R veh/h	Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Lane Length m	SL Type	Cap. Adj. %	Prob. Block. %
South: Daley South																
Lane 1	0	447	21	468	0.0	1888	0.248	100	1.8	LOS A	2.5	17.2	20	–	0.0	1.9
Approach	0	447	21	468	0.0		0.248		1.8	LOS A	2.5	17.2				
East: Linneaus Way																
Lane 1	5	0	11	16	0.0	357	0.044	100	16.3	LOS B	0.2	1.3	80	–	0.0	0.0
Approach	5	0	11	16	0.0		0.044		16.3	LOS B	0.2	1.3				
North: Daley North																
Lane 1	37	211	0	247	0.0	1936	0.128	100	1.2	LOS A	0.0	0.0	500	–	0.0	0.0
Approach	37	211	0	247	0.0		0.128		1.2	LOS A	0.0	0.0				
Intersection				732	0.0		0.248		1.9	NA	2.5	17.2				

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Lane): LOS B. LOS Method for individual lanes: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any lane.

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SIDRA INTERSECTION

FIGURE 16: SIDRA OUTPUT FOR INTERSECTION (DALEY/LINNAEUS)

Unlicensed Trial Version

LANE SUMMARY

Site: Dickson-Daley

2016-AM
Roundabout

Lane Use and Performance

	Demand Flows L veh/h	Demand Flows T veh/h	Demand Flows R veh/h	Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Lane Length m	SL Type	Cap. Adj. %	Prob. Block. %
South: Daley South																
Lane 1	116	137	0	253	0.0	1269	0.199	100	7.9	LOS A	1.5	10.4	80	–	0.0	0.0
Approach	116	137	0	253	0.0		0.199		7.9	LOS A	1.5	10.4				
North: Daley North																
Lane 1	0	37	84	121	0.0	906	0.134	100	11.7	LOS A	0.9	6.6	20	–	0.0	0.0
Approach	0	37	84	121	0.0		0.134		11.7	LOS A	0.9	6.6				
West: Dickson																
Lane 1	505	0	379	884	0.0	1278	0.692	100	10.7	LOS A	8.7	61.0	190	–	0.0	0.0
Approach	505	0	379	884	0.0		0.692		10.7	LOS A	8.7	61.0				
Intersection				1258	0.0		0.692		10.2	LOS A	8.7	61.0				

Level of Service (Aver. Int. Delay): LOS A. Based on average delay for all lanes. LOS Method: Delay (RTA NSW).
Level of Service (Worst Lane): LOS A. LOS Method for individual lanes: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any lane.
Roundabout Capacity Model: SIDRA Standard.

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FIGURE 17: SIDRA OUTPUT FOR INTERSECTION (DALEY/DICKSON)

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LANE SUMMARY

Site: Daley-Sullivans

2016-AM
Giveway / Yield (Two-Way)

Lane Use and Performance

	Demand Flows L veh/h	Demand Flows T veh/h	Demand Flows R veh/h	Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Lane Length m	SL Type	Cap. Adj. %	Prob. Block. %
South: Daley South																
Lane 1	0	196	34	229	0.0	1644	0.140	100	3.9	LOS A	1.4	9.6	155	–	0.0	0.0
Approach	0	196	34	229	0.0		0.140		3.9	LOS A	1.4	9.6				
East: Sullivans Creek																
Lane 1	82	0	95	177	0.0	483	0.366	100	15.7	LOS B	2.2	15.7	50	–	0.0	0.0
Approach	82	0	95	177	0.0		0.366		15.7	LOS B	2.2	15.7				
North: Daley North																
Lane 1	265	202	0	467	0.0	1896	0.246	100	4.6	LOS A	0.0	0.0	80	–	0.0	0.0
Approach	265	202	0	467	0.0		0.246		4.6	LOS A	0.0	0.0				
Intersection				874	0.0		0.366		6.7	NA	2.2	15.7				

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Lane): LOS B. LOS Method for individual lanes: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any lane.

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SIDRA INTERSECTION

FIGURE 18: SIDRA OUTPUT FOR INTERSECTION (DALEY/SULLIVANS)

Unlicensed Trial Version
MOVEMENT SUMMARY

Site: Daley-Ward

2016-AM
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: Ward											
21	L	1	0.0	0.016	8.2	LOS A	0.0	0.0	0.00	0.64	49.0
23	R	28	0.0	0.016	8.4	LOS A	0.0	0.0	0.00	0.70	48.7
Approach		29	0.0	0.016	8.4	LOS A	0.0	0.0	0.00	0.69	48.7
North East: Daley North											
24	L	27	0.0	0.015	8.2	LOS A	0.0	0.0	0.00	0.67	49.0
25	T	1	0.0	0.015	6.9	LOS A	0.0	0.0	0.00	0.56	50.4
Approach		28	0.0	0.015	8.1	LOS A	0.0	0.0	0.00	0.66	49.0
South West: Daley South											
31	T	13	0.0	0.008	7.2	LOS A	0.1	0.5	0.15	0.50	49.5
32	R	1	0.0	0.008	8.6	LOS A	0.1	0.5	0.15	0.69	48.2
Approach		14	0.0	0.008	7.3	LOS A	0.1	0.5	0.15	0.51	49.4
All Vehicles		72	0.0	0.016	8.1	NA	0.1	0.5	0.03	0.65	48.9

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 19: SIDRA OUTPUT FOR INTERSECTION (DALEY/WARD)

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MOVEMENT SUMMARY

Site: Daley- Burgmann

2016-AM
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
North East: Daley North											
25	T	79	0.0	0.123	1.2	LOS A	1.0	6.9	0.32	0.00	53.2
26	R	63	0.0	0.123	9.7	LOS A	1.0	6.9	0.32	0.80	48.2
Approach		142	0.0	0.123	5.0	LOS A	1.0	6.9	0.32	0.36	50.9
North West: Burgmann											
27	L	42	0.0	0.071	9.2	LOS A	0.3	2.3	0.22	0.61	47.8
29	R	21	0.0	0.071	9.5	LOS A	0.3	2.3	0.22	0.72	47.6
Approach		63	0.0	0.071	9.3	LOS A	0.3	2.3	0.22	0.64	47.7
South West: Daley South											
30	L	21	0.0	0.049	8.2	LOS A	0.0	0.0	0.00	0.95	49.0
31	T	74	0.0	0.049	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		95	0.0	0.049	1.8	LOS A	0.0	0.0	0.00	0.21	57.1
All Vehicles		300	0.0	0.123	4.9	NA	1.0	6.9	0.20	0.37	52.0

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 20: SIDRA OUTPUT FOR INTERSECTION (DALEY/BURGMANN CARPARK)

Unlicensed Trial Version

MOVEMENT SUMMARY

Site: Sullivans-Fellows

2016-AM
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: Fellows											
21	L	57	0.0	0.128	9.6	LOS A	0.6	4.5	0.31	0.65	47.4
23	R	51	0.0	0.128	9.6	LOS A	0.6	4.5	0.31	0.69	47.3
Approach		107	0.0	0.128	9.6	LOS A	0.6	4.5	0.31	0.67	47.4
North East: Sullivan-North											
24	L	32	0.0	0.089	9.0	LOS A	0.6	4.0	0.25	0.49	47.8
26	R	57	0.0	0.089	8.7	LOS A	0.6	4.0	0.25	0.63	48.2
Approach		88	0.0	0.089	8.8	LOS A	0.6	4.0	0.25	0.58	48.0
West: Sullivan-West											
10	L	177	0.0	0.176	8.4	LOS A	1.2	8.4	0.12	0.62	48.3
12	R	114	0.0	0.177	7.8	LOS A	1.2	8.4	0.12	0.59	48.9
Approach		291	0.0	0.176	8.2	LOS A	1.2	8.4	0.12	0.61	48.5
All Vehicles		486	0.0	0.176	8.6	NA	1.2	8.4	0.19	0.62	48.2

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 21: SIDRA OUTPUT FOR INTERSECTION (SULLIVANS-FELLOWS)

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MOVEMENT SUMMARY

Site: Fellows-East

2016-AM
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Fellows South											
2	T	95	0.0	0.079	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	57	0.0	0.079	8.4	LOS A	0.0	0.0	0.00	0.94	48.6
Approach		152	0.0	0.079	3.2	LOS A	0.0	0.0	0.00	0.35	55.2
East: East Road											
4	L	32	0.0	0.058	8.2	LOS A	0.0	0.0	0.00	0.65	49.0
6	R	76	0.0	0.058	8.4	LOS A	0.0	0.0	0.00	0.70	48.7
Approach		107	0.0	0.058	8.3	LOS A	0.0	0.0	0.00	0.69	48.7
North: Fellows-North											
7	L	95	0.0	0.094	8.5	LOS A	0.5	3.4	0.16	0.63	48.3
8	T	32	0.0	0.094	7.2	LOS A	0.5	3.4	0.16	0.55	49.4
Approach		126	0.0	0.094	8.1	LOS A	0.5	3.4	0.16	0.61	48.6
All Vehicles		385	0.0	0.094	6.2	NA	0.5	3.4	0.05	0.53	51.0

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 22: SIDRA OUTPUT FOR INTERSECTION (FELLOWS/EAST)

Unlicensed Trial Version

MOVEMENT SUMMARY

Site: Fellows - Garran

2016-AM
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: Garran South											
21	L	95	0.0	0.206	8.8	LOS A	1.1	7.9	0.20	0.64	48.0
23	R	101	0.0	0.206	8.9	LOS A	1.1	7.9	0.20	0.66	47.8
Approach		196	0.0	0.206	8.9	LOS A	1.1	7.9	0.20	0.65	47.9
North East: Fellows											
24	L	44	0.0	0.062	8.7	LOS A	0.5	3.2	0.20	0.53	48.1
26	R	32	0.0	0.062	8.3	LOS A	0.5	3.2	0.20	0.61	48.4
Approach		76	0.0	0.062	8.5	LOS A	0.5	3.2	0.20	0.57	48.2
West: Garran West											
10	L	32	0.0	0.037	8.3	LOS A	0.0	0.0	0.00	0.70	48.8
12	R	38	0.0	0.037	7.8	LOS A	0.0	0.0	0.00	0.66	49.3
Approach		69	0.0	0.037	8.0	LOS A	0.0	0.0	0.00	0.68	49.1
All Vehicles		341	0.0	0.206	8.6	NA	1.1	7.9	0.16	0.64	48.2

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 23: SIDRA OUTPUT FOR INTERSECTION (FELLOWS/GARRAN)

Unlicensed Trial Version

MOVEMENT SUMMARY

Site: Garran-Eggleston

2016-AM
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Eggleston											
1	L	18	0.0	0.047	11.2	LOS A	0.2	1.6	0.25	0.85	46.2
3	R	23	0.0	0.047	11.9	LOS A	0.2	1.6	0.25	0.90	45.6
Approach		41	0.0	0.047	11.6	LOS A	0.2	1.6	0.25	0.88	45.9
South East: Garran East											
21	L	23	0.0	0.039	9.1	LOS A	0.0	0.0	0.00	0.98	48.1
22	T	53	0.0	0.039	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		76	0.0	0.039	2.8	LOS A	0.0	0.0	0.00	0.30	55.7
North West: Garran West											
28	T	29	0.0	0.059	0.8	LOS A	0.4	2.8	0.24	0.00	54.7
29	R	35	0.0	0.059	8.1	LOS A	0.4	2.8	0.24	0.67	49.1
Approach		64	0.0	0.059	4.8	LOS A	0.4	2.8	0.24	0.36	51.5
All Vehicles		181	0.0	0.059	5.5	NA	0.4	2.8	0.14	0.45	51.7

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 24: SIDRA OUTPUT FOR INTERSECTION (GARRAN/EGGLESTON)

Unlicensed Trial Version
MOVEMENT SUMMARY

Site: Mill - Eggleston

2016-AM
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: Mills South											
22	T	6	0.0	0.018	0.2	LOS A	0.1	0.7	0.11	0.00	57.4
23	R	13	0.0	0.018	8.6	LOS A	0.1	0.7	0.11	0.75	48.4
Approach		19	0.0	0.018	5.8	LOS A	0.1	0.7	0.11	0.50	51.1
North East: Eggleston											
24	L	19	0.0	0.030	8.3	LOS A	0.1	1.0	0.05	0.63	48.7
26	R	13	0.0	0.030	8.6	LOS A	0.1	1.0	0.05	0.70	48.4
Approach		32	0.0	0.030	8.4	LOS A	0.1	1.0	0.05	0.66	48.6
North West: Mills North											
27	L	13	0.0	0.007	8.2	LOS A	0.0	0.0	0.00	0.69	49.0
28	T	1	0.0	0.007	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		14	0.0	0.007	7.6	LOS A	0.0	0.0	0.00	0.63	49.7
All Vehicles		64	0.0	0.030	7.5	NA	0.1	1.0	0.06	0.61	49.5

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 25: SIDRA OUTPUT FOR INTERSECTION (MILLS/EGGLESTON)

Unlicensed Trial Version

MOVEMENT SUMMARY

Site: Mills -Balmain

2016-AM
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: Balmian Crescent											
21	L	19	0.0	0.075	10.8	LOS A	0.4	2.7	0.03	0.95	46.3
22	T	38	0.0	0.075	10.3	LOS A	0.4	2.7	0.03	0.96	46.7
23	R	19	0.0	0.075	10.8	LOS A	0.4	2.7	0.03	1.04	46.2
Approach		76	0.0	0.075	10.6	LOS A	0.4	2.7	0.03	0.98	46.5
North East: Balmain North											
25	T	1	0.0	0.007	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
26	R	13	0.0	0.007	8.4	LOS A	0.0	0.0	0.00	0.72	48.6
Approach		14	0.0	0.007	7.8	LOS A	0.0	0.0	0.00	0.67	49.3
North West: Mills											
27	L	19	0.0	0.011	8.2	LOS A	0.0	0.0	0.00	0.67	49.0
29	R	1	0.0	0.011	8.4	LOS A	0.0	0.0	0.00	0.73	48.6
Approach		20	0.0	0.011	8.2	LOS A	0.0	0.0	0.00	0.67	48.9
South West: Balmain South											
30	L	1	0.0	0.002	10.8	LOS A	0.0	0.1	0.10	0.92	46.4
31	T	1	0.0	0.002	10.4	LOS A	0.0	0.1	0.10	0.92	46.7
Approach		2	0.0	0.002	10.6	LOS A	0.0	0.1	0.10	0.92	46.6
All Vehicles		112	0.0	0.075	9.8	NA	0.4	2.7	0.02	0.88	47.2

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 26: SIDRA OUTPUT FOR INTERSECTION (MILLS-BALMAIN)

Unlicensed Trial Version
MOVEMENT SUMMARY

Site: Liversidge - Balmain

2016-AM
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
North East: Liversidge North											
25	T	38	0.0	0.043	0.7	LOS A	0.3	2.4	0.25	0.00	54.8
26	R	19	0.0	0.043	8.9	LOS A	0.3	2.4	0.25	0.78	48.7
Approach		57	0.0	0.043	3.5	LOS A	0.3	2.4	0.25	0.26	52.6
North West: Balmain											
27	L	25	0.0	0.024	10.9	LOS A	0.1	0.7	0.14	0.91	46.4
29	R	1	0.0	0.023	10.9	LOS A	0.1	0.7	0.14	0.93	46.4
Approach		26	0.0	0.024	10.9	LOS A	0.1	0.7	0.14	0.91	46.4
South West: Liversidge South											
30	L	32	0.0	0.036	8.2	LOS A	0.0	0.0	0.00	0.84	49.0
31	T	38	0.0	0.036	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		69	0.0	0.036	3.7	LOS A	0.0	0.0	0.00	0.38	54.4
All Vehicles		153	0.0	0.043	4.9	NA	0.3	2.4	0.12	0.43	52.2

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 27: SIDRA OUTPUT FOR INTERSECTION (LIVERSIDGE/BALMAIN)

Unlicensed Trial Version
MOVEMENT SUMMARY

Site: Lennox- Bachelors

2016-AM
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Liversige South											
2	T	76	0.0	0.043	0.1	LOS A	0.3	2.1	0.10	0.00	58.0
3	R	6	0.0	0.043	8.5	LOS A	0.3	2.1	0.10	1.05	48.7
Approach		82	0.0	0.043	0.7	LOS A	0.3	2.1	0.10	0.08	57.2
East: Bachelors											
4	L	6	0.0	0.175	9.1	LOS A	0.9	6.6	0.23	0.55	47.8
6	R	133	0.0	0.174	9.4	LOS A	0.9	6.6	0.23	0.67	47.6
Approach		139	0.0	0.174	9.4	LOS A	0.9	6.6	0.23	0.66	47.6
North: Liversidge											
7	L	25	0.0	0.014	8.2	LOS A	0.0	0.0	0.00	0.68	49.0
8	T	1	0.0	0.014	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		26	0.0	0.014	7.9	LOS A	0.0	0.0	0.00	0.65	49.3
All Vehicles		247	0.0	0.174	6.4	NA	0.9	6.6	0.16	0.47	50.6

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 28: SIDRA OUTPUT FOR INTERSECTION (LENNOX/BACHELORS)

Unlicensed Trial Version

MOVEMENT SUMMARY

Site: Liversidge - Garran

2016-AM
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: McCoy Circuit											
21	L	23	0.0	0.322	8.8	LOS A	2.5	17.2	0.56	0.68	47.5
22	T	138	0.0	0.320	8.1	LOS A	2.5	17.2	0.56	0.64	47.4
23	R	173	0.0	0.320	13.1	LOS A	2.5	17.2	0.56	0.78	45.0
Approach		334	0.0	0.320	10.7	LOS A	2.5	17.2	0.56	0.71	46.1
North East: Liversidge North											
24	L	23	0.0	0.234	7.6	LOS A	1.7	11.9	0.37	0.59	48.6
25	T	175	0.0	0.233	6.9	LOS A	1.7	11.9	0.37	0.53	48.8
26	R	86	0.0	0.233	11.9	LOS A	1.7	11.9	0.37	0.75	45.8
Approach		284	0.0	0.233	8.5	LOS A	1.7	11.9	0.37	0.60	47.8
North West: Garran Rd											
27	L	35	0.0	0.149	8.1	LOS A	1.0	7.1	0.46	0.61	48.0
28	T	53	0.0	0.149	7.4	LOS A	1.0	7.1	0.46	0.56	48.1
29	R	75	0.0	0.149	12.4	LOS A	1.0	7.1	0.46	0.74	45.4
Approach		162	0.0	0.149	9.9	LOS A	1.0	7.1	0.46	0.66	46.7
South West: Liversidge South											
30	L	86	0.0	0.194	8.9	LOS A	1.4	9.9	0.57	0.68	47.6
31	T	69	0.0	0.195	8.2	LOS A	1.4	9.9	0.57	0.64	47.5
32	R	35	0.0	0.194	13.2	LOS A	1.4	9.9	0.57	0.79	45.0
Approach		191	0.0	0.194	9.4	LOS A	1.4	9.9	0.57	0.69	47.0
All Vehicles		971	0.0	0.320	9.7	LOS A	2.5	17.2	0.49	0.67	46.9

Level of Service (Aver. Int. Delay): LOS A. Based on average delay for all vehicle movements. LOS Method: Delay (RTA NSW).
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.
Roundabout Capacity Model: SIDRA Standard.

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SIDRA INTERSECTION

FIGURE 29: SIDRA OUTPUT FOR INTERSECTION (LIVERSIDGE/GARRAN)

Unlicensed Trial Version

MOVEMENT SUMMARY

Site: McCoy - Hales

2016 -AM
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: Hales Street											
21	L	284	0.0	0.241	8.4	LOS A	1.3	9.4	0.09	0.65	48.4
Approach		284	0.0	0.241	8.4	LOS A	1.3	9.4	0.09	0.65	48.4
East: McCoy East											
5	T	19	0.0	0.010	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		19	0.0	0.010	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
West: McCoy West											
11	T	38	0.0	0.019	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		38	0.0	0.019	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
All Vehicles		341	0.0	0.241	7.0	NA	1.3	9.4	0.08	0.55	50.0

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 30: SIDRA OUTPUT FOR INTERSECTION (MCCOY/HALES)

Unlicensed Trial Version

MOVEMENT SUMMARY

Site: McCoy- Gordon

2016-AM
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
North East: Gordon											
25	T	63	0.0	0.121	5.2	LOS A	0.8	5.4	0.07	0.39	51.9
26	R	133	0.0	0.121	12.3	LOS A	0.8	5.4	0.07	0.77	45.6
Approach		196	0.0	0.121	10.0	LOS A	0.8	5.4	0.07	0.65	47.4
North: McCoy North											
7	L	11	0.0	0.017	6.7	LOS A	0.1	0.7	0.12	0.51	50.0
9	R	14	0.0	0.017	10.2	LOS A	0.1	0.7	0.12	0.65	47.0
Approach		24	0.0	0.017	8.7	LOS A	0.1	0.7	0.12	0.59	48.2
South West: McCoy East											
30	L	38	0.0	0.054	5.6	LOS A	0.3	2.2	0.27	0.45	50.7
31	T	32	0.0	0.054	5.7	LOS A	0.3	2.2	0.27	0.46	50.6
Approach		69	0.0	0.054	5.6	LOS A	0.3	2.2	0.27	0.46	50.6
All Vehicles		289	0.0	0.121	8.9	LOS A	0.8	5.4	0.13	0.60	48.1

Level of Service (Aver. Int. Delay): LOS A. Based on average delay for all vehicle movements. LOS Method: Delay (RTA NSW).
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.
Roundabout Capacity Model: SIDRA Standard.

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SIDRA INTERSECTION

FIGURE 31: SIDRA OUTPUT FOR INTERSECTION (MCCOY/GORDON)

Unlicensed Trial Version
MOVEMENT SUMMARY

Site: Ellery - McCoy

2016 - AM
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: McCoy											
22	T	95	0.0	0.114	7.4	LOS A	0.7	5.1	0.33	0.54	48.7
23	R	38	0.0	0.114	12.5	LOS A	0.7	5.1	0.33	0.78	45.3
Approach		133	0.0	0.114	8.8	LOS A	0.7	5.1	0.33	0.61	47.7
East: Ellery East											
4	L	38	0.0	0.141	8.0	LOS A	0.9	6.4	0.16	0.60	48.5
6	R	158	0.0	0.141	10.2	LOS A	0.9	6.4	0.16	0.67	46.6
Approach		196	0.0	0.141	9.8	LOS A	0.9	6.4	0.16	0.65	46.9
North West: Ellery North											
27	L	6	0.0	0.039	6.7	LOS A	0.2	1.7	0.15	0.52	50.0
28	T	44	0.0	0.039	6.7	LOS A	0.2	1.7	0.15	0.52	49.9
Approach		51	0.0	0.039	6.7	LOS A	0.2	1.7	0.15	0.52	49.9
All Vehicles		379	0.0	0.141	9.1	LOS A	0.9	6.4	0.22	0.62	47.6

Level of Service (Aver. Int. Delay): LOS A. Based on average delay for all vehicle movements. LOS Method: Delay (RTA NSW).
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.
Roundabout Capacity Model: SIDRA Standard.

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SIDRA INTERSECTION

FIGURE 32: SIDRA OUTPUT FOR INTERSECTION (ELLERY/MCCOY)

Unlicensed Trial Version

MOVEMENT SUMMARY

Site: Ellery - Liversidge

2016 - AM
Giveway / Yield (Two-Way)

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: Ellery South											
21	L	29	0.0	0.145	8.2	LOS A	0.0	0.0	0.00	0.71	49.0
22	T	253	0.0	0.145	6.9	LOS A	0.0	0.0	0.00	0.59	50.4
Approach		282	0.0	0.145	7.1	LOS A	0.0	0.0	0.00	0.60	50.2
North West: Ellery North											
28	T	29	0.0	0.048	10.5	LOS A	0.4	2.9	0.49	0.29	46.2
29	R	18	0.0	0.048	12.1	LOS A	0.4	2.9	0.49	0.76	45.3
Approach		47	0.0	0.048	11.1	LOS A	0.4	2.9	0.49	0.47	45.9
South West: Liversidge West											
30	L	81	0.0	0.072	8.2	LOS A	0.0	0.0	0.00	0.66	49.0
32	R	53	0.0	0.072	8.4	LOS A	0.0	0.0	0.00	0.72	48.6
Approach		134	0.0	0.072	8.3	LOS A	0.0	0.0	0.00	0.68	48.8
All Vehicles		463	0.0	0.145	7.8	NA	0.4	2.9	0.05	0.61	49.3

Movement Performance - Vehicles

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 33: SIDRA OUTPUT FOR INTERSECTION (ELLERY/LIVERSIDGE)

Unlicensed Trial Version
MOVEMENT SUMMARY

Site: Ellery - East

2016 - AM
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Ellery South											
1	L	32	0.0	0.156	8.2	LOS A	0.0	0.0	0.00	1.02	49.0
2	T	272	0.0	0.156	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		303	0.0	0.156	0.9	LOS A	0.0	0.0	0.00	0.11	58.6
North: Ellery North											
8	T	76	0.0	0.063	1.4	LOS A	0.5	3.3	0.40	0.00	52.2
9	R	25	0.0	0.063	9.8	LOS A	0.5	3.3	0.40	0.87	48.6
Approach		101	0.0	0.063	3.5	LOS A	0.5	3.3	0.40	0.22	51.3
West: East Road											
10	L	88	0.0	0.166	10.8	LOS A	0.8	5.6	0.45	0.71	46.2
12	R	32	0.0	0.165	11.0	LOS A	0.8	5.6	0.45	0.82	46.1
Approach		120	0.0	0.165	10.8	LOS A	0.8	5.6	0.45	0.74	46.2
All Vehicles		524	0.0	0.165	3.6	NA	0.8	5.6	0.18	0.27	53.8

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 34: SIDRA OUTPUT FOR INTERSECTION (ELLERY/EAST)

Unlicensed Trial Version

MOVEMENT SUMMARY

Site: Kingsley - Hutton

2016 - AM
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South East: Hutton											
21	L	1	0.0	0.526	14.7	LOS B	4.0	28.3	0.53	0.88	43.5
23	R	311	0.0	0.465	14.5	LOS A	4.0	28.3	0.53	0.94	43.7
Approach		312	0.0	0.465	14.5	LOS B	4.0	28.3	0.53	0.94	43.7
North East: Kingsley North											
24	L	385	0.0	0.211	8.2	LOS A	0.0	0.0	0.00	0.67	49.0
25	T	6	0.0	0.211	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		392	0.0	0.211	8.1	LOS A	0.0	0.0	0.00	0.66	49.1
South West: Kingsley South											
31	T	1	0.0	0.003	4.2	LOS A	0.0	0.1	0.49	0.00	50.0
32	R	1	0.0	0.003	12.7	LOS A	0.0	0.1	0.49	0.75	45.4
Approach		2	0.0	0.003	8.4	LOS A	0.0	0.1	0.49	0.38	47.6
All Vehicles		705	0.0	0.465	10.9	NA	4.0	28.3	0.24	0.79	46.5

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS B. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 35: SIDRA OUTPUT FOR INTERSECTION (KINGSLEY/HUTTON)

Unlicensed Trial Version
MOVEMENT SUMMARY

Site: Childers - Hutton

2016 - AM
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
North East: Childers North											
25	T	1	0.0	0.001	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
26	R	1	0.0	0.001	8.4	LOS A	0.0	0.0	0.00	0.88	48.6
Approach		2	0.0	0.001	4.2	LOS A	0.0	0.0	0.00	0.44	53.7
North West: Hutton											
27	L	43	0.0	0.054	12.1	LOS A	0.4	3.1	0.35	0.64	45.6
29	R	22	0.0	0.054	11.9	LOS A	0.4	3.1	0.35	0.88	45.8
Approach		65	0.0	0.054	12.1	LOS A	0.4	3.1	0.35	0.72	45.7
South West: Childers South											
30	L	300	0.0	0.304	10.7	LOS A	2.1	14.6	0.02	0.98	46.4
31	T	105	0.0	0.304	10.2	LOS A	2.1	14.6	0.02	0.98	46.7
Approach		405	0.0	0.304	10.6	LOS A	2.1	14.6	0.02	0.98	46.5
All Vehicles		473	0.0	0.304	10.7	NA	2.1	14.6	0.06	0.94	46.4

LOS (Aver. Int. Delay): NA. The average intersection delay is not a good LOS measure for two-way sign control due to zero delays associated with major road movements.
Level of Service (Worst Movement): LOS A. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on the worst delay for any vehicle movement.

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SIDRA INTERSECTION

FIGURE 36: SIDRA OUTPUT FOR INTERSECTION (CHILDERS/HUTTON)

Unlicensed Trial Version

MOVEMENT SUMMARY

Site: Barry-Kingsley

2016 -AM
Signals - Fixed Time   Cycle Time = 50 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kingsley											
1	L	140	0.0	0.165	10.2	LOS A	1.6	11.3	0.43	0.69	46.8
3	R	63	0.0	0.071	15.6	LOS B	1.3	9.0	0.56	0.72	42.0
Approach		203	0.0	0.165	11.9	LOS A	1.6	11.3	0.47	0.70	45.2
East: Barry East											
4	L	158	0.0	0.304	24.0	LOS B	4.4	30.8	0.83	0.78	36.1
5	T	677	0.0	0.620	17.7	LOS B	9.3	64.8	0.92	0.79	38.0
Approach		835	0.0	0.620	18.9	LOS B	9.3	64.8	0.91	0.79	37.6
West: Barry West											
11	T	866	0.0	0.793	22.1	LOS B	12.9	90.4	0.98	0.96	35.2
12	R	203	0.0	0.791	34.9	LOS C	6.0	41.8	0.98	0.91	30.6
Approach		1069	0.0	0.793	24.6	LOS B	12.9	90.4	0.98	0.95	34.2
All Vehicles		2107	0.0	0.793	21.1	LOS B	12.9	90.4	0.90	0.86	36.4

Level of Service (Aver. Int. Delay): LOS B. Based on average delay for all vehicle movements. LOS Method: Delay (RTA NSW).
Level of Service (Worst Movement): LOS C. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on average delay for all vehicle movements.

FIGURE 37: SIDRA OUTPUT FOR INTERSECTION (BARRY/KINGSLEY)

Intersection Performance - Annual Values

Performance Measure	Vehicles	Pedestrians	Persons
Demand Flows (Total)	1,011,537 veh/y	76,320 ped/y	1,290,164 pers/y
Delay	5,930 veh-h/y	375 ped-h/y	7,491 pers-h/y
Effective Stops	872,616 veh/y	64,109 ped/y	1,111,248 pers/y
Travel Distance	613,813 veh-km/y	2,938 ped-km/y	739,513 pers-km/y
Travel Time	16,865 veh-h/y	1,003 ped-h/y	21,240 pers-h/y
Cost	512,133 $/y	19,254 $/y	531,387 $/y
Fuel Consumption	74,167 L/y		
Carbon Dioxide	185,416 kg/y		
Hydrocarbons	322 kg/y		
Carbon Monoxide	14,247 kg/y		
NOx	430 kg/y		

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SIDRA INTERSECTION

FIGURE 38: INTERSECTION PERFORMANE MEASURES (BARRY/KINGSLEY)

Appendix M: SIDRA Analysis of Proposed Change

Unlicensed Trial Version

MOVEMENT SUMMARY **Site: Barry-Kingsley - Adjusted**

2016 -AM
Signals - Fixed Time Cycle Time = 60 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kingsley											
1	L	68	0.0	0.100	10.2	LOS A	0.9	6.1	0.39	0.67	46.8
3	R	32	0.0	0.043	19.9	LOS B	0.9	6.2	0.63	0.71	38.8
Approach		100	0.0	0.100	13.2	LOS A	0.9	6.2	0.46	0.68	44.0
East: Barry East											
4	L	158	0.0	0.213	21.0	LOS B	4.3	30.2	0.69	0.77	38.0
5	T	780	0.0	0.500	14.8	LOS B	10.4	72.8	0.80	0.69	40.4
Approach		938	0.0	0.500	15.8	LOS B	10.4	72.8	0.78	0.70	40.0
West: Barry West											
11	T	866	0.0	0.555	15.2	LOS B	11.6	81.2	0.82	0.71	40.0
12	R	203	0.0	0.668	32.3	LOS C	6.3	43.8	0.92	0.85	31.8
Approach		1069	0.0	0.668	18.5	LOS B	11.6	81.2	0.84	0.74	38.2
All Vehicles		2107	0.0	0.668	17.0	LOS B	11.6	81.2	0.80	0.72	39.2

Level of Service (Aver. Int. Delay): LOS B. Based on average delay for all vehicle movements. LOS Method: Delay (RTA NSW).
Level of Service (Worst Movement): LOS C. LOS Method for individual vehicle movements: Delay (RTA NSW).
Approach LOS values are based on average delay for all vehicle movements.

FIGURE 39: SIDRA OUTPUT FOR IMPROVED INTERSECTION (BARRY/KINGSLEY)

Intersection Performance - Annual Values

Performance Measure	Vehicles	Pedestrians	Persons
Demand Flows (Total)	1,011,537 veh/y	76,320 ped/y	1,290,164 pers/y
Delay	4,788 veh-h/y	422 ped-h/y	6,168 pers-h/y
Effective Stops	728,117 veh/y	61,904 ped/y	935,645 pers/y
Travel Distance	613,523 veh-km/y	2,938 ped-km/y	739,165 pers-km/y
Travel Time	15,648 veh-h/y	1,050 ped-h/y	19,827 pers-h/y
Cost	475,989 $/y	20,157 $/y	496,146 $/y
Fuel Consumption	69,485 L/y		
Carbon Dioxide	173,712 kg/y		
Hydrocarbons	296 kg/y		
Carbon Monoxide	12,671 kg/y		
NOx	397 kg/y		

Processed: Saturday, 1 October 2016 3:09:00 PM
SIDRA INTERSECTION 5.0.5.1510

Project: C:\Users\Alex\MEGA\UNIVERSITY\2016 Semester 2\ENGN2226\Analysis of the ANU Traffic Network \SIDRA Model\PM Model\ANU Traffic Analysis.sip
Unlicensed Trial Version

FIGURE 40: IMPROVED INTERSECTION PERFORMANCE MEASURES (BARRY/KINGSLEY)

Appendix N: Location of Signalised intersections

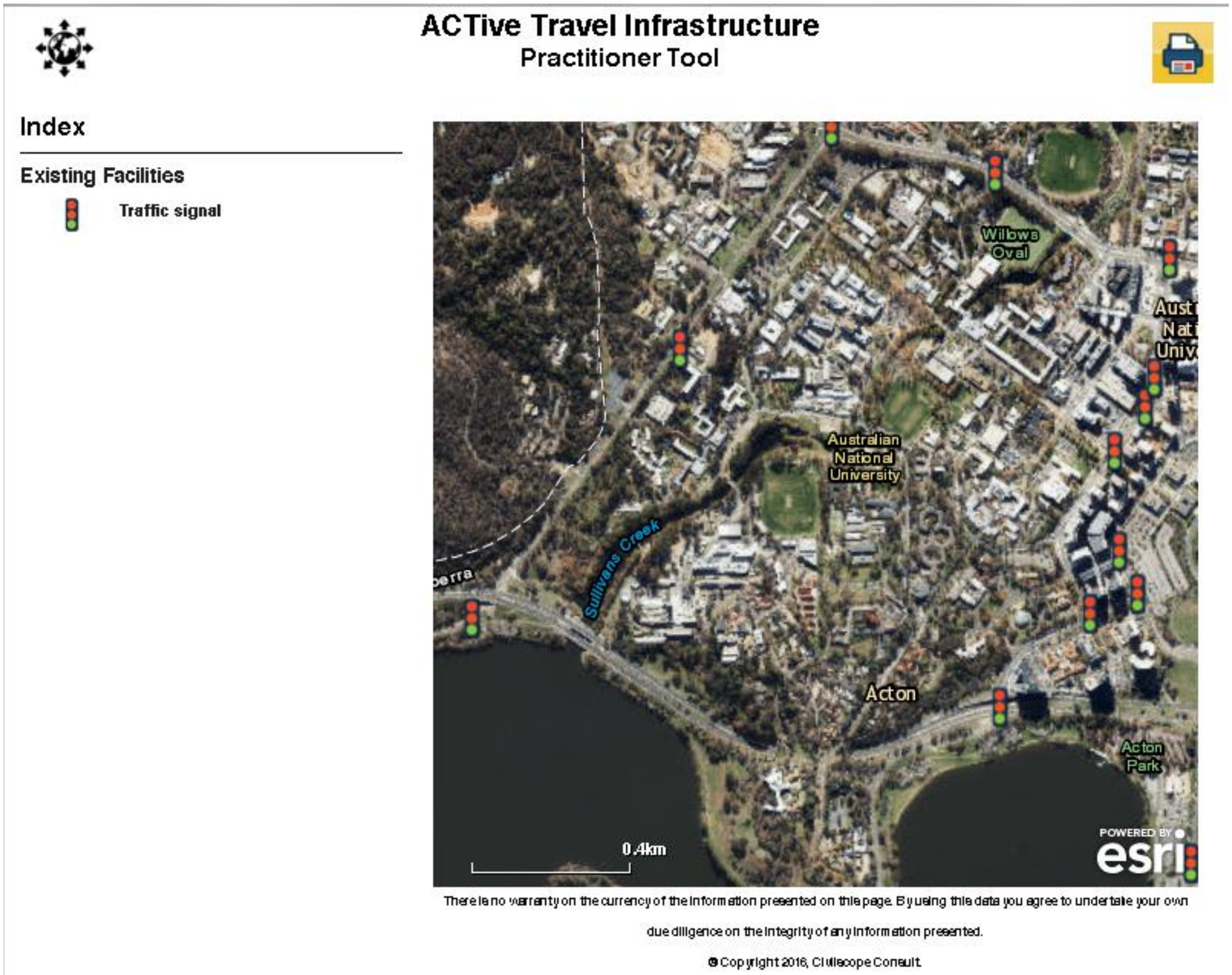

FIGURE 41: LOCATION OF TRAFFIC LIGHTS SURROUNDING THE ANU CAMPUS (ACT GOVERNMENT, 2016)

Appendix O: Carpark Analysis

Australian National University

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Director

Facilities & Services Division

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11 June 2015

CAR PARKING – Dickson Precinct Parking Station

The ANU has a multistorey car parking station on College Ave in the Dickson Precinct on the University's Acton Campus. The parking station has access from both College Ave and Clunies Ross Street.

The capacity of the parking station is 482 spaces. As at 30 April 2015 there were 257 spaces or 53.3% sold leaving 225 vacant spaces.

Attached are the usage reports depicting a week in previous months (Jan, Feb, March & May) of 2015. April data is unavailable as the counting system was out of order.

Yours sincerely

Christine Allard
Director
Facilities and Services Division

The Australian National University | Canberra ACT 0200 Australia | CRICOS Provider No. 00120C

FIGURE 42: LETTER FROM THE ANU REGARDING BURGMANN CAR PARK (SELLICK CONSULTANTS PTY LTD, 2015)

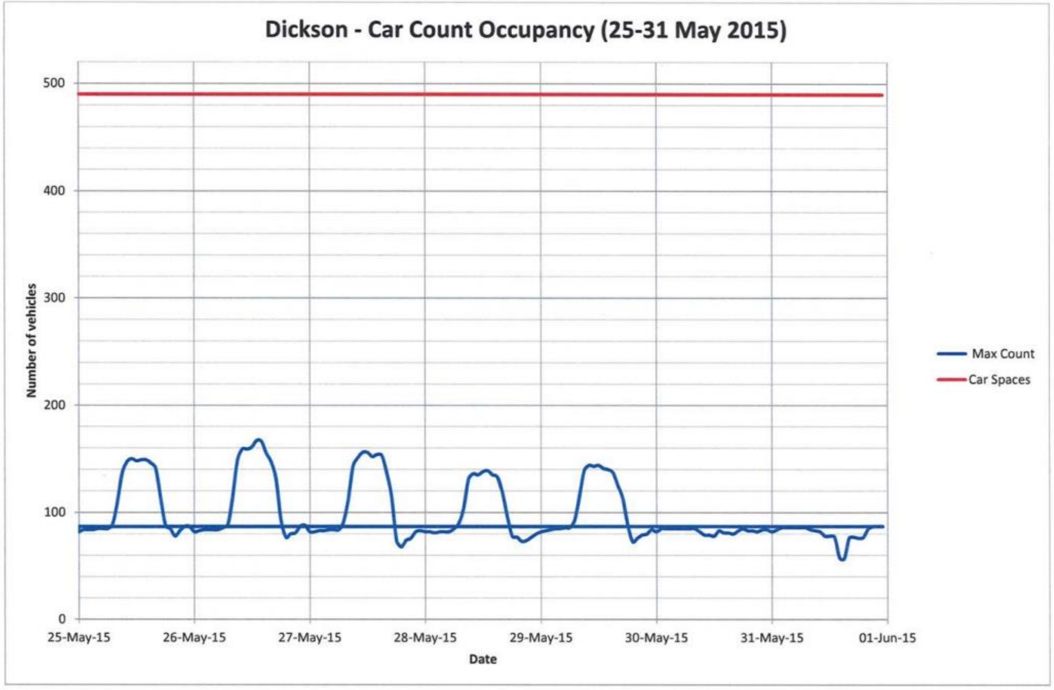


FIGURE 43: GRAPH FROM THE ANU REGARDING BURGMANN CAR PARK OCCUPANCY (SELLICK CONSULTANTS PTY LTD, 2015)

From this it can be seen that the Dickson Precinct carpark generates roughly 80 cars (slightly overestimating to be conservative) and this makes up approximately 16.6% of the car park. This will be used to calculate an estimation for every car park on campus. This is an assumption but one that is made due to time constraints and one that quite likely holds for most student parks. Also as the data and the letter have a conflict the validity of the data should be questioned in further work.

Carpark	Number of Car Spaces	Traffic Generated for 1 hour in peak(Cars)
Dickson Precinct carpark	482	80
Melville Hall	505	84
Bruce Hall	195	33
B and G	281	47
Physics	276	46
Kingsley	326	55
Balmain Lane	96	16
CBE Car Park	72	12
ANU Sport Car Parking	102	17
Chemistry Car Park	137	23

For the purpose of this report data was collected at the Burgmann car park by timing the average service time and noting the period of time over which these cars arrived. This was then processed using queuing theory, descriptive statistics, hypothesis testing and confidence intervals to find the average service time and then expand this to determine the chance the queue will need to hold a certain number of cars.

Service Time (s)	Confidence Interval	Date	31/08/2015	
14.8	5.296014665			
12.5	4.472985359			
7.6	2.719575098	Start Time	17:13	
14.9	5.331798548	Finish Time	17:42	
11.0	3.936227116	Minutes	29	
16.0	5.72542126			
11.5	4.115146531			*Units*
8.0	2.86271063	Average Arrival Rate	1.034	cars/minute
10.5	3.757307702	Average Service Time	11.600	seconds
10.6	3.793091585	Average Service Rate	5.172	cars/minute
7.9	2.826926747			
13.1	4.687688657	Utilisation Rate	20%	
12.0	4.294065945			
9.1	3.256333342	1 Hour max number of cars served	310.3448276	cars
16.3	5.832772909			
9.0	3.220549459			
16.1	5.761205143			
13.7	4.902391954			
14.2	5.081311368			
12.1	4.329849828	M/D/1		
12.3	4.401417594	Average number of Cars in the queue	0.025	
10.3	3.685739936	Average Waiting Time in the System	0.024166667	
9.0	3.220549459			
10.3	3.685739936	Percent Chance of	2	
10.3	3.685739936		car being in the queue	3.20%
13.9	4.97395972			
11.7	4.186714296	Average Length ofcar is	5	
9.3	3.327901107	Therefore Average Length of Queue is	0.125	
9.9	3.542604405			
10.1	3.61417217			

FIGURE 44: DATA COLLECTED AND PROCESSED FROM THE BURGMANN CAR PARK ENTRANCE

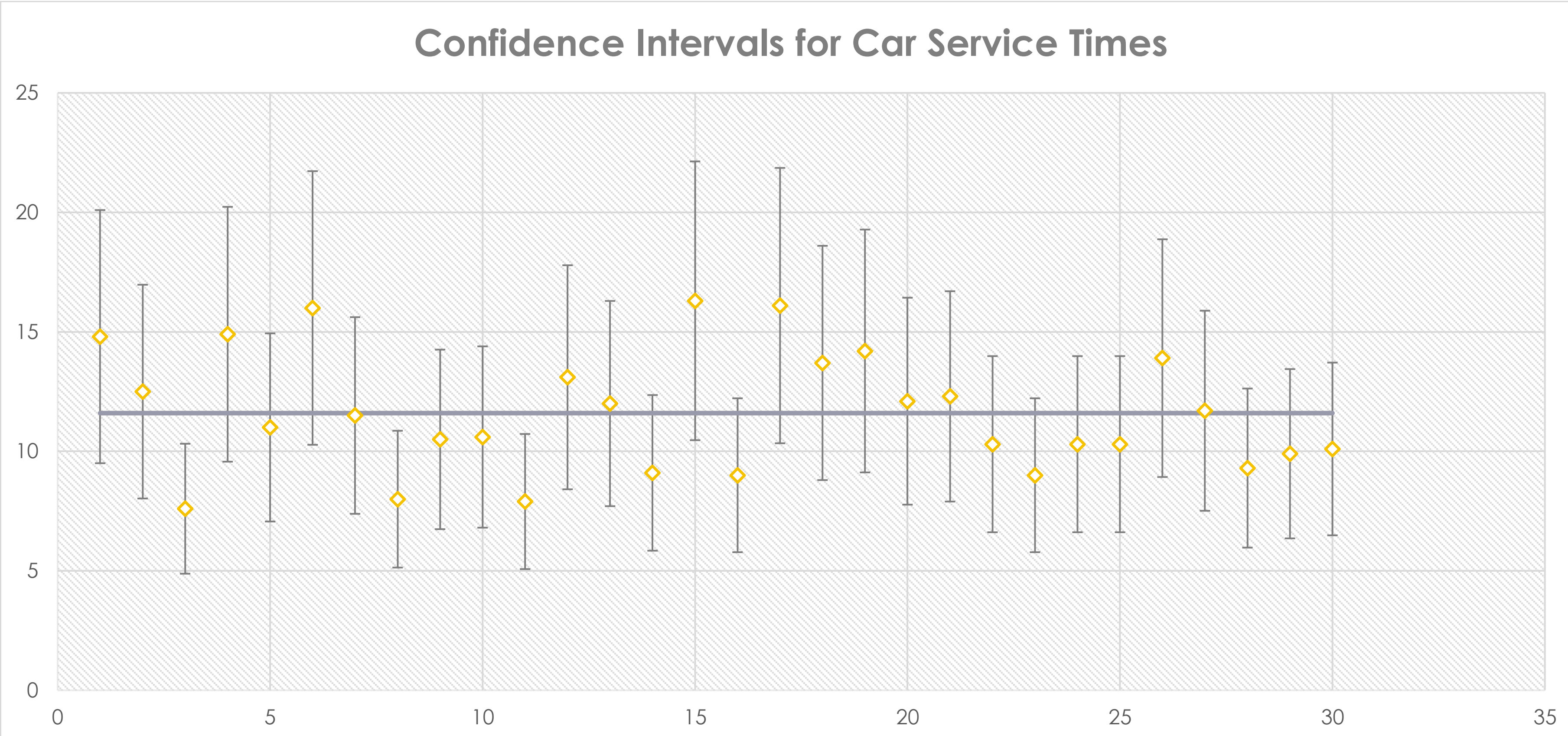


FIGURE 45: SERVICE TIMES FOR THE BURGMANN GROUND FLOOR GATE WITH CONFIDENCE INTERVALS AND AVERAGE CALCULATED

Appendix P: Road Treatments

This appendix includes a list of the possible traffic calming devices that can be implemented, advantages, disadvantages and the expected cost of these treatments. The data presented in this section is used to inform the recommendations and the economic analysis compiled in the report.

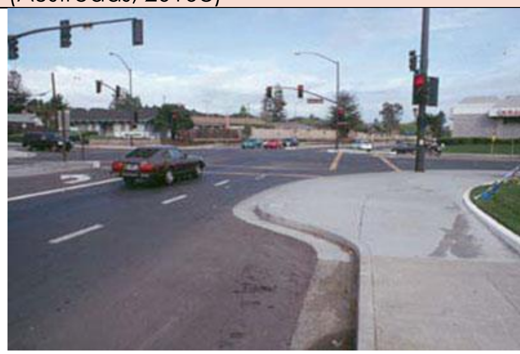
TABLE 10: POTENTIAL TRAFFIC CALMING DEVICES

Treatment	Picture	Pros	Cons	Cost
Traffic Lights	 (Kay, 2004)	Customisable phasing that can be changed at later point. Easily Enforced	Can cause a slowdown in traffic if implemented incorrectly. High Cost Option	$15,000 - $60,000 for a new signal
Surface Treatments	 (Kay, 2004)	Can provide a psychological warning to drivers of a shared use zone like the bottom of union court.	Doesn't actually require a reduction in speed.	$3,000

Roundabout	 (Austroads, 2016b)	Effective at reducing speed on all connecting roads on approach to intersection. Gives equal right of way to all movements so can help clear congestion.	Can be less effective as a main connecting road might become congested due to priority going to a low priority road. May not be suitable for cyclists. Any landscaping to improve appearance requires maintenance.	$6,000 – Highly dependent on complexity and aesthetics.
Channelised Right Turn Lane	 (Austroads, 2016c)	Increases Safety for turning vehicles Increased efficiency of through lane	The increased efficiency of the through road can result in increased speeding.	Unknown: Is expected to be expensive if the lane must also be widened to accommodate the extra through lane and will depend on the length of the lane etc. Is a cheap option if the lane is already wide enough to accommodate?

Raised Platform	 (Austroads, 2016b)	Increases awareness and hence safety of pedestrians crossing the road. Very effective at recuing the speed of vehicles.	Can increase noise generation. Generally high levels of complaint from the public upon installation.	$7,000 – No mention of size of road in the Austroads guidelines where this was found.
Pedestrian Refuge	 (Kay, 2004)	Increases safety of crossings for pedestrians. Can reduce the traffic speed due to lane narrowing.	Not as effective as a full pedestrian crossing.	$6,000 - $9,000 depending on materials and size.

Marked Shoulder	 (Arizonabikelaw, 2012)	Can reduce traffic speed due to increased friction with current traffic. Increased safety for vehicles turning right into driveways.	Line marking is easily crossed and therefore not as effective as a physical barrier.	Highly dependent on size. High fixed cost to get expertise and equipment on site but smaller cost for increasing the scope of the work.
Painted Median	 (Transportation, 2009a)	Can reduce traffic speed due to increased friction with the kerb. Increased safety for vehicles turning right.	Line marking is easily crossed and therefore not as effective as a physical barrier.	Highly dependent on size. High fixed cost to get expertise and equipment on site but smaller cost for increasing the scope of the work.

Centre Island	 (Austroads, 2016c)	Can reduce traffic speed due to increased friction with kerb. More effective than painted median for speed reduction.	Higher cost compared to marked shoulders.	$15,000-20,000 per 100 feet. Highly dependent on size.
Kerb Extension	 (Kay, 2004)	Can reduce traffic speed via increased friction with incoming traffic. More effective than marked shoulders for speed reduction.	Higher cost than marked shoulders.	Unknown
Speed Cushion	 (Austroads, 2016c)	Very effective at reducing traffic speed as a mid-block treatment.	Increase in noise generated. Generally high levels of complaints from the public upon installation.	$2,000 per hump.

Chicane	 (Kay, 2004)	Effective at reducing vehicle speed. Effective at improving safety at intersections.	Moderate cost Generally, not suitable for cyclists.	$14,000: Highly dependent on landscaping and size.

Appendix Q: New South Wales Guidelines for Sidra Analysis

Roads ACT | TAMS
Traffic Signal Section | Office of Transport

GUIDELINES FOR SIDRA ANALYSIS

The following outlines what is required to be included in traffic studies utilising Sidra. The guidelines seek to provide a base line for Sidra reports and ensure accurate modelling is undertaken.

The Following Reports should be Included in Modelling Reports:

Tables	Diagrams
Table B.1 – Movement Definitions & Flow Rates	Layout
Table B02 – Pedestrian Flow Rates	Movement Summary
Table S.8 – Lane Flow and Capacity Information	Phasing Summary
Table D.5 – Progression Factors & Actuated Signal Parameters	Queue Distance

Traffic Counts

The time when the traffic counts were taken (i.e. 1st Week March 2007) and any assumptions regarding turning proportions.

Default Values.

Saturation Flow Rate – 1850 vehicles / hour
Yellow Period – 60km/hr – 4 seconds
Yellow Period – 80 km/hr – 5 seconds
All Red Period – Intersection width < 30m – 2 Seconds (60km/hr)
All Red Period – Intersection width >30m – 3 Seconds (60km/hr)
All Red Period – Intersection width < 40m – 2 Seconds (>60km/hr)
All Red Period – Intersection width >40m – 3 Seconds (>60km/hr)

Mode of Operation.

For signalised intersections **Fixed** time should be used.

Cycle Time

For modelling existing conditions the cycle time used on site should be used. This information can be obtained from the traffic signals section. Do not allow Sidra to workout the optimal cycle time as this will most likely be different to the cycle time used by SCATS (on site).

Lane Lengths

Ensure lane lengths are accurate including short lanes / turning lanes (to nearest 5m).

Progression Factors

For **non-coordinated** approaches a progression factor of **3** is to be used.
For **coordinated** approaches a coordination factor of **4** is to be used.

Some approaches way warrant a progression factor of 5. If a progression factor of 5 is used it should be noted and justified within the traffic modelling report.

Queue Lengths

Ensure queue lengths are realistic. If the queue lengths will affect the surrounding intersections then this should be noted / taken into account in the modelling of the surrounding intersections.

Version 3.00 | Reviewed 11/02/2009
For clarification of the Guidelines please contact the Traffic Signal Section on 02 6207 5222

FIGURE 46: GUIDELINES FOR SIDRA ANALYSIS (ROADS & MARITIME, 2015)

Appendix R: ANU Pedestrian Counts

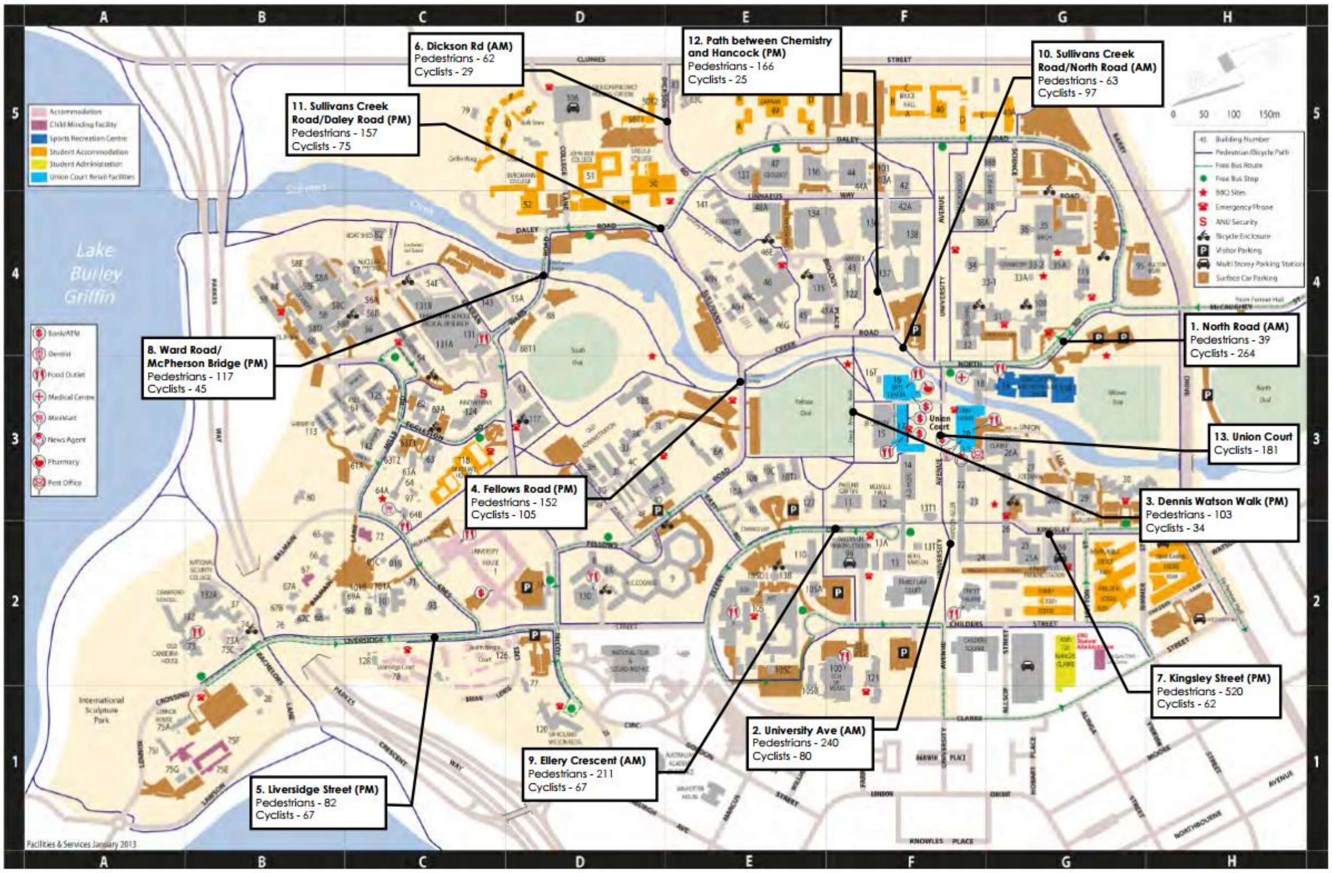


FIGURE 47: PEDESTRIAN AND CYCLIST TRAFFIC COUNTS CONDUCTED BY THE ANU (ANU SUSTAINABILITY OFFICE, 2013)