City of Wanneroo

# DISTRICT PLANNING SCHEME No. 2

Amendment No. 119

**FORM 1C**

**PLANNING AND DEVELOPMENT ACT 2005**

**RESOLUTION DECIDING TO AMEND A LOCAL PLANNING SCHEME**

**CITY OF WANNEROO**

**DISTRICT PLANNING SCHEME NO. 2 - AMENDMENT NO. 119**

RESOLVED that the Council, in pursuance of Section 75 of the Planning and Development Act 2005, amend the above local planning scheme by:

(i) Inserting a new clause 4.5.4 and 4.5.5 as follows:

"4.5.4 Split Density Code – Development

Where a split residential density code is depicted on the Scheme Maps, any development shall conform to the lower density code applicable to the lot, unless the Council determines that development up to the higher density code would comply with the following requirements:

a) Sufficient capacity exists in all necessary public utility services to adequately meet the needs of the development;

b) The development has one consolidated vehicular access point with reciprocal access rights to serve all dwellings, and restricted vehicular access to other areas of road frontage;

c) All dwellings located adjacent to the street frontage present to the streetscape and provide passive surveillance of the public realm; and

4.5.5 Split Density Code – Subdivision

Council will base its recommendations in respect to applications for subdivision of land depicted on the Scheme Maps with a split residential density code in accordance with the development requirements set out in clause 4.5.4."

(ii) Amending the scheme maps as depicted in Attachment 1.

Dated this day of 20

....................................................
CHIEF EXECUTIVE OFFICER

**TEXT MODIFICATION PAGE**

**PLANNING AND DEVELOPMENT ACT 2005**

**CITY OF WANNEROO**

**DISTRICT PLANNING SCHEME NO. 2 - AMENDMENT NO. 119**

The City of Wanneroo under and by virtue of the powers conferred upon it in that behalf by the Planning and Development Act 2005 hereby amends the above local planning scheme by:

(iii) Inserting a new clause 4.5.4 and 4.5.5 as follows:

"4.5.4 Split Density Code – Development

Where a split residential density code is depicted on the Scheme Maps, any development shall conform to the lower density code applicable to the lot, unless the Council determines that development up to the higher density code would comply with the following requirements:

a) Sufficient capacity exists in all necessary public utility services to adequately meet the needs of the development;

b) The development has one consolidated vehicular access point with reciprocal access rights to serve all dwellings, and restricted vehicular access to other areas of road frontage;

c) All dwellings located adjacent to the street frontage present to the streetscape and provide passive surveillance of the public realm; and

4.5.5 Split Density Code – Subdivision

Council will base its recommendations in respect to applications for subdivision of land depicted on the Scheme Maps with a split residential density code in accordance with the development requirements set out in clause 4.5.4."

(iv) Amending the scheme maps as depicted in Attachment 1.

# PLANNING AND DEVELOPMENT ACT 2005

# CITY OF WANNEROO

# DISTRICT PLANNING SCHEME NO 2 - AMENDMENT NO. 119

# SCHEME AMENDMENT REPORT

**Strategic Context**

The City of Wanneroo has a rapidly growing population that is projected to almost double to approximately 354,000 by 2036. To house this population and make efficient use of existing infrastructure, public transport, activity centres and community facilities Directions 2031 and Beyond sets a 'connected city' infill target of 47% for the Perth metropolitan area. This equates to approximately 33,000 dwellings being provided through infill development outside of the central sub region by 2031. The 2013 Delivering Directions 2031 Report Card sets an infill dwelling target of 16,360 for the City of Wanneroo by 2031. According to the 2014 Urban Growth Monitor the City of Wanneroo has only provided 194 dwellings towards reaching this target. The proposed amendment may enable the development of up to 18,500 additional infill dwellings, significantly contributing to the delivery of the regional infill dwelling targets from Directions 2031 and Beyond.

The City of Wanneroo Local Housing Strategy, which was adopted in 2005, aims to guide the future form and type of housing within the City of Wanneroo to ensure it is appropriate and affordable for future communities. Key objectives of the strategy are to:

- Promote appropriate forms of housing close to existing and proposed community facilities and services to enable more efficient and effective use of those facilities and services; and
- Ensure an overall residential density which will improve the viability and range of transport alternatives.

Increased residential density allows the development of a wider range of housing types to meet the needs of the population in the City of Wanneroo. It will help to reduce the rate of urban sprawl and the impacts of development on the environment by planning a more compact city.

The Local Housing Strategy analyses the existing residential development within the City of Wanneroo and identifies several areas that may be suitable for residential redevelopment due to the age of the existing housing stock, lot sizes and proximity to existing services and infrastructure.

In 2010 Council adopted Local Planning Policy 3.1: Local Housing Strategy Implementation (LPP 3.1) which introduced housing precincts in the suburbs of Wanneroo, Girrawheen-Koondoola, Quinns, Yanchep and Two Rocks. LPP 3.1 defined the boundaries of these housing precincts, identify the extent of potential density increases in these areas and provide guidance on the process for implementing the residential density increases in an orderly way. A subsequent amendment to LPP 3.1 was adopted in 2011, which expanded the areas to be recoded.

This scheme amendment will implement the recommendations of Directions 2031 and Beyond and the City of Wanneroo Local Housing Strategy and LPP 3.1 for the Wanneroo and Girrawheen-Koondoola housing precincts. It is intended to progress the recoding of the Quinns, Yanchep and Two Rocks housing precincts through a future scheme amendment.

**Background**

LPP 3.1 prioritises the Wanneroo and Girrawheen-Koondoola housing precincts as priority one and two for implementation, and requires the following three key issues to be addressed prior to, or as part of, a scheme amendment to increase the R-Coding in these areas:

1. *Assess the existing infrastructure provision and identify infrastructure upgrades needed to facilitate redevelopment at a higher density;*

   Following the adoption of the amended LPP 3.1, Administration engaged consultants to assess the capacity of the road, water and sewer networks and their ability to accommodate the higher densities proposed for the housing precincts. A copy of these studies is included as **Attachment 2** and **Attachment 3**. These desktop studies concluded that the following infrastructure upgrades may be required to achieve full development in the housing precincts:

   - Nine upgrades to Wanneroo Road to be funded by Main Roads WA;
   - Nine road upgrades to local and neighbourhood roads;
   - A main sewer in Girrawheen to be funded by the Water Corporation; and
   - Numerous upgrades to local water and sewer infrastructure.

   Further consultation with the Water Corporation following the completion of these studies has indicated that there may be more capacity within existing water and sewer infrastructure than what has been indicated in the consultant studies. A copy of this correspondence is included as **Attachment 4**. The Water Corporation has advised that this capacity may be sufficient to accommodate the proposed infill development without completing any infrastructure upgrades.

2. *Establishment of a development contribution arrangement for funding of infrastructure upgrades; and*

   The establishment of a development contribution arrangement to fund infrastructure upgrades was considered as a part of the City's preparation of this Amendment. However, it is not considered that a development contribution arrangement could be implemented equitably in accordance with State Planning Policy 3.6 – Development Contributions across such a large area. The Department of Planning has advised that they do not support the establishment of a development contribution arrangement to fund any necessary infrastructure upgrades in the housing precincts as they could not support an arrangement that would run for an uncertain amount of time.

   Based on the advice of the Water Corporation and Department of Planning the City has not proceeded with the preparation of a development contributions arrangement. Instead, the upgrading of local and neighbourhood roads is intended to be met by the City through existing road upgrade programs as and when required. Any upgrades to the local water and sewer network that may be required in the future are proposed to be met by private developers as and when the need arises. It is considered more rational to allow redevelopment to occur using existing capacity and only complete upgrades if and when that capacity has been reached.

3. *Introduction of provisions for the application of Design Guidelines to address the specific aspects and context of each housing precinct to facilitate appropriate future residential development and subdivision.*

   It is necessary to ensure that development within the housing precincts contributes to the streetscape and public realm of the local area. There is a risk that development allowed to proceed without design guidance or control could result in inactive street frontages characterised by a dominance of carports and garages, a proliferation of crossovers, and a reduced capacity for street trees and verge landscaping.

   Rather than prepare a specific design guideline, the provisions of the scheme amendment have been designed to address subdivision and development design issues. Further policy guidance may be prepared in the future to support the application of the proposed scheme provisions.

To address the infrastructure, funding and design issues identified above, the City is proposing to initiate an amendment to DPS 2 to implement a split density code for the Wanneroo and Girrawheen-Koondoola housing precincts.

**Detail**

The proposed amendment to DPS 2 comprises the following components:

<u>Amending the Scheme R-Code Maps to recode lots in the Wanneroo and Girrawheen-Koondoola housing precincts to R20/R40 and R20/R60.</u>

It is proposed to implement a split density code over the Girrawheen-Koondoola and Wanneroo housing precincts in accordance with the Scheme Amendment Maps included as **Attachment 1**.

In this case the base code reflects the existing R-Code, and the higher code reflects the R-Codes identified, and previously adopted by Council, in LPP 3.1.

The application of a split density code gives the City greater control and influence over subdivision and development than a conventional recoding by only allowing development at the higher R-Code where the proposed development can be adequately serviced and meets the necessary design requirements.

Where the servicing and design requirements cannot be met then the existing base code of R20 will apply and redevelopment at the higher R-Code cannot be approved.

<u>Introducing new provisions that apply to split code areas.</u>

To support the proposed split density code, it is proposed to introduce two new sub-clauses under clause 4.5 of DPS 2 – Special Application of the Residential Design Codes, which deal with the application of the split density code. These provisions provide guidance on development and subdivision applications.

The first clause applies to development proposals under the split density coding and sets out the criteria that must be met for the higher R-Code to apply. These criteria would be applied by the City in determining applications for planning approval. They aim to ensure that proposed development is capable of being adequately serviced, that it does not contribute to a proliferation of driveways and crossovers at the expense of usable, attractive streetscapes and that passive surveillance of the public realm is maintained as infill development occurs.

The second clause acknowledges that subdivision applications may also be made under the split density coding and that the City is not the determining authority for subdivision applications. It states that Council will base its recommendations on subdivision applications referred to it by the Western Australian Planning Commission on the same requirements for development applications.

**Comment**

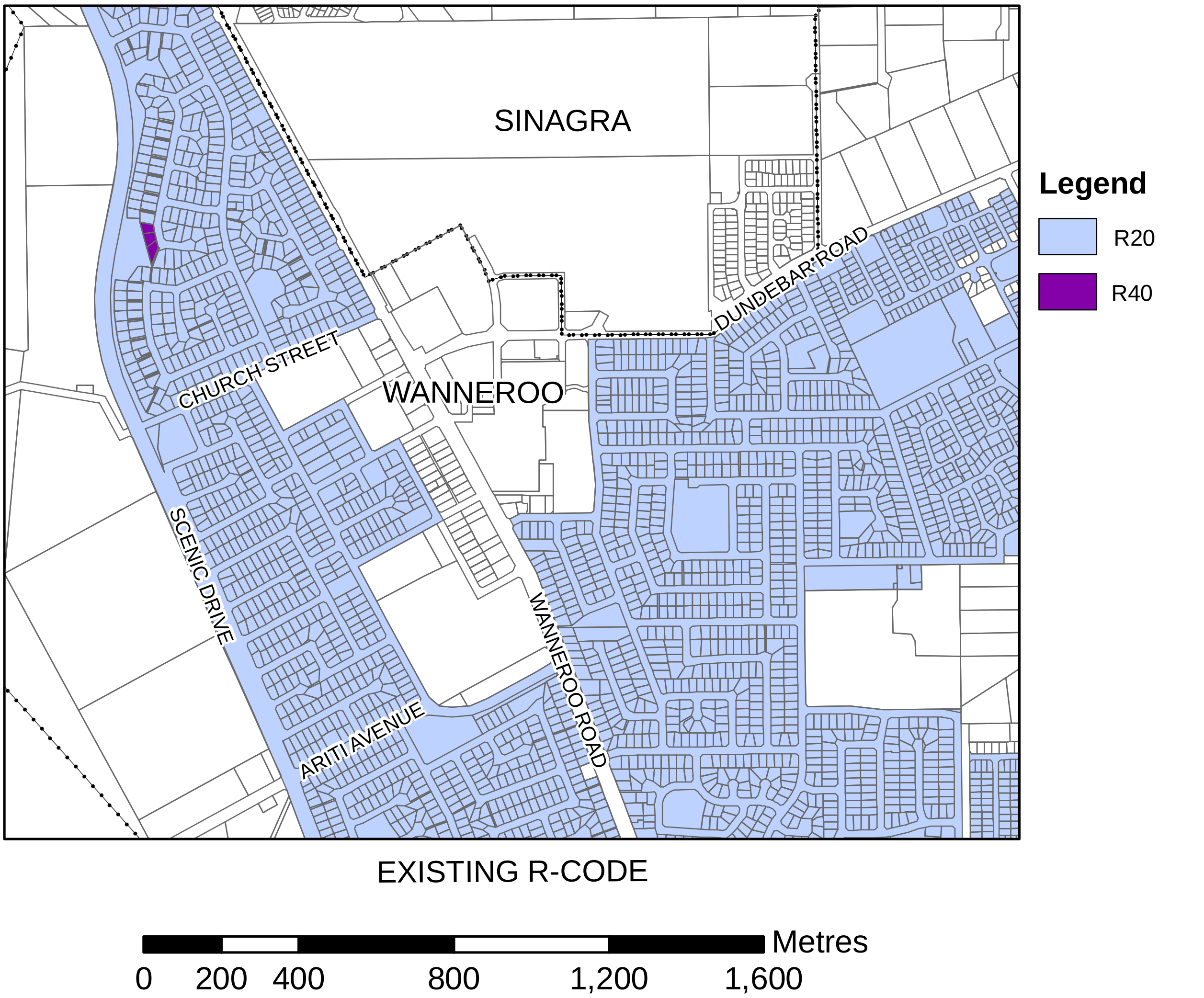
The implementation of a split density code over the Girrawheen-Koondoola and Wanneroo housing precincts is seen as the optimum solution to complex infrastructure and urban design issues. The split density code approach directly links any required infrastructure upgrades with actual development uptake rather than basing infrastructure upgrades on assumptions about when and where development might occur. It will also provide a safeguard against poor urban design outcomes and negative impacts on streetscapes and the public realm that could potentially result from infill redevelopment.

It is acknowledged that the split density code does not provide absolute certainty of the timing or location of future infrastructure upgrades, or unrestricted development opportunities for landowners within the housing precincts. It is possible that some land owners may not be able to proceed with development at the higher R Coding until infrastructure capacity is addressed and there may be a perceived inequality associated with this.

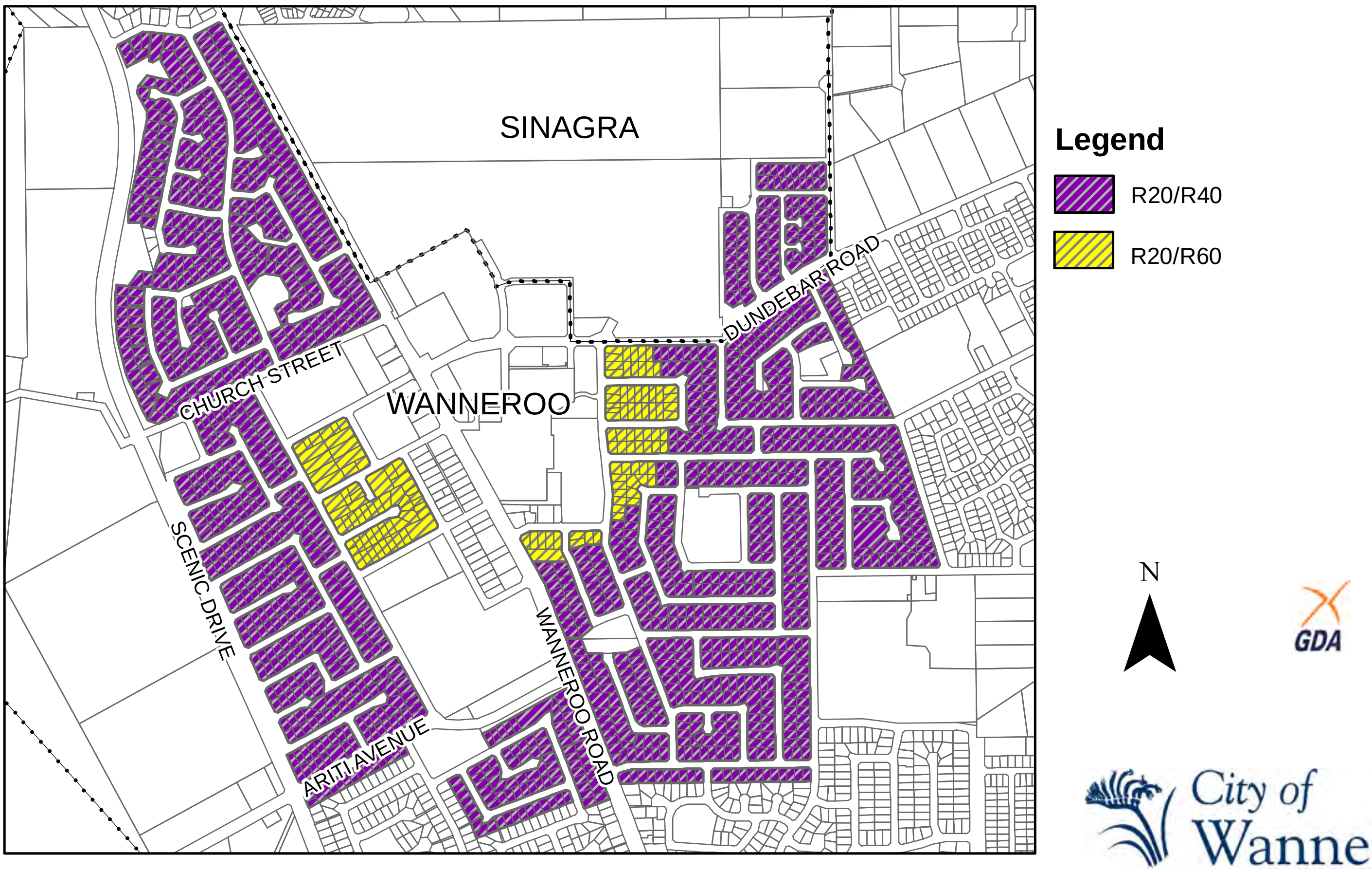
There may be a risk that the community expects the City to provide necessary infrastructure upgrades when capacity is reached. To mitigate this risk the City intends to closely monitor the uptake of development in the housing precincts and will continue to liaise with the Water Corporation to monitor infrastructure capacity. If and when infrastructure capacity is reached, Council has the ability, but is not required, to consider funding infrastructure upgrades to allow this development to proceed. Notwithstanding that potential infrastructure upgrades may be required; some infrastructure capacities may never be reached. The split code approach is therefore considered the most appropriate option given the uncertainty in relation to infrastructure capacity.

# ATTACHMENT 1 – SCHEME AMENDMENT MAPS

# CITY OF WANNEROO
# DISTRICT PLANNING SCHEME No. 2
# AMENDMENT No. 119




EXISTING R-CODE

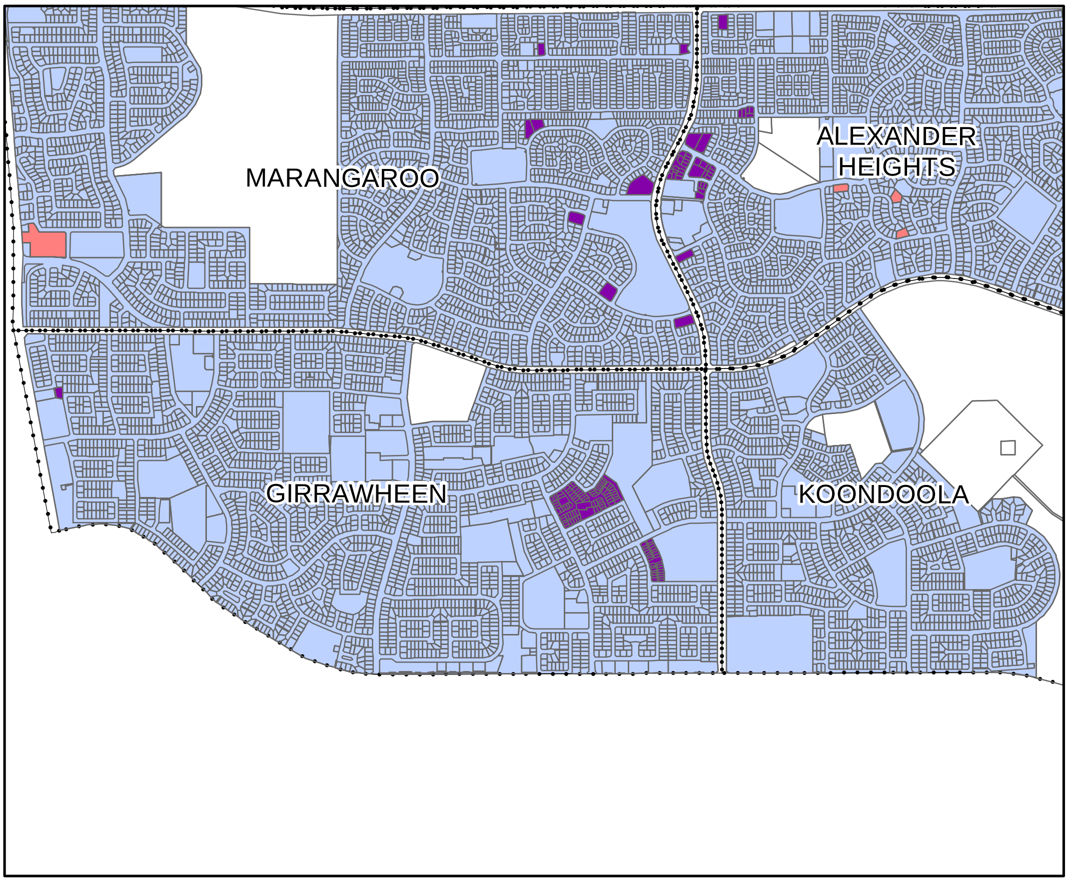



R-CODE (AMENDMENT) MAP

City of Wanneroo

Produced by Planning & Sustainability
7 January 2015

# CITY OF WANNEROO
# DISTRICT PLANNING SCHEME No. 2
# AMENDMENT No. 119

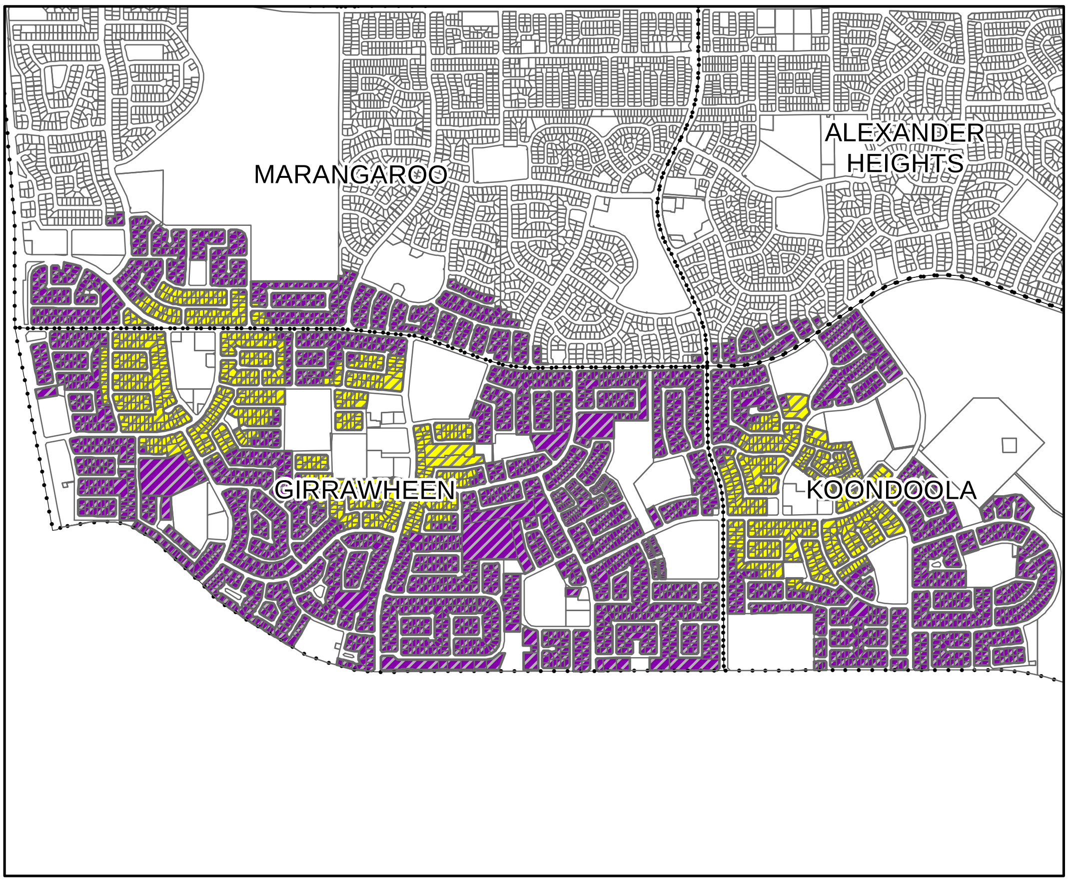



**Legend**

- R20
- R35
- R40

EXISTING R-CODE

0 0.5 1 2 3 4 Kilometres




**Legend**

- R20/R40
- R20/R60

N

GDA

R-CODE (AMENDMENT) MAP

City of Wanneroo

Produced by Planning & Sustainability
7 January 2015

# ATTACHMENT 2 – WATER AND SEWER CAPACITY STUDY

# Sewer & Water Capacity Assessment

## Wanneroo & Girrawheen-Koondoola Precincts

E11042

Prepared for
City of Wanneroo

January 2013

Cardno
Shaping the Future

# Document Information

| | |
|---|---|
| Prepared for | City of Wanneroo |
| Project Name | Wanneroo & Girrawheen-Koondoola Precincts |
| File Reference | E11042-001 City of Wanneroo-Sewer & Water Assessment-JT.docx |
| Job Reference | E11042 |
| Date | January 2013 |

# Contact Information

**Cardno WA Pty Ltd**
**Trading as Cardno**
ABN 77 009 119 000

11 Harvest Terrace, West Perth WA 6005

Telephone: 08 9273 3888
Facsimile: 08 9486 8664
International: +61 8 9273 3888

wa@cardno.com
www.cardno.com

# Document Control

| Version | Date | Author | Author Initials | Reviewer | Reviewer Initials |
|---|---|---|---|---|---|
| 1 | 29/10/12 | Jarryd Treacy | JT | Paul Broadhurst | PAB |
| 2 | 25/01/13 | Jarryd Treacy | JT | Paul Broadhurst | PAB |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

# Executive Summary

Cardno was engaged by the City of Wanneroo (the City) to undertake a sewer and water review for services within the Wanneroo and Girrawheen-Koondoola housing precincts (the Precincts).

The work scope for the study required Cardno to:

- Assess the capacity of the existing infrastructure within the Precincts.
- Determine the future maximum number of dwellings as a result of the new planning scheme.
- Determine what upgrades are required to the existing infrastructure so that the increased demand due to the Town Planning Scheme Amendment can be supported.
- Assess the cost of the required upgrades and determine approximate trigger dates.

In carrying out the study, the following information was collected and reviewed:

- Local Housing Strategy Plans
- Report titled 'Estimated Rates of Development of New Dwellings in Wanneroo' by the City of Wanneroo
- The Water Corporations review of sewer reticulation capacity within the Precincts
- Notes from the Water Corporation explaining methodology for calculating water reticulation capacities
- Digital data showing alignments and sizes of existing water & sewer reticulation

The Water Corporations review of the existing water headworks infrastructure found that no immediate upgrades were required to support redevelopment in the short term future. Their review of the sewer headworks infrastructure found a significant section of sewer that would require upgrading prior to redevelopment being permitted within a major catchment area in the Girrawheen-Koondoola Precinct. The Water Corporation advised that they would monitor capacity over the long term and make additional headworks upgrades when required.

Cardno's assessment of water and sewer reticulation found that several areas within the precincts required significant immediate upgrades before any redevelopment would be approved by the Water Corporation. However, it was found that the majority of catchments within the precincts had no immediate capacity restrictions and would be approved for redevelopment if the amended planning scheme was rolled out to these areas in advance of the capacity restricted catchments.

It was estimated that the cost of upgrading water reticulation infrastructure within the critical catchments (catchments flagged for upgrades within 2 years) would be in the order of $3,990,000 (excl GST). From 2014 onwards, upgrades will cost approximately $2.2 million per decade on average until the expected maximum build out date (2081). The total extent of recommended water main upgrades is 22,418m at an estimated cost of $19.5 million over 68 years.

The total extent of recommended sewer main upgrades is 629m at an estimated cost of $720,000 over 26 years. The first upgrade required is predicted to be in 2016 at an estimated cost of $210,000.

# Table of Contents



# Appendices



# Tables

# 1 Background

The project covers two areas within the City of Wanneroo, the Wanneroo precinct and the Girrawheen-Koondoola precinct. The City of Wanneroo (the City) has chosen these two precincts for re-zoning as a part of the recommendations put forward in the Local Housing Strategy (2005) and Local Planning Policy 3.1. The locality and re-zoning is shown by the City's Local Housing Strategy Implementation plans (Appendix A).

The City of Wanneroo engaged Cardno to undertake a sewer and water capacity assessment in order to review the adequacy of the existing services within the Precincts and to determine any necessary upgrades which would be required to support future demand as a result of the amendment to the town planning scheme.

Prior to Cardno commencing the project, the Water Corporation were requested by the City to complete the headworks review for the Precincts. This review included the assessment of sewer pressure mains, pumping stations and treatment plants, and all water reticulation pipes 300mm in diameter and larger to determine if the capacity of these assets would be sufficient to cope with future demand. The Water Corporation advised that no water or sewer headworks assets would require immediate upgrading to increase capacity. During their review, the Water Corporation also reviewed the sewer reticulation network and their findings were provided to Cardno to assist with their assessment.

# 2 Servicing Investigations

## 2.1 Water Reticulation

### 2.1.1 Capacity Assessment

Cardno requested the Water Corporation to provide all required information necessary to undertake the water reticulation capacity assessments in both the Girrawheen-Koondoola and Wanneroo precincts. This included all existing reprographics covering both precincts as well as capacities of all existing pipe types and methods for calculating the capacities of complex networks. The Water Corporation provided all required information, noting that the data for existing pipe capacities was now considered conservative as water consumption has reduced in recent years. The Water Corporation was in the process of reviewing the data but the revised data would not be available for this review. The Water Corporation requested that this data not be published.

Cardno liaised with The City in order to determine a method for estimating the future maximum dwelling numbers based on the proposed planning codes of R40 and R60 within each precinct. It was agreed that for R40 coded areas, the predicted maximum dwelling number for a given area would be the developable area divided by 240m$^2$(the predicted average area per dwelling), for R60 coded areas the developable area would be divided by 210m$^2$. The difference between the predicted maximum dwellings and the current number of dwellings was then reduced by 25% to allow for factors such as lot owners not wanting to subdivide and lots that couldn't be subdivided for any reason (the method for this calculation is further explained in the report under Appendix B). The resulting figure is described as the estimated number of dwellings (75% build out) on the concept design drawings.

In order to assess the capacity of the network within the precincts, they were divided into smaller catchment areas as per the methods advised by the Water Corporation for assessing water reticulation networks. The catchment areas were assessed by comparing the capacity of existing pipes versus the estimated future number of dwellings to determine if any upgrades would be required within the catchment. If future demand was higher than existing capacity, the minimum possible upgrade was applied in order to exceed future demand whilst complying with Water Corporation design standards.

After the initial assessment process by Cardno, drawings showing recommended upgrades were issued to the City and the Water Corporation for review and comment. The Water Corporation performed a technical review of the assessment and recommended minor changes to the otherwise approved drawings which have been incorporated into the final drawings and cost estimates.

### 2.1.2 Cost Estimates

As the Water Corporation manages the construction of all upgrades to their existing assets, Cardno requested their advice for estimating the cost of upgrades for each catchment. The Water Corporation were not willing to provide any figures for upgrading pipes citing many variables which would make it very difficult to estimate a cost to some degree of accuracy without an extensive review of each catchment. The variables which will cause significant variation of rates between catchment areas include:

- Locations of existing services that need to be protected
- Number/size of trees that need protection/removal.
- Extent of traffic management required.

- Number/complexity of bore shots under driveways/intersections.

- Location of valves - trenches need to be kept open until lot connections are switched from old to new water mains which will incur traffic & safety management costs.

- Reinstatement costs - brick paving/turf/concrete/asphalt etc.

Taking these points into consideration, it should be emphasized that the cost estimates provided in this report are concept level estimates and any decisions based on these estimates should reflect this.

In order to determine realistic rates for calculating the cost estimates, Cardno assessed costs from several recent jobs where similar works were undertaken. Rates were then determined for three aspects of the works to be undertaken: Preliminaries ($25,000 per catchment), installation of water main ($380-$550/m depending on pipe size), and reinstatement ($195/m). An allowance was also made for engineering fees and contingency which has been estimated at 20% of construction costs.

#### 2.1.3 Trigger Date Estimates

Trigger dates were determined in order to estimate when upgrades for each catchment would be required to be constructed such that supply can meet demand at all times. Based on the advice from The City that full build out (to 75%) is expected to occur by 2081, a linear rate of development was determined by dividing the additional number of dwellings estimated for each catchment by the time (69 years) it will take to reach this number. The trigger dates were then determined by adding the rate of development to the number of existing dwellings and finding the year when demand (estimated number of dwellings) overtook supply (existing capacity). The formula used is as follows:

$$\text{Trigger Date (year)} = 2013 + \frac{(C-E)}{(F-E)/(2081-2013)}$$

Where: C = Capacity of existing water reticulation (No. dwellings)

E = Number of existing dwellings

F = Estimated number of dwellings as at 2081

As development rates are rarely linear, it should be noted that the City will be required to monitor development and liaise with the Water Corporation on a yearly basis to determine actual trigger dates for each catchment.

## 2.2 Sewer Reticulation

### 2.2.1 Capacity Assessment

Cardno obtained all required information for the sewer capacity assessment from the Water Corporation. This included the reprographics which included all existing sewer alignments and pipe sizes as well as existing flows entering the precincts from adjacent catchments. Water Corporation also provided their own sewer reticulation review which identified the headworks upgrades required to cope with the increased demand. The headworks review included existing pipes over 300mm in diameter as well as pipes currently less than 300mm in diameter that would need to be upgraded to 300mm. Cardno completed an independent review to determine upgrades required for reticulation which included all pipes with an upgraded size of less than 300mm in diameter. The Water Corporation also reviewed Cardno's assessment using their own method for determining critical pipes which identified several more pipes that will require upgrading.

In completing Cardno's assessment, the precincts were broken up into catchments and areas were calculated for both R40 and R60 developable land within each catchment. These areas could then be used to calculate flow rates for the sewer network based on future maximum population density as per the Water Corporation design manual for gravity sewers (DS 50). DS 50 was then used to determine which existing pipes would be unable to cope with the increased flow that would be created and suitable upgraded pipe sizes were chosen.

### 2.2.2 Cost Estimates

As per the water reticulation cost estimates, the Water Corporation were not willing to provide advice for estimating the cost to upgrade the sewer reticulation. The variables described in section 2.1.2 also apply to estimating the cost of the sewer reticulation, as well as the following significant factors:

- Alignment of sewer – Significant portions of the existing sewer are currently located within private property (generally at the back of lots). The Water Corporation require that the sewer reticulation be relocated to the road reserve where possible and significant design work will be required to determine a suitable alignment.
- Trench or trenchless – Most, if not all of the sewer installation may be done by trenchless technique. The decision to use trench or trenchless will depend on several factors including depth of sewer, final alignment, duplication or replacement of sewer, and existing assets (above & below ground).
- Duplication or replacement of sewer – In some sections, it may be more practical to duplicate the sewer rather than replace it resulting in smaller pipes being used. Further investigations will be needed to determine the locations where this method may be viable.

Taking these points into consideration, it should be emphasized that the cost estimates provided in this report are concept level estimates and any decisions based on these estimates should reflect this.

## 2.3 Assessment Outcomes

### 2.3.1 Water

The assessment of the water reticulation network within the two precincts found that significant upgrades will be required as a result of the amendment to the town planning scheme. Concept design drawings have been produced to show the proposed upgrades for each catchment (Appendix C). Several catchments have been identified as critical which means the demand is currently higher than the theoretical supply capacity.

A brief summary of cost estimates sorted by trigger dates is shown below. A more comprehensive breakdown of costs estimates, trigger dates and quantities is shown under Appendix D.

**Table 2-1 Summary of estimated costs for water reticulation upgrades**

| Trigger Date | Total Cost (Excl GST) | Catchments |
|---|---|---|
| Critical | $3,990,000 | W4, GK3, GK7, GK10, GK18, GK22, GK28, GK31, GK8, GK13, GK36 |
| 2015 | $876,000 | GK16 |
| 2017 | $1,029,000 | GK21 |
| 2020-2029 | $2,467,000 | GK30, GK25, GK12, GK17, GK14, GK15, GK19 |
| 2030-2039 | $2,143,000 | GK1, W5, GK23, GK37, GK4, W3 |
| 2040-2049 | $2,460,000 | W1, GK5, GK11, GK34, GK33 |
| 2050-2059 | $2,316,000 | GK9, GK32, GK26, W10, W7, W8 |
| 2060-2069 | $2,055,000 | GK35, W6, W2, GK29, GK24, GK6 |
| 2070-2081 | $2,106,000 | GK38, GK2, W9, GK20, GK27 |

The following comments and assumptions can be made regarding the cost estimate for the upgrading of water reticulation within the Precincts:

- Cost estimates are intended to be all inclusive allowing for items such as engineering & surveying fees, mobilisation, traffic management, protection of existing assets and reinstatement.

- No allowance has been made for inflation of construction and material costs as it is not certain when construction will commence. An allowance of 3% inflation per year should be made when predicting future construction costs.

- Rates for scheduled items are based on rates for similar activities from recent projects that have been managed by Cardno.

- Cost estimates are concept level only. Costing advice should be updated regularly as the design process progresses.

- Trigger dates are estimates only. Development rates should be monitored closely with trigger dates updated accordingly.

- It is assumed that horizontal drilling techniques will be used to install water mains under intersections in order to reduce traffic management requirements and prevent unnecessary road closures.

- It is assumed that reinstatement will be required for a 2.5m width over the alignment of the proposed water mains.

- It is assumed that the new water mains will be installed adjacent to existing water mains with the redundant water mains remaining in the ground.

As shown in table 1, a number of catchments have already reached capacity or are expected to reach capacity within the next 2 years. It is recommended that these catchments be upgraded prior to amending the planning scheme for these areas. If possible, it may be beneficial to roll out the planning scheme such that other areas within the Precincts may be redeveloped without being restricted by the need for upgrades within the critical catchments.

It is recommended that a developer's contribution scheme be considered by the City in order to recoup the costs associated with upgrading the water reticulation. Although catchment boundaries on the drawings show lots which directly affect the required upgrades for each given catchment, all lots within the Precincts indirectly contribute to requirement for increased capacity. As such, it is recommended that all lots with the Precincts be subject to contributions for upgrades.

### 2.3.2 Sewer

The assessment of the sewer reticulation network within the two precincts found that a significant section of the existing 230mm diameter sewer main within the Girrawheen-Koondoola precinct requires upgrading to 300mm diameter. The main in question services the majority of the catchments within the precinct and runs from the connection to the trunk main near the intersection of Wanneroo Rd & Shortland Way, down to Beach Rd, then up and along Nanovich Ave. The extent of the proposed upgrade is shown on the concept design under Appendix E (GSU4). As this section of sewer is being upgraded to 300mm diameter, it is considered a headworks upgrade which falls under the responsibility of the Water Corporation. The Water Corporation advised that upgrade of this sewer main would be a condition of redevelopment, as such, the trigger date for the proposed works is considered critical at present.

It was found that 4 minor sections of 150mm diameter sewer reticulation would require upgrading to 225mm diameter mains as shown under Appendix E (WSU1 & GSU1-3) totaling a length of 629m. These upgrades will not be funded by the Water Corporation and come to an estimated cost of $720,000 as per the summary below.

**Table 2-2 Summary of estimated costs for sewer reticulation upgrades**

| Trigger Date | Total Cost (Excl GST) | Catchment |
|---|---|---|
| 2016 | $210,000 | GSU2 |
| 2027 | $127,000 | GSU3 |
| 2036 | $257,000 | GSU1 |
| 2039 | $125,000 | WSU1 |

The following comments and assumptions can be made regarding the cost estimate for the upgrading of sewer reticulation within the Precincts:

- Cost estimates are intended to be all inclusive allowing for items such as engineering & surveying fees, mobilisation, traffic management, protection of existing assets and reinstatement.

- No allowance has been made for inflation of construction and material costs as it is not certain when construction will commence. An allowance of 3% inflation per year should be made when predicting future construction costs.

- Rates for scheduled items are based on rates for similar activities from recent projects that have been managed by Cardno.

- Cost estimates are concept level only. Costing advice should be updated regularly as the design process progresses.

- Trigger dates are estimates only. Development rates should be monitored closely with trigger dates updated accordingly.

- It is assumed that horizontal drilling techniques will be used to install all sewer mains.

- Reinstatement costs relate to the disturbed areas due to bore pits and relocated sewer pits.

- It is assumed that the new sewer mains will be installed adjacent to existing sewer mains with the redundant sewer mains remaining in the ground. Allowance has been made for relocation/reconstruction of sewer pits for this reason.

It is recommended that a developer's contribution scheme be considered by the City in order to recoup the costs associated with upgrading the sewer reticulation. Catchment boundaries shown on the drawings identify all lots which contribute to the increased flow in the section of sewer that requires upgrading. The City is to determine whether to collect contributions from only lots within these catchments or to apply a flat contribution amount for all lots within the Precincts in addition to the contribution for water reticulation upgrades.

# 3 Recommendations and Conclusions

It is recommended that:

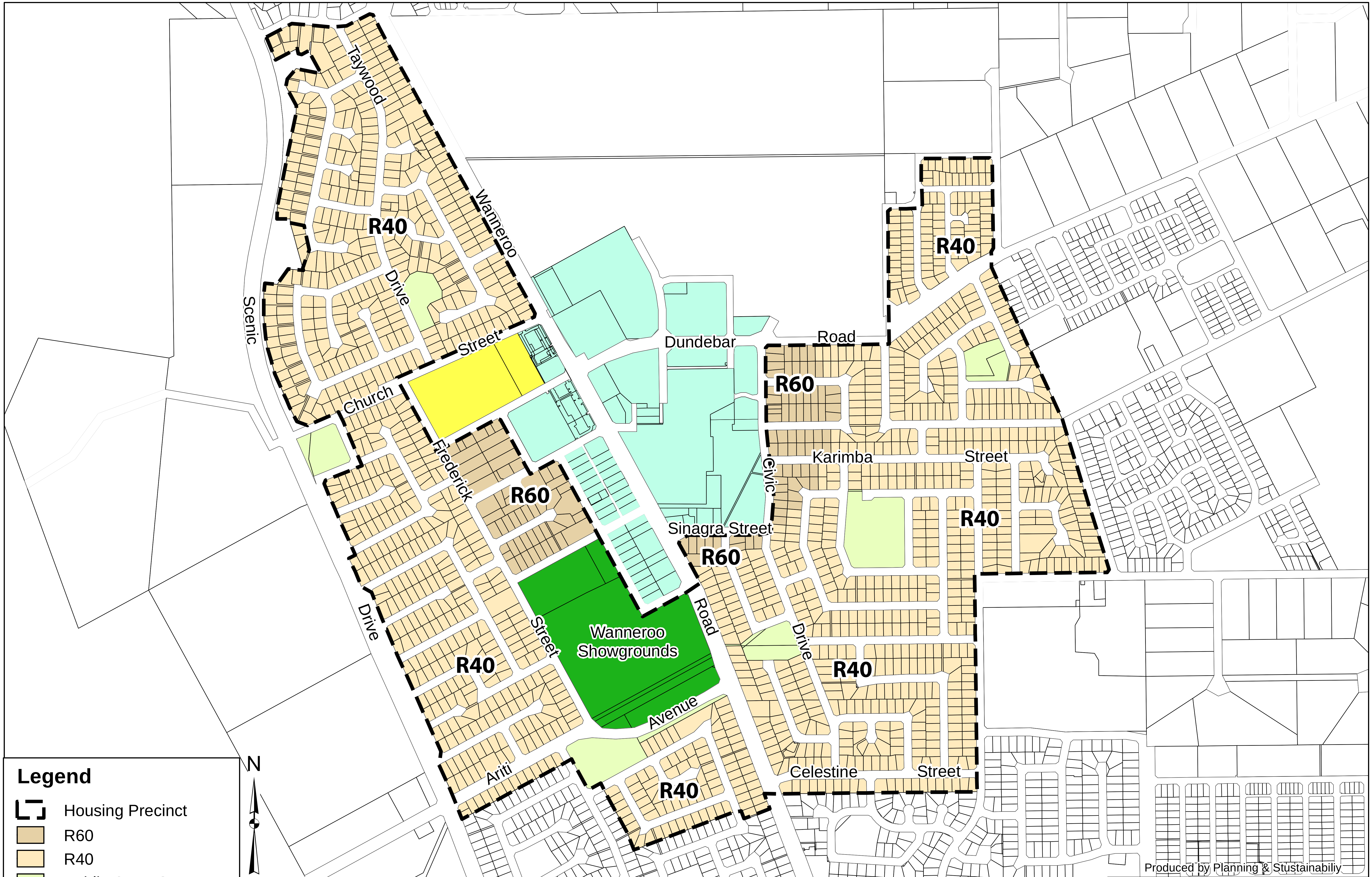
- Upgrades to water reticulation within catchments identified as critical are completed prior to allowing any redevelopment within these areas.
- The amended planning scheme is rolled out gradually such that areas not restricted by water & sewer capacities may be redeveloped prior to critical upgrades being completed.
- The City considers the introduction of a developer's contribution scheme such that the City is not responsible for the full cost of the upgrades for both water and sewer reticulation.
  - For water reticulation upgrades, contributions to be collected from all lots within both Precincts.
  - For sewer reticulation upgrades, the City to decide whether contributions be collected from all lots or lots within catchment boundaries only.
- The City continually monitors development rates and adjust trigger dates as required.

It is concluded that:

- Significant upgrades are required to both the existing sewer and water infrastructure to ensure they can cope with future demand.
- The estimated total cost to upgrade water reticulation infrastructure within the Precinct for critical catchments within the next two years is $3,990,000 (excl GST).
- Excluding works recommended within the next two years, upgrades will cost approximately $2.2 million per decade on average until the expected maximum build out date (2081).
- The estimated total cost for upgrades to sewer reticulation infrastructure is $720,000 (excl GST).
- A major sewer headworks upgrade is to be undertaken by the Water Corporation before a significant area within the Girrawheen-Koondoola Precinct is approved for redevelopment.

Wanneroo & Girrawheen-Koondoola Precincts

# APPENDIX A
LOCAL HOUSING STRATEGY PLANS




## Legend

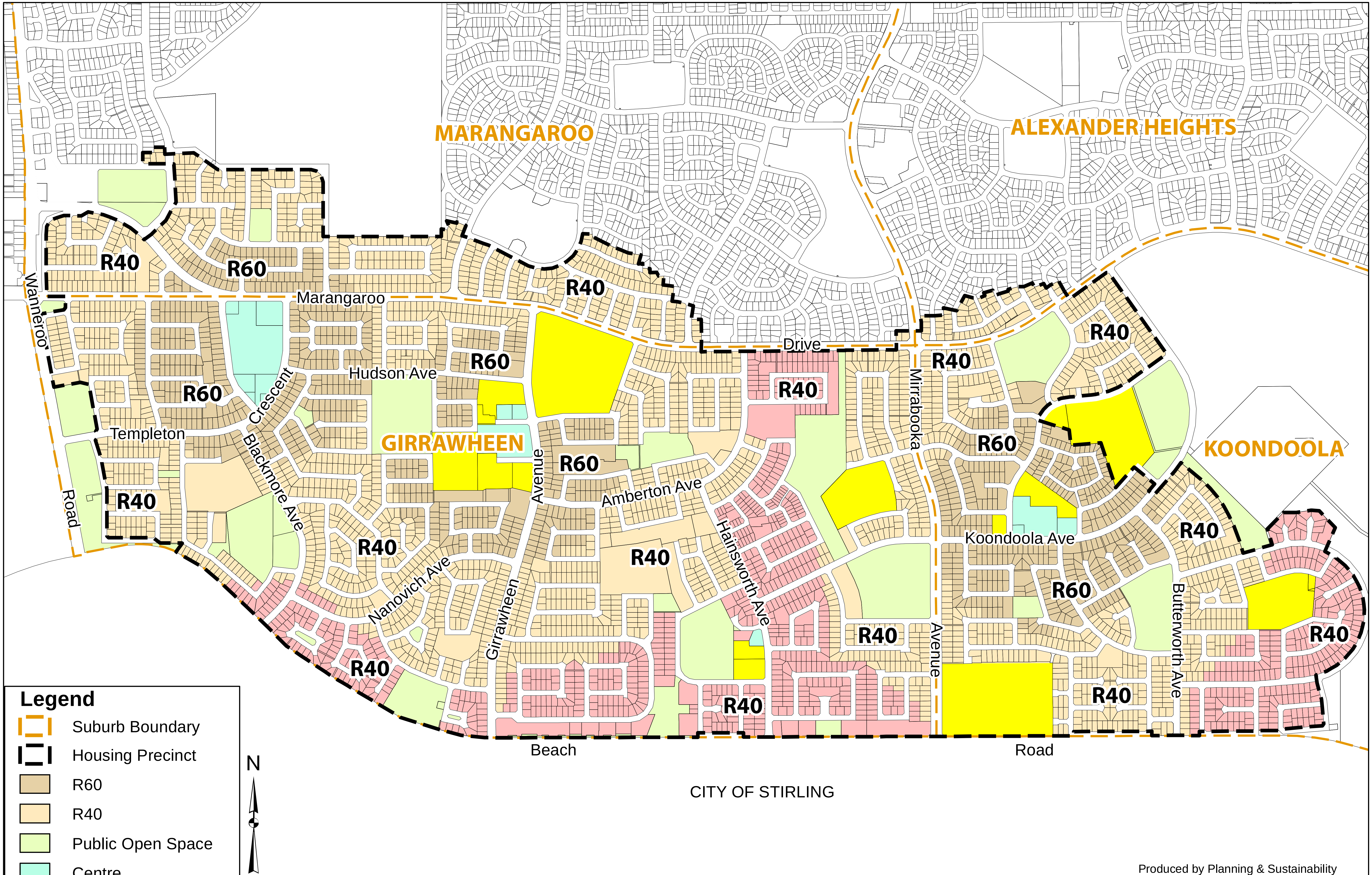
- Housing Precinct
- R60
- R40
- Public Open Space
- Centre
- Public Purpose

Local Housing Strategy Implementation:

# Wanneroo Housing Precinct

0 100 200 400 600 800
Metres

City of Wanneroo




## Legend

- Suburb Boundary
- Housing Precinct
- R60
- R40
- Public Open Space
- Centre
- Public Purpose
- Extended Area R40

Produced by Planning & Sustainability

City of Wanneroo

Local Housing Strategy Implementation:

# Girrawheen - Koondoola Housing Precinct

Wanneroo & Girrawheen-
Koondoola Precincts

# APPENDIX B
## ESTIMATED RATES OF DEVELOPMENT OF NEW DWELLINGS IN WANNEROO

# City of Wanneroo Local Housing Strategy

## *Estimated Rates of Development of New Dwellings in Wanneroo and Girrawheen-Koondoola Precincts*

***January 2011***

# Table of Contents

# Estimated Rates of Development of New Dwellings in Wanneroo, Koondoola and Girrawheen Precincts

## Background

This document supports the City of Wanneroo's Draft Amendment to Local Planning Policy 3.1: Local Housing Strategy Implementation (LHS).

The LHS identifies six 'Housing Precincts' divided across the suburbs of Wanneroo, Koondoola, Girrawheen, Yanchep, Two Rocks and Quinns Rocks. The Housing Precinct boundaries identified in the LHS are generally based on close proximity/easy access to existing retail and employment centres, public transport nodes, high amenity public open space, recreational facilities, major arterial routes and community facilities/education institutions.

These Housing Precincts are targeted for an increase in density coding from R20 to R40 or R60 as identified on LHS maps below.

The recommended density increases will require amendments to the City of Wanneroo District Planning Scheme No. 2 (DPS 2). In addition, other planning issues may also need to be addressed prior to or in support of amendment proposals. This includes assessment of the existing infrastructure provision and identification of possible infrastructure upgrades needed to facilitate redevelopment at a higher density, possible establishment of development contribution arrangements for funding of infrastructure upgrades, and preparation of design guidelines

## Introduction

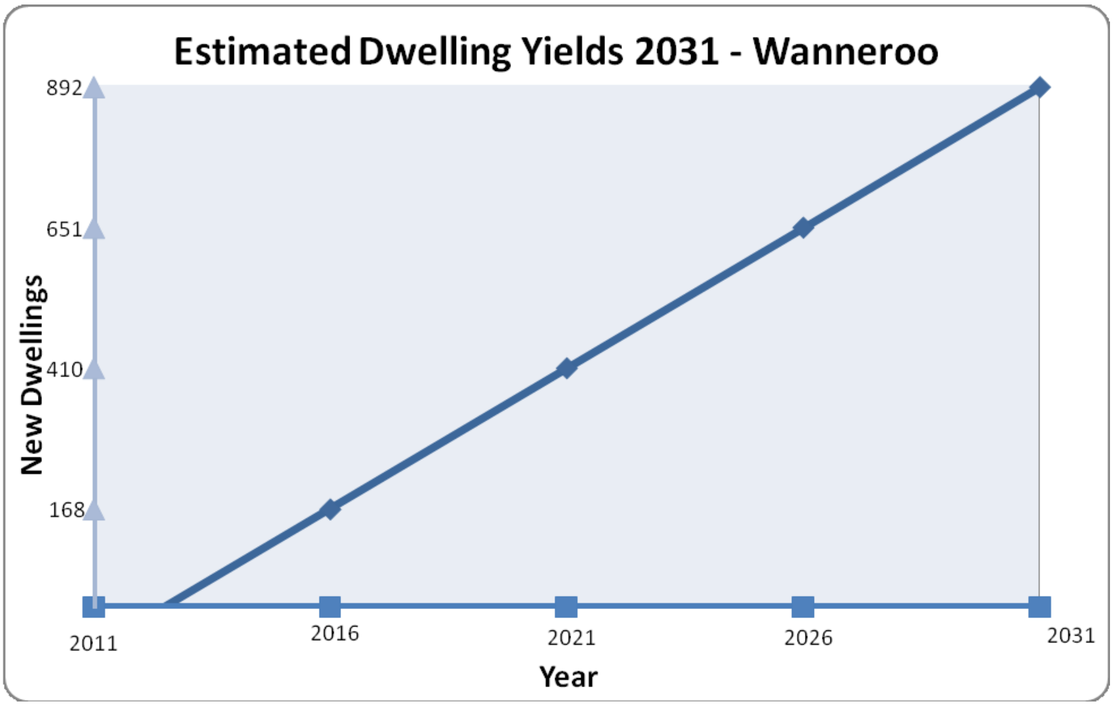
Discussion in this document will focus on the estimated rates of development of new dwellings in the precincts of Wanneroo and Girrawheen-Koondoola, as identified by the LHS. The methodology of how the City of Wanneroo calculated these rates of development will also be discussed.

The main purpose of this document is to enable service agencies to accurately assess both their relevant existing infrastructure and to identify any infrastructure upgrades that may be required by 2031 in the Housing Precincts of Wanneroo and Girrawheen-Koondoola using the following models created by the City of Wanneroo.

**Wanneroo Housing Precinct**

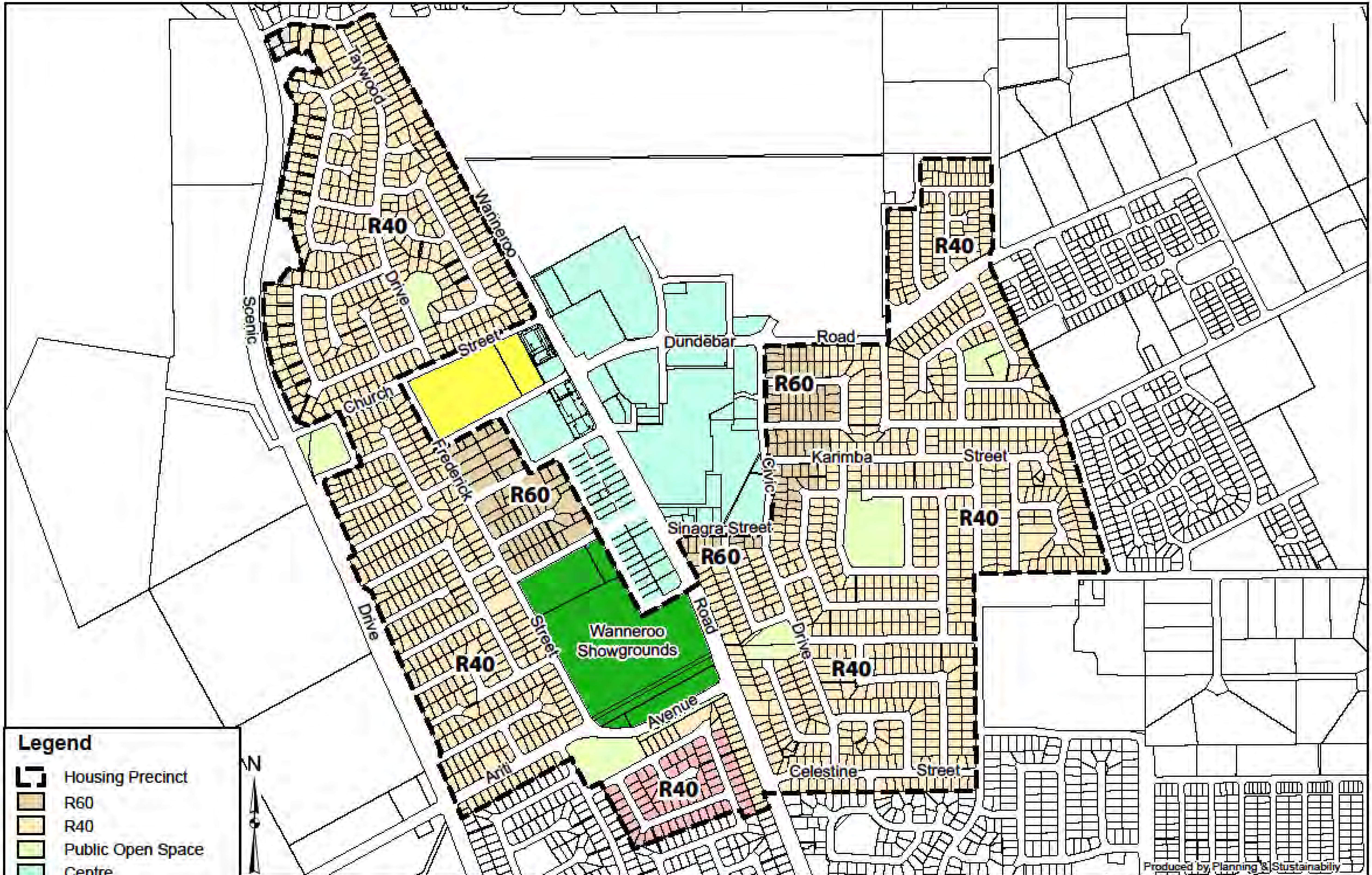
The following graph shows the estimated dwelling yields for the Wanneroo Housing Precinct.

Graph 1




As shown by Graph 1 above, it is estimated that by 2031, there shall be a total of 892 new dwellings in the Wanneroo Housing Precinct. This equates to roughly 45 new dwellings per year.

As explained below in 'Methodology', this figure is approximated using a number of techniques that reflect a realistic development scenario. If, however, every landowner was to subdivide his/her land to its maximum potential then the theoretical number of new dwellings that could be constructed would be 3678. Having said this, it is estimated that in over 80 years time at final build out, due to constraints in land layout, existing dwelling layout, personal reasons or location, this number will be closer to 2758 (75% of 3678).



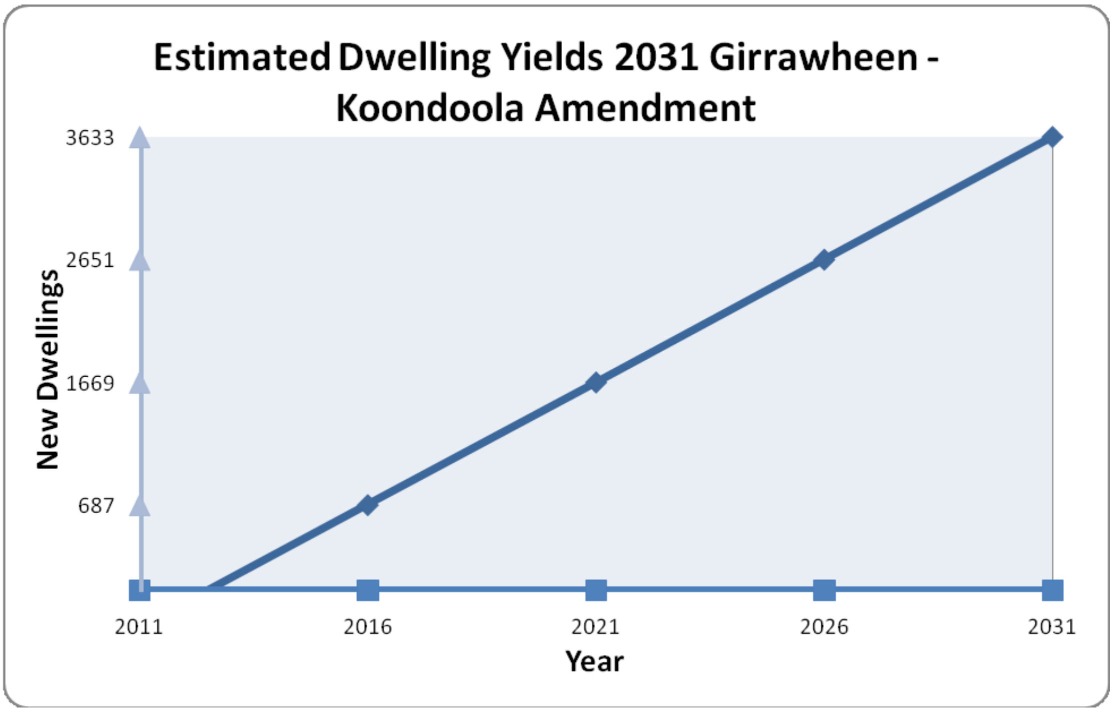

Local Housing Strategy Implementation:

Wanneroo Housing Precinct

**Girrawheen-Koondoola Housing Precinct**

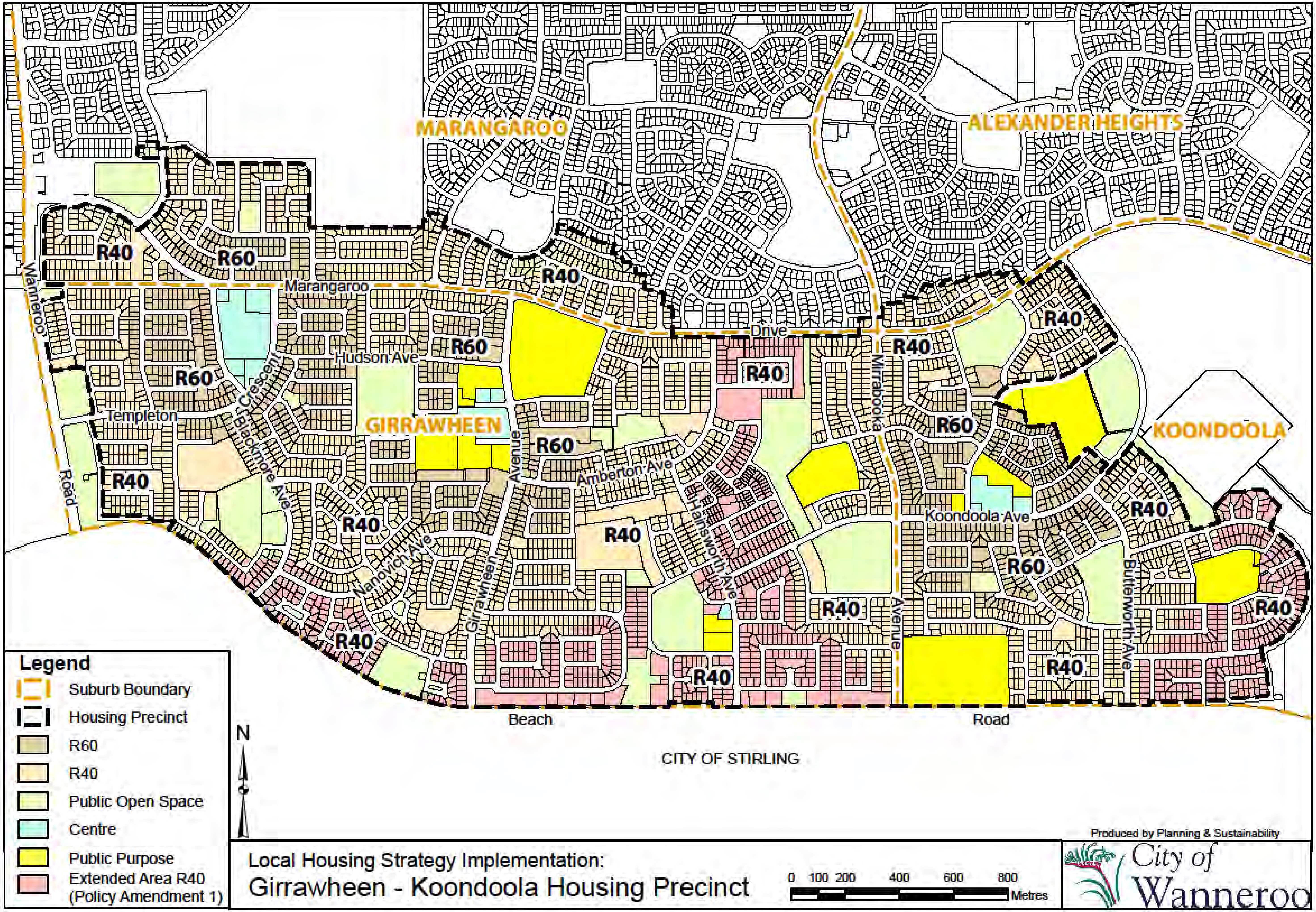
The following graph shows the estimated dwelling yields for the Girrawheen-Koondoola Housing Precinct.

Graph 2




As shown by Graph 2 above, it is estimated that by 2031, there shall be a total of 3,633 new dwellings in the Girrawheen-Koondoola Housing Precinct. This equates to roughly 181 new dwellings per year.

As explained below in ‘Methodology’, this figure is approximated using a number of techniques that reflect a realistic development scenario. If, however, every landowner was to subdivide his/her land to its maximum potential then the theoretical number of new dwellings that could be constructed would be 14,964. Having said this, it is estimated that in over 80 years time at final build out, due to constraints in land layout, existing dwelling layout, personal reasons or location, this number will be closer to 11,223. (75% of 14,964).


MARANGAROO
ALEXANDER HEIGHTS
GIRRAWHEEN
KOONDOOLA
R40
R60
R40
R60
R40
R60
R40
R40
R60
R60
R60
R40
R40
R40
R40
R60
R40
R40
R40
R40
Marangaroo
Drive
Wanneroo
Road
Hudson Ave
Templeton
Blackmore Ave
Crescent
Girrawheen
Avenue
Amberton Ave
Hainsworth Ave
Nanovich Ave
Mirrabooka
Avenue
Koondoola Ave
Butterworth Ave
Beach
Road
CITY OF STIRLING
N
Legend
Suburb Boundary
Housing Precinct
R60
R40
Public Open Space
Centre
Public Purpose
Extended Area R40
(Policy Amendment 1)
Local Housing Strategy Implementation:
Girrawheen - Koondoola Housing Precinct
0 100 200 400 600 800
Metres
Produced by Planning & Sustainability
City of Wanneroo

**Summary**

The large increase in dwellings per year of Girrawheen-Koondoola over Wanneroo is due to its larger number of lots and, as outlined in the LHS, three major centres have been identified in Girrawheen-Koondoola to increase to R60 coding instead of one centre as per all other Housing Precincts.

The following table shows the two precincts' predicted future growth.

| | Wanneroo | Girrawheen-Koondoola |
|---|---|---|
| 2011 | 0 | 0 |
| 2016 | 168 | 687 |
| 2021 | 410 | 1 669 |
| 2026 | 651 | 2 651 |
| 2031 | 892 | 3 633 |

The table below shows the effect of the additional areas, as per the LHS.

| Precinct | Current Policy | | | Additional Area | | |
|---|---|---|---|---|---|---|
| | *2031* | *Estimated Full Build Out (75%)* | *Theoretical Full Build Out (100%)* | *2031* | *Estimated Full Build Out (75%)* | *Theoretical Full Build Out (100%)* |
| Wanneroo | 866 | 2 676 | 3 568 | 26 | 82 | 110 |
| Girrawheen-Koondoola | 2 894 | 8 942 | 11 922 | 739 | 2 281 | 3042 |

| Precinct | Total Future Dwellings | | |
|---|---|---|---|
| | *2031* | *Estimated Full Build Out (75%)* | *Theoretical Full Build Out (100%)* |
| Wanneroo | 892 | 2 758 | 3 678 |
| Girrawheen-Koondoola | 3 633 | 11 223 | 14964 |

**Methodology**

In order to calculate dwelling yields for 2031, a number of variables were involved. These variables included lot sizes, number of lots, existing dwellings, and theoretical dwellings per lot.

| | |
|---|---|
| Mean lot size in proposed R40 area | a |
| Mean lot size in proposed R60 area | b |
| Number of lots in proposed R40 area | c |
| Number of lots in proposed R60 area | d |
| Rounded down maximum dwellings per lot after recoding in R40 area | e |
| Rounded down maximum dwellings per lot after recoding in R60 area | f |
| Existing single dwellings | x |
| Existing multiple/grouped dwellings | y |
| Total dwellings (theoretical maximum) | t |
| Additional dwellings (theoretical maximum) | g |
| Additional dwellings (less 25%) | u |
| Estimated additional dwellings 2031 | v |

**Step 1.**

The maximum numbers of dwellings per lot (with proposed coding changes) are equated as follows:

$$e \text{ (unrounded)} = \frac{a}{220} \qquad f \text{ (unrounded)} = \frac{b}{160}$$

The values of 220 and 160 above are taken from the Residential Design Codes and are minimum average site area per dwelling requirements for R40 and R60 coded areas respectively. The above formula has therefore calculated, on average, how many dwellings may be constructed on each lot, subsequent to recoding.

The above dwelling figures were then rounded down to 0 decimal places to recognise that a portion of a dwelling cannot be built. For example, in an area coded R40, a 650 $m^2$ lot can have a maximum of 2 dwellings built on it, the same as a 440 $m^2$ lot.

**Step 2.**
To calculate the total theoretical maximum amount of dwellings, the rounded-down maximum dwellings per lot is multiplied by the number of lots in the two separate coding areas.

$$t = e.c + f.d$$

**Step 3.**
Subtract the existing dwellings from the total ($t$) to achieve a value for the number of additional dwellings that will be created ($g$)

$$g = t - (x + y)$$

**Step 4.**
To allow for lots that may never be developed due to varying reasons such as landform, personal reasons, location, and existing dwelling layout, it has been assumed that 75% of the theoretical maximum number of new dwellings will actually ever eventuate:

$$u = 0.75g$$

**Step 5.**
To translate the above total figures into a rate of development, it is assumed that 35% of the estimated total additional dwellings will be achieved over a 20 year period. This is the rate that the Department of Planning has previously used to estimate rates of development in similar situations.

The 2031 additional dwelling estimate is therefore:

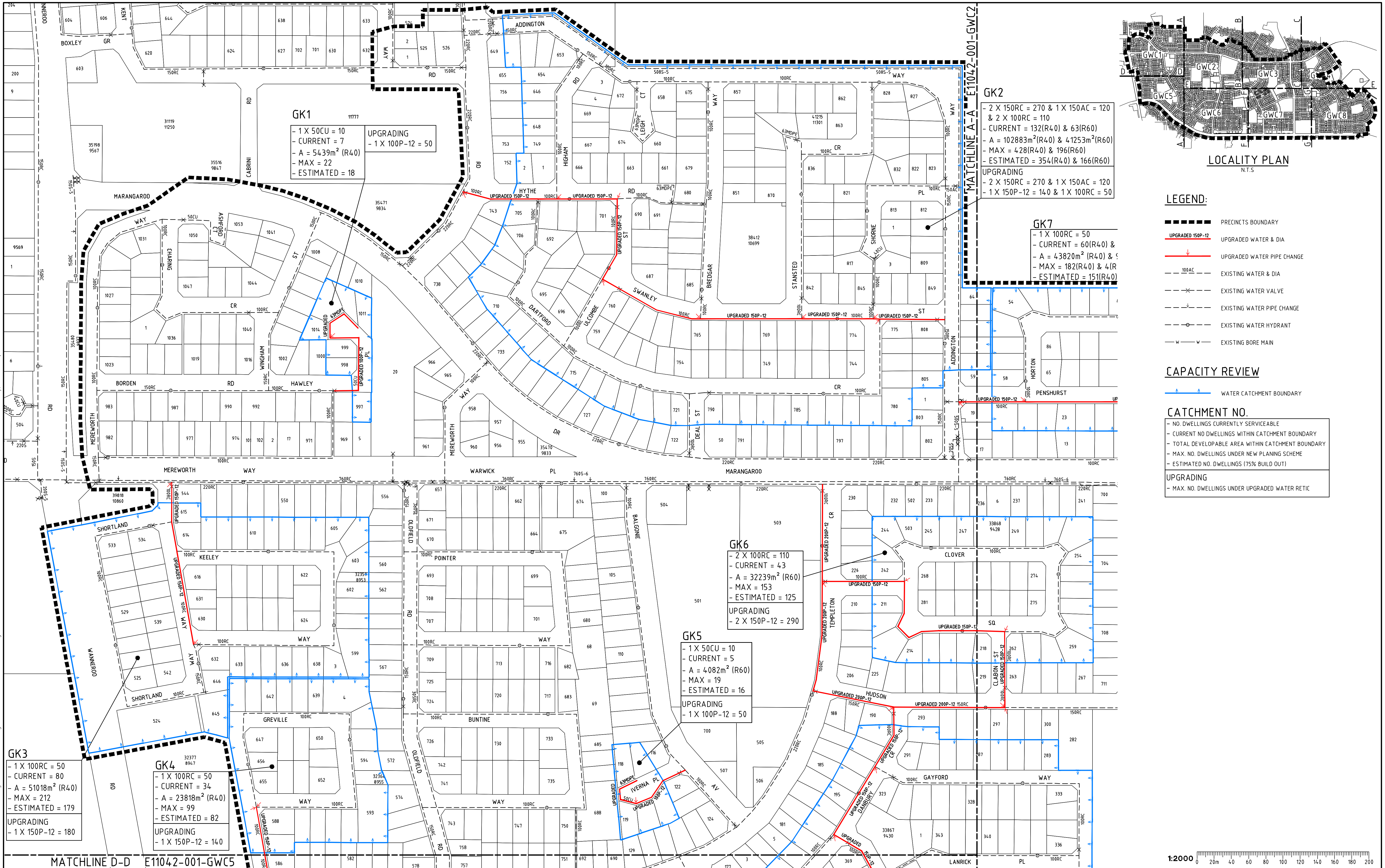
$$v = 0.35u$$

Finally, due to normal planning practices and any delays that may arise, development applications are estimated to take place in approximately 18 months time. This has been represented on the final graphs as a +1.5 year shift on the x axis.

Wanneroo & Girrawheen-
Koondoola Precincts

# APPENDIX C
## WATER RETICULATION – CONCEPT DESIGNS

Cardno
Shaping the Future




| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| D | 12.12.2012 | AMENDED CHTCHMENT BDY TYPE | JYY | |
| C | 14.9.2012 | AMENDED AS PER WC COMMENTS | JYY | |
| B | 28.6.2012 | AMENDED UPDATING CAL | JYY | |
| A | 16.12.2011 | PRELIMINARY ISSUE | JYY | JT |



Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn: JYY — Date: 16.12.2011
Designed
Checked
Reviewed
Approved

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Status: PRELIMINARY ISSUE

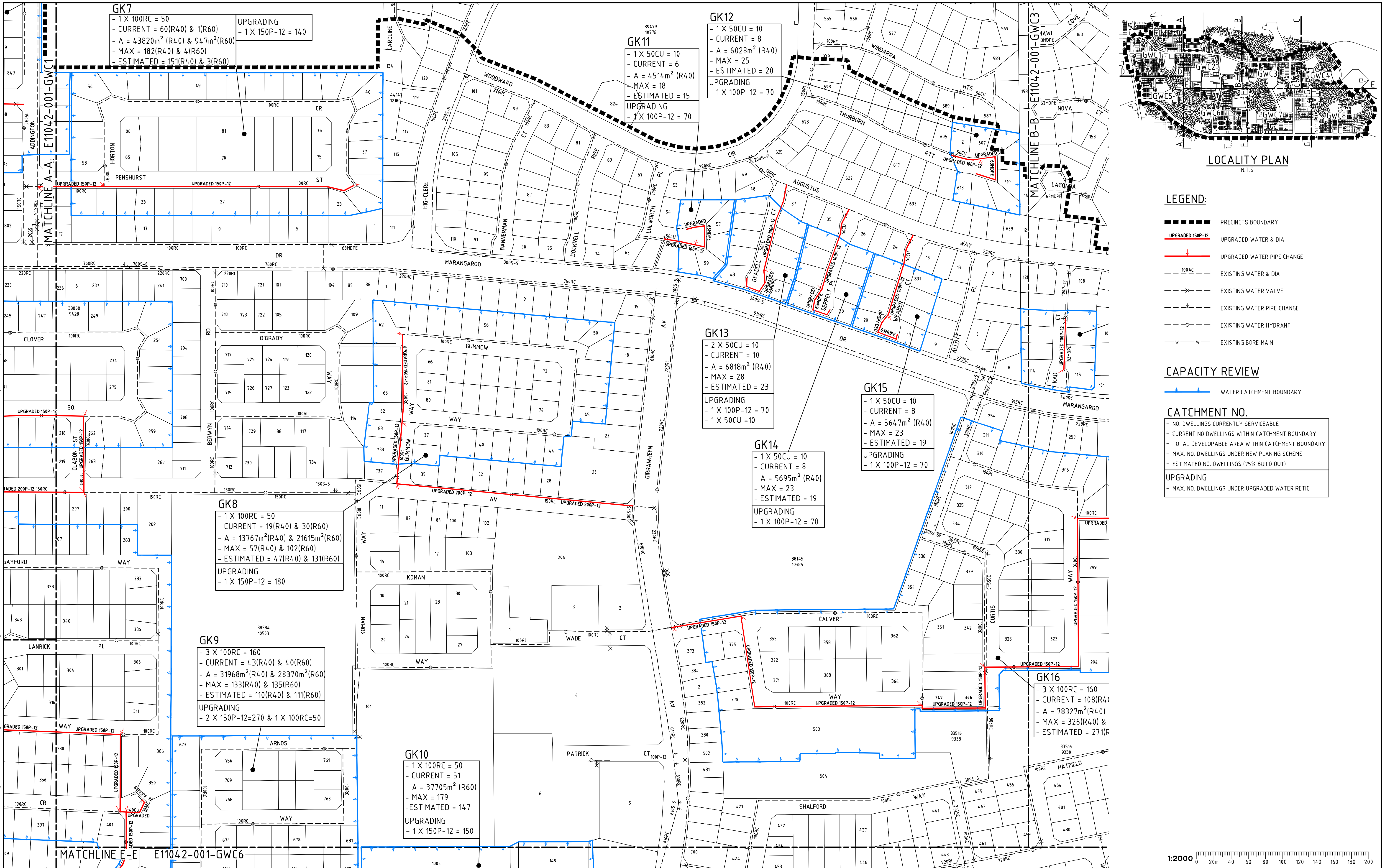
Date: 16.12.2011 | Datum: A.H.D | Scale: 1:2000 | Size: A1

Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS WATER CATCHMENT PLAN SHT 1 OF 8

Drawing Number: E11042-001-GWC1 | Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

XREF's: Xref _GA(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg




| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| D | 12.12.2012 | AMENDED CHTCHMENT BDY TYPE | JYY | |
| C | 14.9.2012 | AMENDED AS PER WC COMMENTS | JYY | |
| B | 28.6.2012 | AMENDED UPDATING CAL | JYY | |
| A | 16.12.2011 | PRELIMINARY ISSUE | JYY | JT |

N W E S



Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn JYY Date 16.12.2011
Designed Date
Checked Date
Reviewed Date
Approved Date

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS WATER CATCHMENT PLAN SHT 2 OF 8

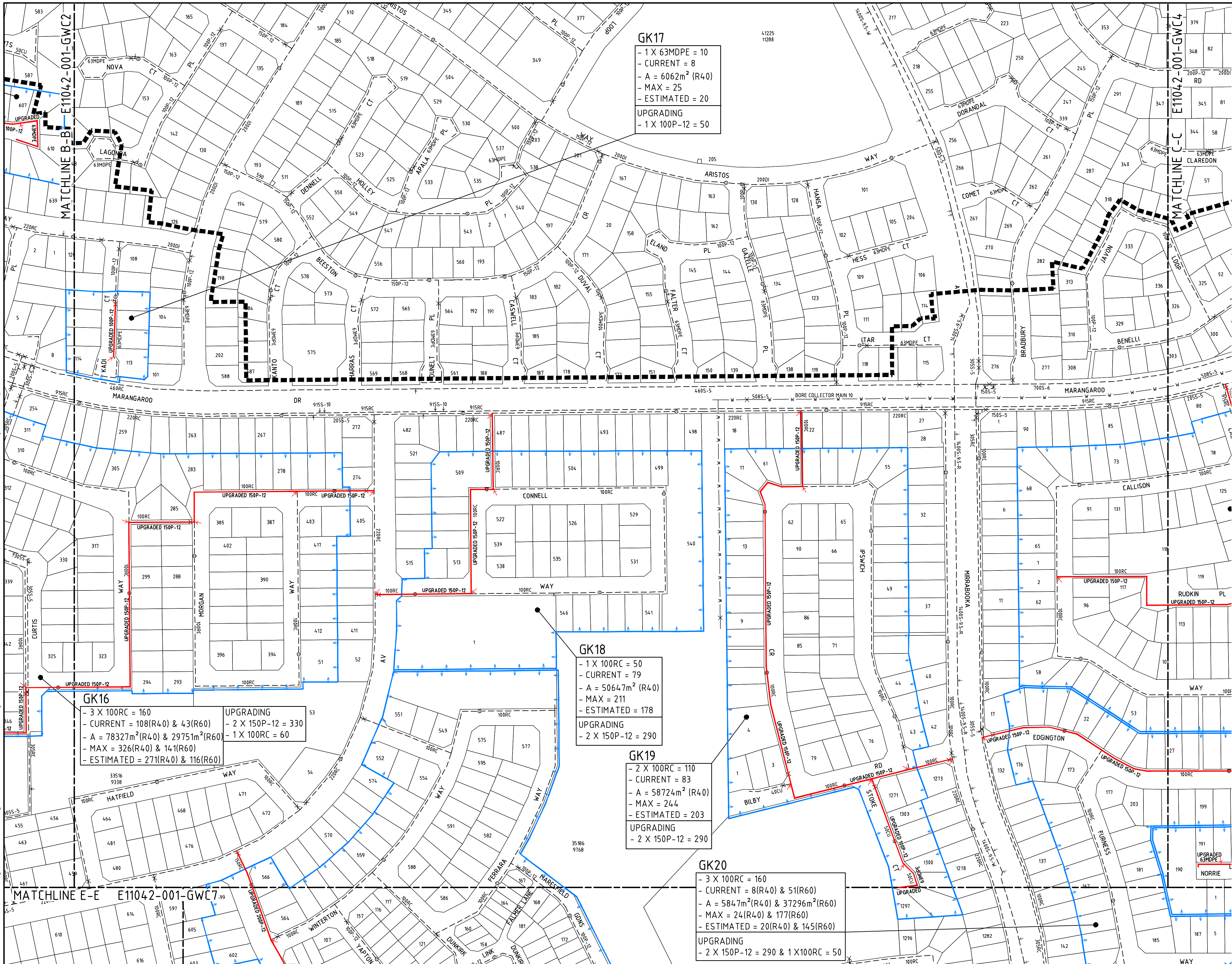
Status: PRELIMINARY ISSUE

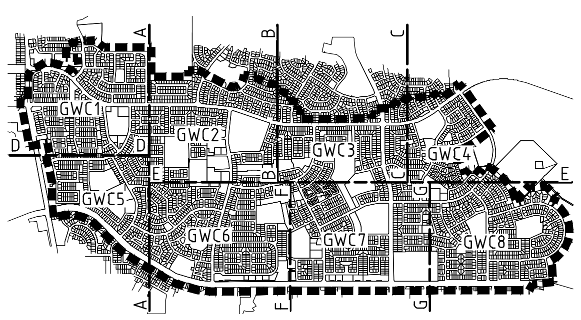
| Date | Datum | Scale | Size |
|---|---|---|---|
| 16.12.2011 | A.H.D | 1:2000 | A1 |

Drawing Number: E11042-001-GWC2 Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

XREF's: Xref_OA(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg
DATE PLOTTED: 25 January, 2013 - 5:02pm




LOCALITY PLAN
N.T.S

LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED WATER & DIA (UPGRADED 150P-12)
- UPGRADED WATER PIPE CHANGE
- EXISTING WATER & DIA (100AC)
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- EXISTING BORE MAIN

CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING

- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

1:2000 — 0 20m 40 60 80 100 120 140 160 180 200

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| D | 12.12.2012 | AMENDED CHTCHMENT BDY TYPE | JYY | |
| C | 14.9.2012 | AMENDED AS PER WC COMMENTS | JYY | |
| B | 28.6.2012 | AMENDED UPDATING CAL | JYY | |
| A | 16.12.2011 | PRELIMINARY ISSUE | JYY | JT |

N W E S



Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

| | |
|---|---|
| Drawn: JYY | Date: 16.12.2011 |
| Designed | Date |
| Checked | Date |
| Reviewed | Date |
| Approved | Date |

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS WATER CATCHMENT PLAN SHT 3 OF 8

Status: PRELIMINARY ISSUE

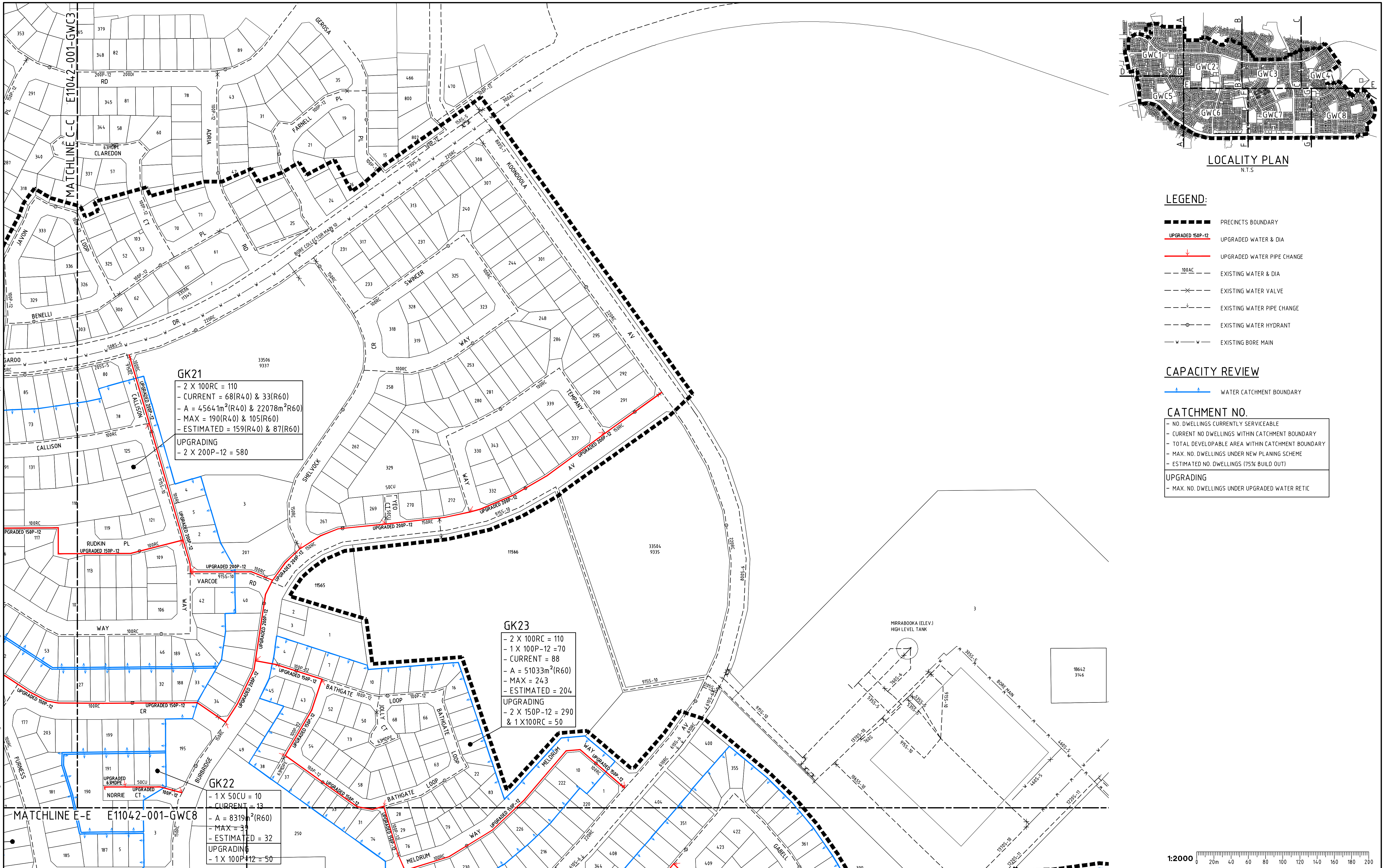
| Date | Datum | Scale | Size |
|---|---|---|---|
| 16.12.2011 | A.H.D | 1:2000 | A1 |

Drawing Number: E11042-001-GWC3 — Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

DATE PLOTTED: 25 January, 2013 - 5:02pm

XREF's: Xref_0A(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg




DATE PLOTTED: 25 January, 2013 - 5:02pm

XREF's: Xref_GA(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| D | 12.12.2012 | AMENDED CHTCHMENT BDY TYPE | JYY | |
| C | 14.9.2012 | AMENDED AS PER WC COMMENTS | JYY | |
| B | 28.6.2012 | AMENDED UPDATING CAL | JYY | |
| A | 16.12.2011 | PRELIMINARY ISSUE | JYY | JT |

N W E S



Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn JYY Date 16.12.2011
Designed Date
Checked Date
Reviewed Date
Approved Date

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

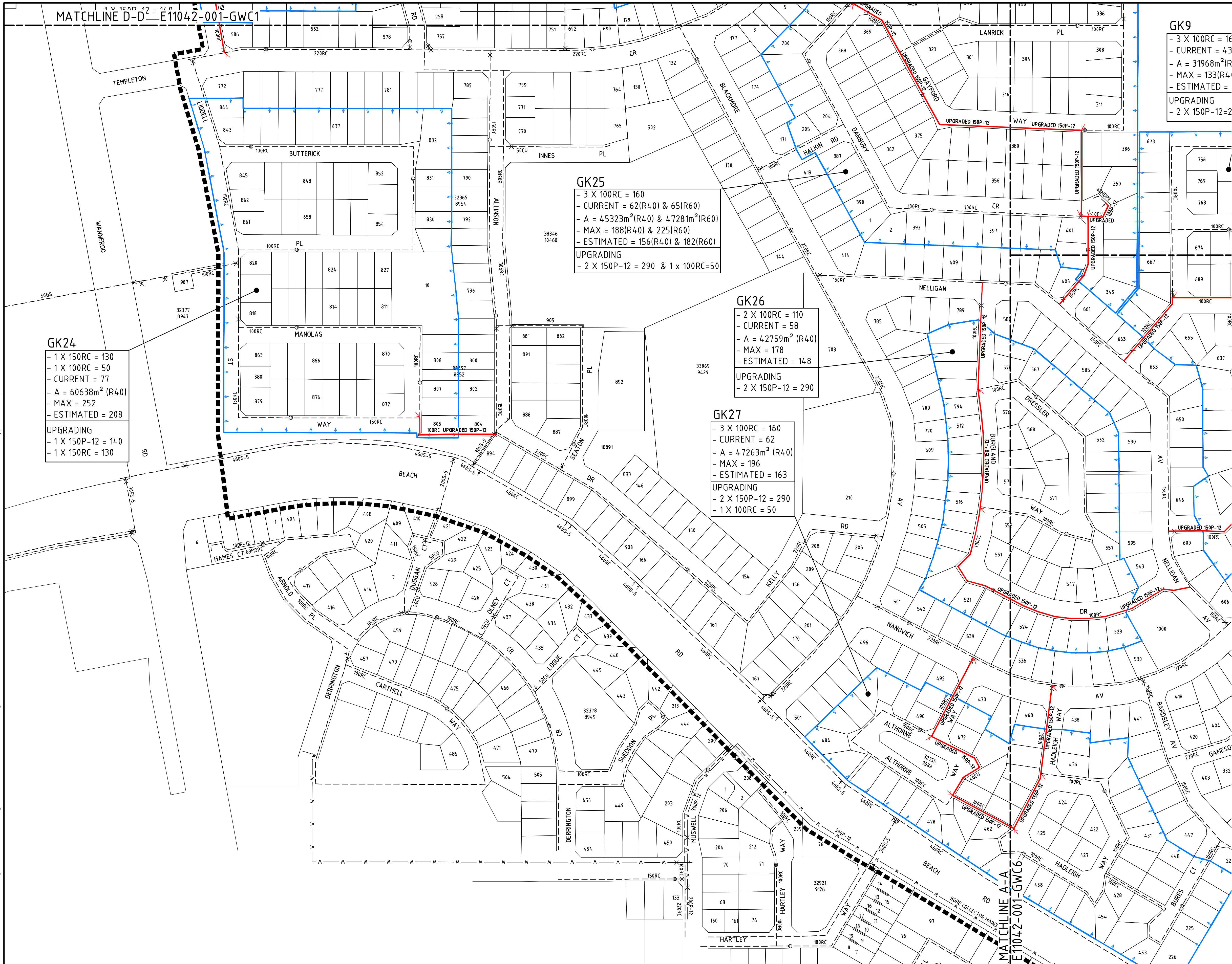
Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS WATER CATCHMENT PLAN SHT 4 OF 8

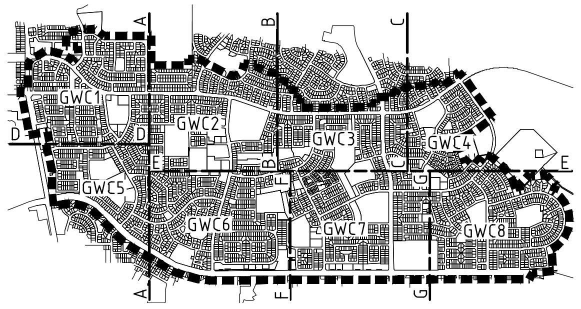
Status: PRELIMINARY ISSUE

| Date | Datum | Scale | Size |
|---|---|---|---|
| 16.12.2011 | A.H.D | 1:2000 | A1 |

Drawing Number: E11042-001-GWC4 Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL




LOCALITY PLAN
N.T.S

## LEGEND:

PRECINCTS BOUNDARY
UPGRADED WATER & DIA
UPGRADED WATER PIPE CHANGE
EXISTING WATER & DIA
EXISTING WATER VALVE
EXISTING WATER PIPE CHANGE
EXISTING WATER HYDRANT
EXISTING BORE MAIN

## CAPACITY REVIEW

WATER CATCHMENT BOUNDARY

## CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

1:2000 0 20m 40 60 80 100 120 140 160 180 200

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| D | 12.12.2012 | AMENDED CHTCHMENT BDY TYPE | JYY | |
| C | 14.9.2012 | AMENDED AS PER WC COMMENTS | JYY | |
| B | 28.6.2012 | AMENDED UPDATING CAL | JYY | |
| A | 16.12.2011 | PRELIMINARY ISSUE | JYY | JT |



Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

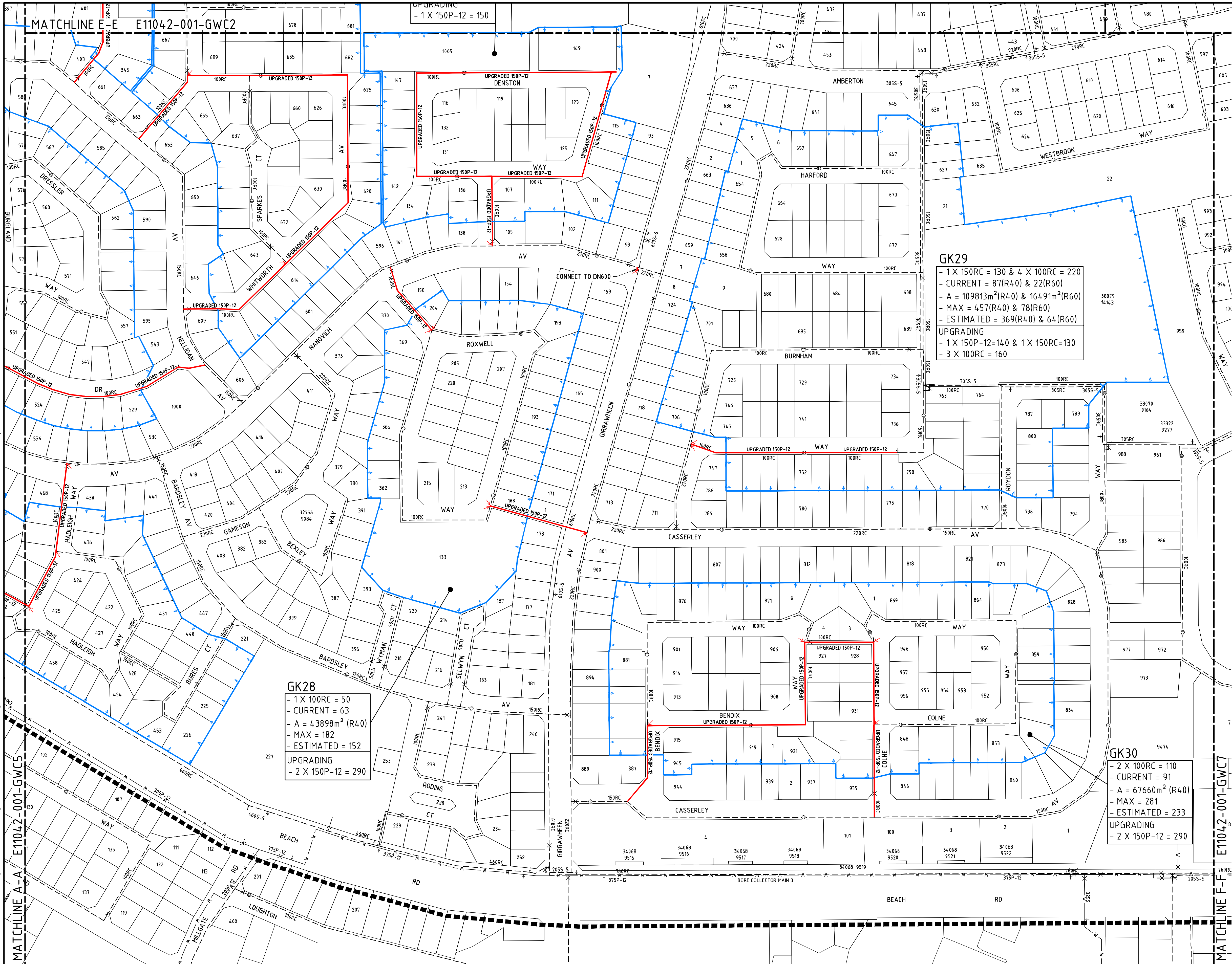
Drawn JYY Date 16.12.2011
Designed
Checked
Reviewed
Approved

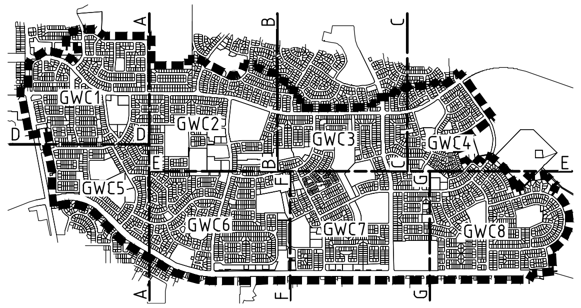
Client: CITY OF WANNEROO
Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS
Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS WATER CATCHMENT PLAN SHT 5 OF 8

Status: PRELIMINARY ISSUE
Date 16.12.2011 | Datum A.H.D | Scale 1:2000 | Size A1
Drawing Number E11042-001-GWC5 | Revision D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

DATE PLOTTED: 25 January, 2013 - 5:02pm
XREF's: Xref_0A(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg




LOCALITY PLAN
N.T.S

## LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- EXISTING BORE MAIN

## CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

## CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

1:2000 0 20m 40 60 80 100 120 140 160 180 200

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| D | 12.12.2012 | AMENDED CHTCHMENT BDY TYPE | JYY | |
| C | 14.9.2012 | AMENDED AS PER WC COMMENTS | JYY | |
| B | 28.6.2012 | AMENDED UPDATING CAL | JYY | |
| A | 16.12.2011 | PRELIMINARY ISSUE | JYY | JT |

N W E S



Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

| | | |
|---|---|---|
| Drawn: JYY | Date: 16.12.2011 | |
| Designed | Date | |
| Checked | Date | |
| Reviewed | Date | |
| Approved | Date | |

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS WATER CATCHMENT PLAN SHT 6 OF 8

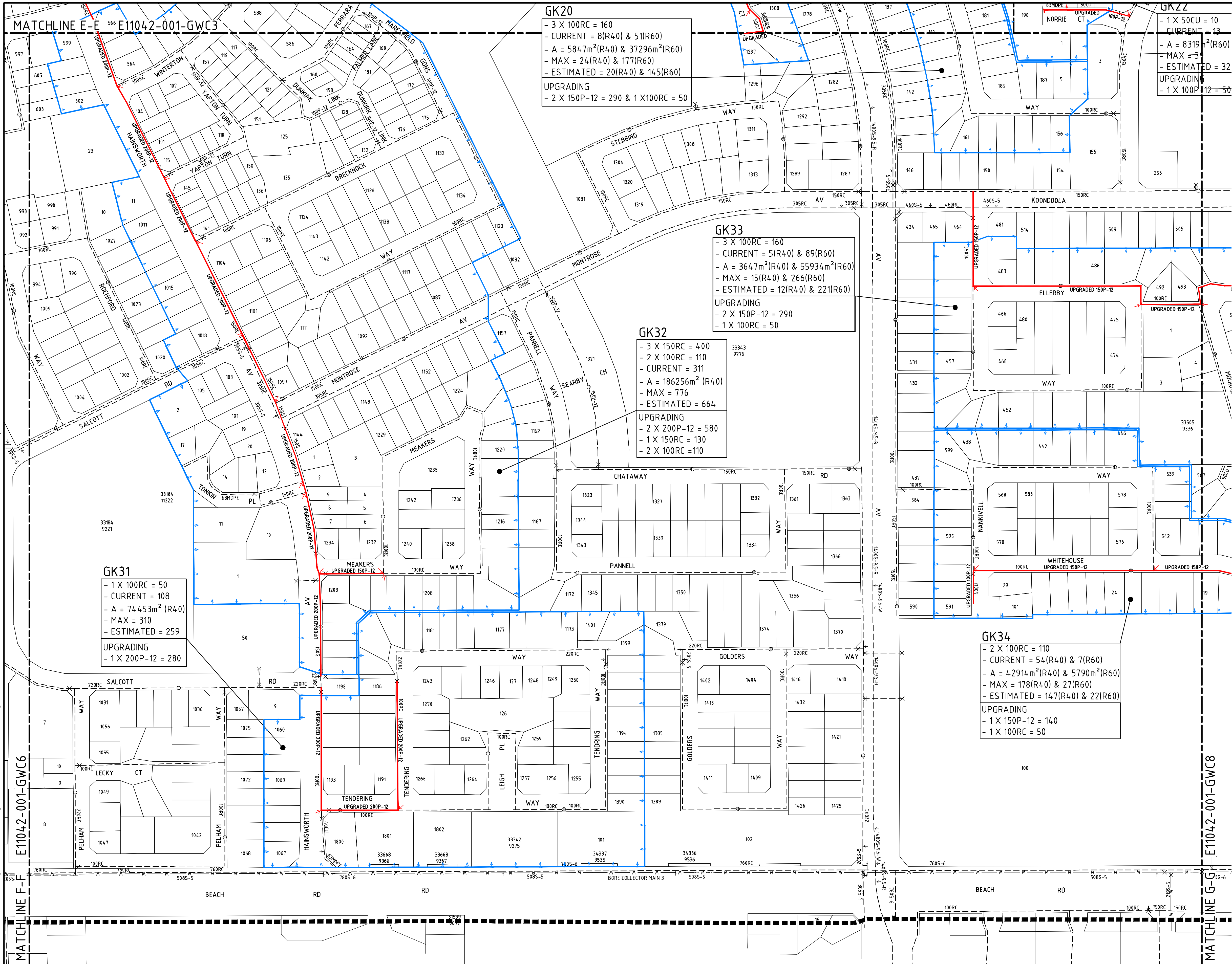
Status: PRELIMINARY ISSUE

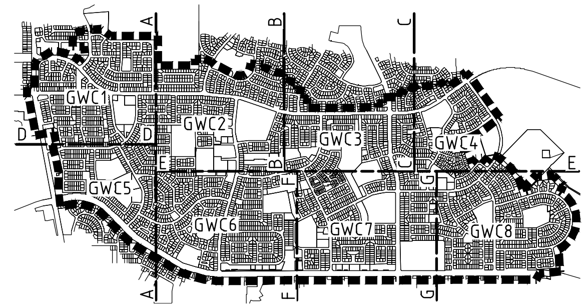
| Date | Datum | Scale | Size |
|---|---|---|---|
| 16.12.2011 | A.H.D | 1:2000 | A1 |

Drawing Number: E11042-001-GWC6 Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

DATE PLOTTED: 25 January, 2013 - 5:02pm
XREF's: Xref _DA(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg




LOCALITY PLAN
N.T.S

## LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- W — W — EXISTING BORE MAIN

## CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

## CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

1:2000 0 20m 40 60 80 100 120 140 160 180 200

DATE PLOTTED: 25 January, 2013 - 5:02pm

XREF's: Xref _ DA(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| D | 12.12.2012 | AMENDED CHTCHMENT BDY TYPE | JYY | |
| C | 14.9.2012 | AMENDED AS PER WC COMMENTS | JYY | |
| B | 28.6.2012 | AMENDED UPDATING CAL | JYY | |
| A | 16.12.2011 | PRELIMINARY ISSUE | JYY | JT |

N W E S



Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

| | | |
|---|---|---|
| Drawn | JYY | Date 16.12.2011 |
| Designed | | Date |
| Checked | | Date |
| Reviewed | | Date |
| Approved | | Date |

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

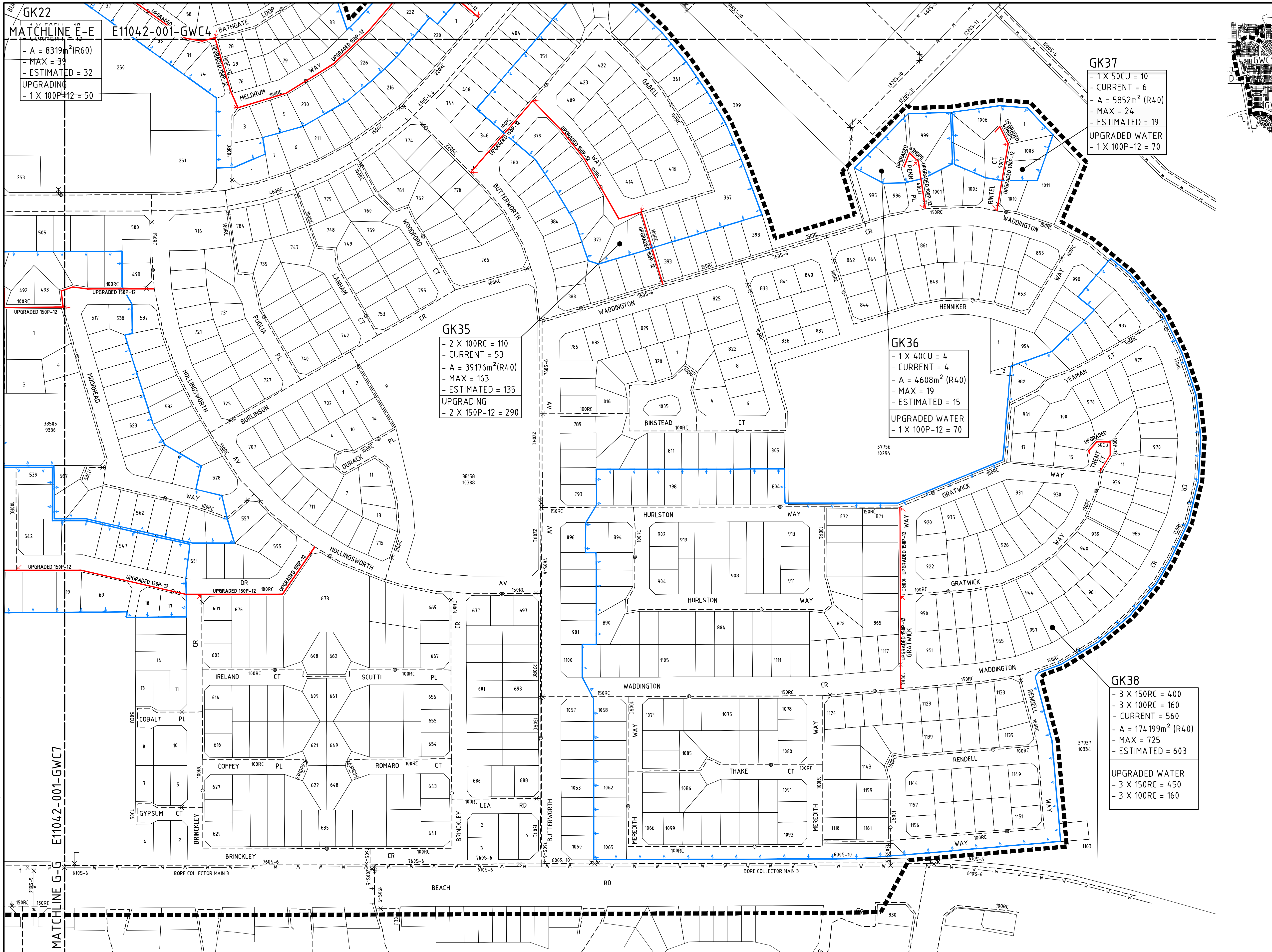
Status: PRELIMINARY ISSUE

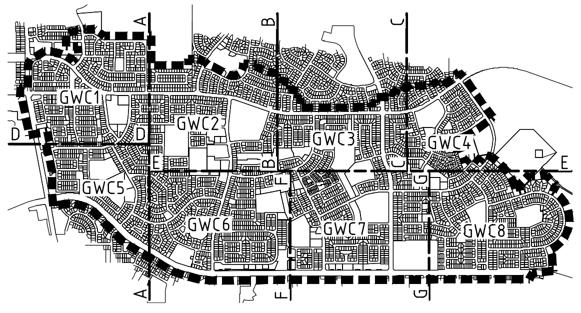
| Date | Datum | Scale | Size |
|---|---|---|---|
| 16.12.2011 | A.H.D | 1:2000 | A1 |

Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS WATER CATCHMENT PLAN SHT 7 OF 8

Drawing Number: E11042-001-GWC7 Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL




LOCALITY PLAN
N.T.S.

## LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- W — EXISTING BORE MAIN

## CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

## CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

DATE PLOTTED: 25 January, 2013 - 5:03pm

XREF's: Xref_OA(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| D | 12.12.2012 | AMENDED CHTCHMENT BDY TYPE | JYY | |
| C | 14.9.2012 | AMENDED AS PER WC COMMENTS | JYY | |
| B | 28.6.2012 | AMENDED UPDATING CAL | JYY | |
| A | 16.12.2011 | PRELIMINARY ISSUE | JYY | JT |

N W E S



Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

| | |
|---|---|
| Drawn | JYY |
| Date | 16.12.2011 |
| Designed | |
| Checked | |
| Reviewed | |
| Approved | |

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

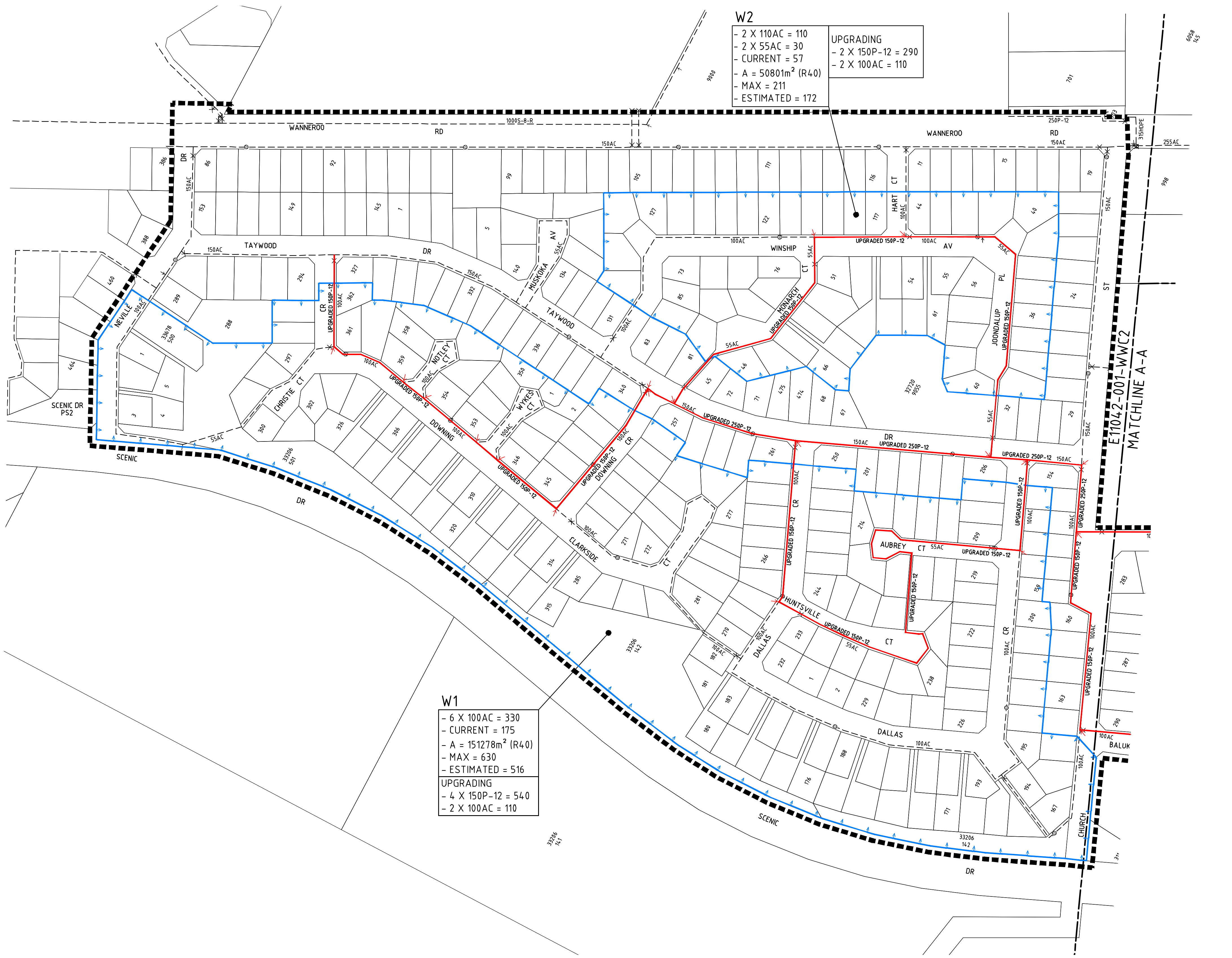
Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS WATER CATCHMENT PLAN SHT 8 OF 8

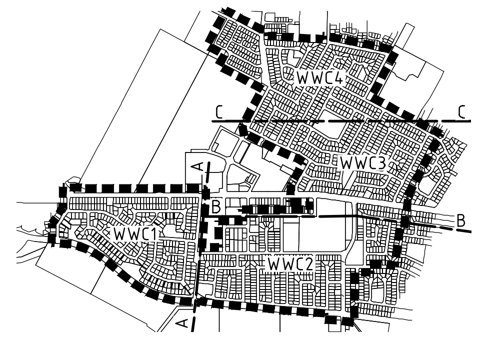
Status: PRELIMINARY ISSUE

| Date | Datum | Scale | Size |
|---|---|---|---|
| 16.12.2011 | A.H.D | 1:2000 | A1 |

| Drawing Number | Revision |
|---|---|
| E11042-001-GWC8 | D |

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL




LOCALITY PLAN
N.T.S

## LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- EXISTING BORE MAIN

## CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

## CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

1:2000 0 20m 40 60 80 100 120 140 160 180 200

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| D | 12.12.2012 | AMENDED CHTCHMENT BDY TYPE | JYY | |
| C | 14.9.2012 | AMENDED AS PER WC COMMENTS | JYY | |
| B | 28.6.2012 | AMENDED UPDATING CAL | JYY | |
| A | 16.12.2011 | PRELIMINARY ISSUE | JYY | JT |



Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn JYY Date 16.12.2011
Designed Date
Checked Date
Reviewed Date
Approved Date

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Status: PRELIMINARY ISSUE

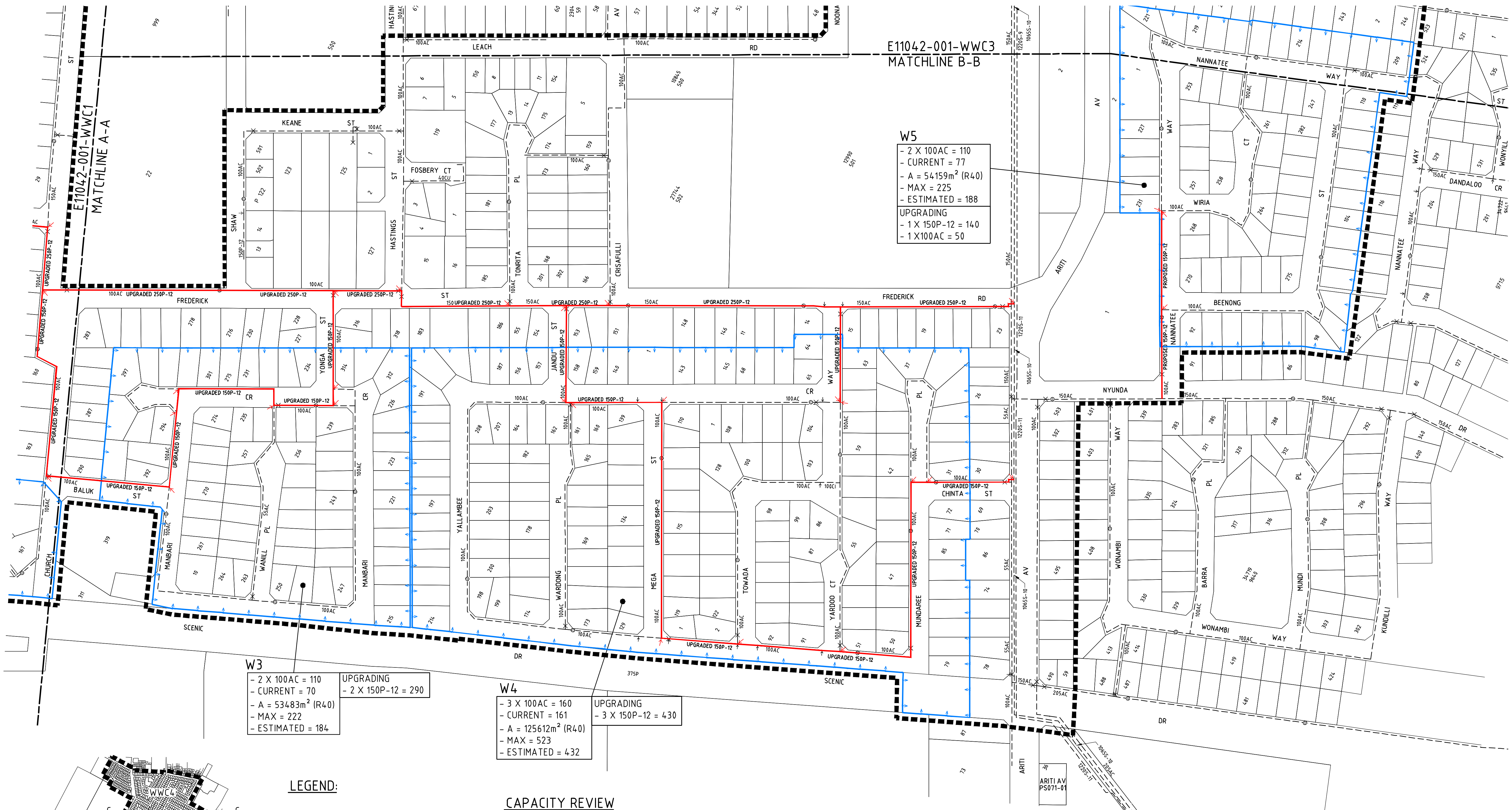
Title: WANNEROO HOUSING PRECINCT WATER CATCHMENT PLAN SHT 1 OF 4

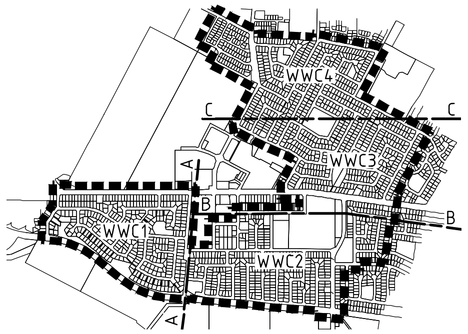
| Date | Datum | Scale | Size |
|---|---|---|---|
| 16.12.2011 | A.H.D | 1:2000 | A1 |

Drawing Number: E11042-001-WWC1 Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

DATE PLOTTED: 25 January, 2013 - 5:06pm
XREF's: Xref_OA(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-WWC1-WWC4.dwg




LOCALITY PLAN
N.T.S

## LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- W — W — EXISTING BORE MAIN

## CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

## CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

1:2000 0 20m 40 60 80 100 120 140 160 180 200

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| D | 12.12.2012 | AMENDED CHTCHMENT BDY TYPE | JYY | |
| C | 14.9.2012 | AMENDED AS PER WC COMMENTS | JYY | |
| B | 28.6.2012 | AMENDED UPDATING CAL | JYY | |
| A | 16.12.2011 | PRELIMINARY ISSUE | JYY | JT |



Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn JYY Date 16.12.2011
Designed Date
Checked Date
Reviewed Date
Approved Date

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Status: PRELIMINARY ISSUE

Date 16.12.2011 | Datum A.H.D | Scale 1:2000 | Size A1

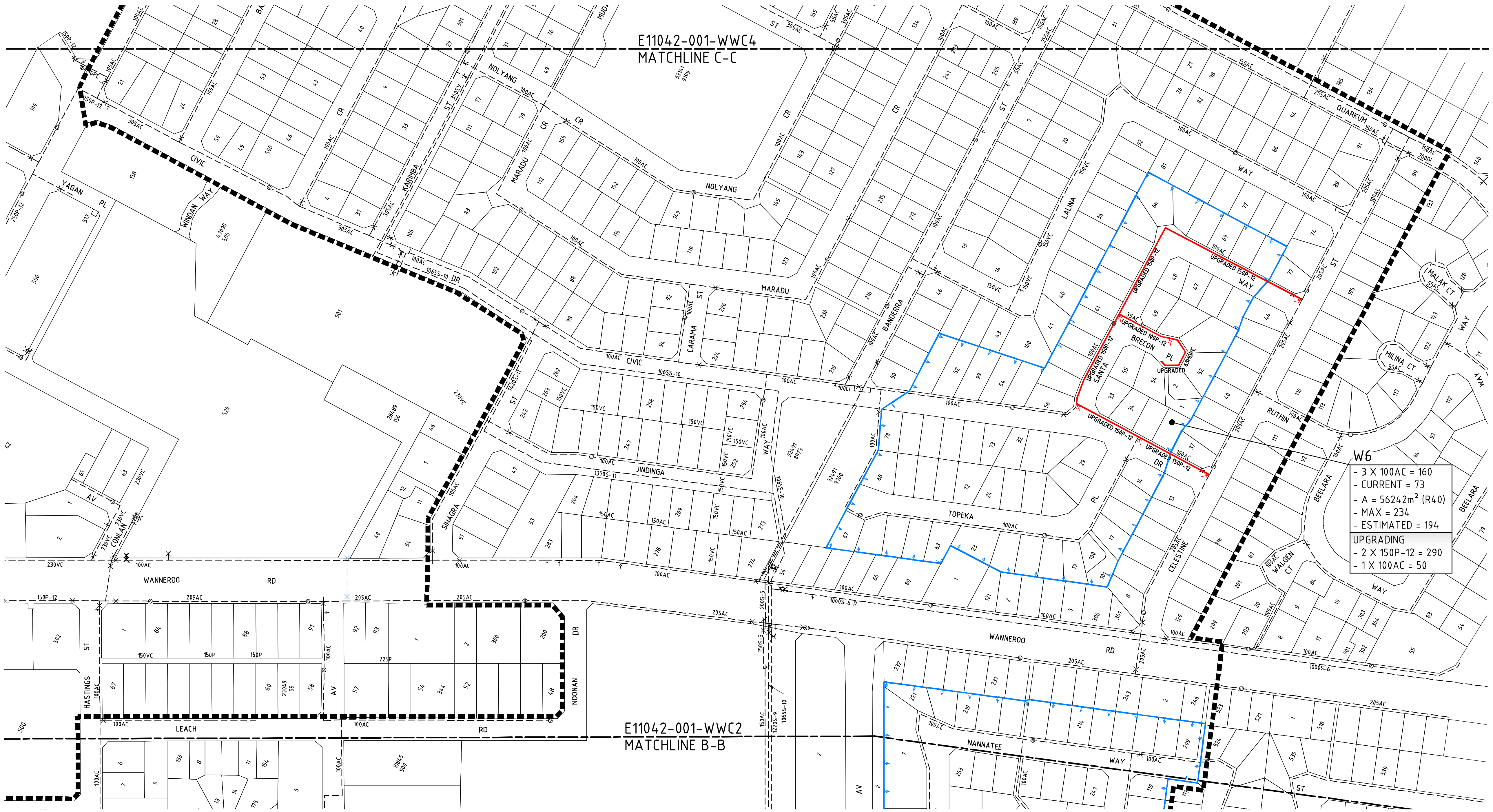
Title: WANNEROO HOUSING PRECINCT WATER CATCHMENT PLAN SHT 2 OF 4

Drawing Number E11042-001-WWC2 | Revision D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

DATE PLOTTED: 25 January, 2013 - 5:07pm

XREF's: Xref_OA(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-WWC1-WWC4.dwg




## LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- W — W — EXISTING BORE MAIN

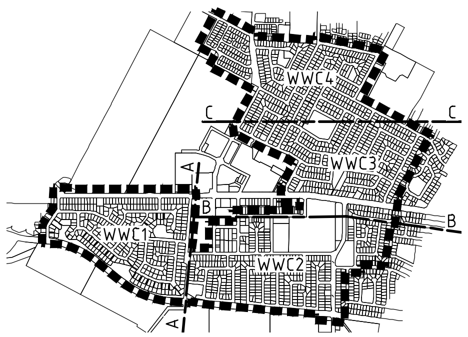
## CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

## CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC




LOCALITY PLAN
N.T.S

1:2000 0 20m 40 60 80 100 120 140 160 180 200

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| D | 12.12.2012 | AMENDED CHTCHMENT BDY TYPE | JYY | |
| C | 14.9.2012 | AMENDED AS PER WC COMMENTS | JYY | |
| B | 28.6.2012 | AMENDED UPDATING CAL | JYY | |
| A | 16.12.2011 | PRELIMINARY ISSUE | JYY | JT |



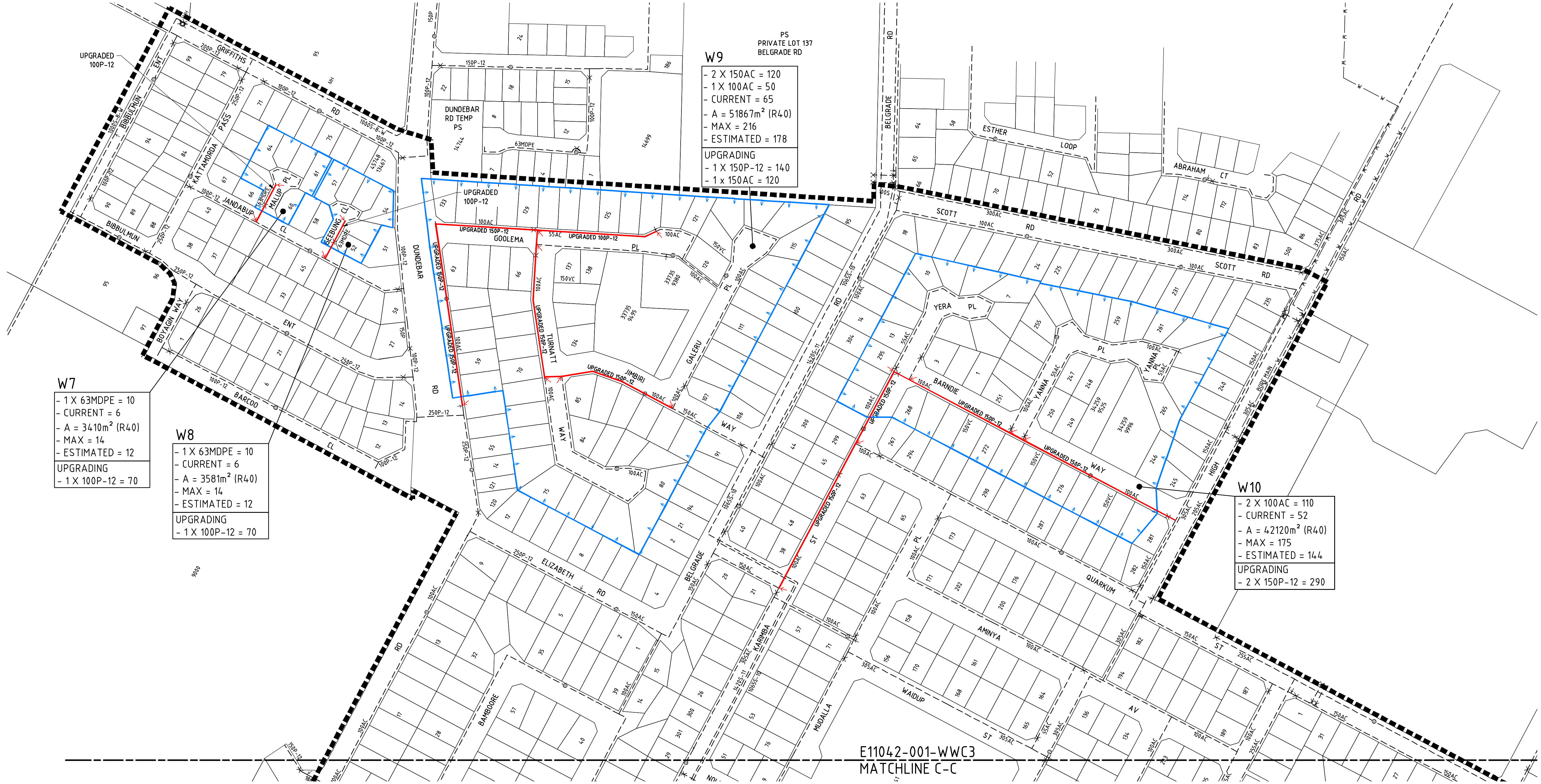
Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

| | |
|---|---|
| Drawn | JYY |
| Date | 16.12.2011 |
| Designed | |
| Checked | |
| Reviewed | |
| Approved | |
| Client | CITY OF WANNEROO |
| Project | WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS |
| Title | WANNEROO HOUSING PRECINCT WATER CATCHMENT PLAN SHT 3 OF 4 |
| Status | PRELIMINARY ISSUE |
| Date | 16.12.2011 |
| Datum | A.H.D |
| Scale | 1:2000 |
| Size | A1 |
| Drawing Number | E11042-001-WWC3 |
| Revision | D |

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

DATE PLOTTED: 25 January, 2013 - 5:07pm
XREF's: Xref_OA(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-WWC1-WWC4.dwg




LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- W — W — EXISTING BORE MAIN

CAPACITY REVIEW

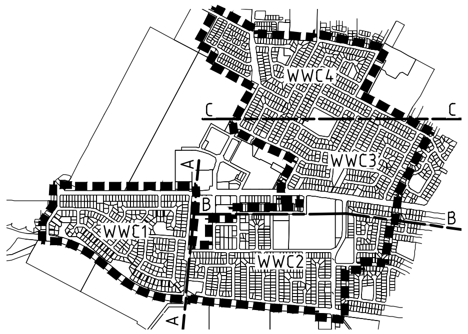
- WATER CATCHMENT BOUNDARY

CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING

- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC




LOCALITY PLAN
N.T.S

1:2000 0 20m 40 60 80 100 120 140 160 180 200

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| D | 12.12.2012 | AMENDED CHTCHMENT BDY TYPE | JYY | |
| C | 14.9.2012 | AMENDED AS PER WC COMMENTS | JYY | |
| B | 28.6.2012 | AMENDED UPDATING CAL | JYY | |
| A | 16.12.2011 | PRELIMINARY ISSUE | JYY | JT |



Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn JYY Date 16.12.2011
Designed Date
Checked Date
Reviewed Date
Approved Date

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Title: WANNEROO HOUSING PRECINCT WATER CATCHMENT PLAN SHT 4 OF 4

Status: PRELIMINARY ISSUE

| Date | Datum | Scale | Size |
|---|---|---|---|
| 16.12.2011 | A.H.D | 1:2000 | A1 |

Drawing Number: E11042-001-WWC4 Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

DATE PLOTTED: 25 January, 2013 - 5:07pm
XREF's: Xref_OA(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-WWC1-WWC4.dwg

Wanneroo & Girrawheen-Koondoola Precincts

# APPENDIX D

## WATER RETICULATION – COST ESTIMATES & TRIGGER DATES

Cardno
Shaping the Future

PROJECT BUDGET - PRELIMINARY ONLY

| | |
|---|---|
| Project: | City of Wanneroo - Water Reticulation |
| Reference: | E11042 |
| Subject: | Project Budget 29-10-2012 |
| Client: | City of Wanneroo |

| *Trigger Date* | *Total Cost* | | *Precinct* |
|---|---|---|---|
| Critical | $ | 1,389,000.00 | W4 |
| Critical | $ | 181,000.00 | GK3 |
| Critical | $ | 321,000.00 | GK7 |
| Critical | $ | 563,000.00 | GK10 |
| Critical | $ | 277,000.00 | GK18 |
| Critical | $ | 99,000.00 | GK22 |
| Critical | $ | 177,000.00 | GK28 |
| Critical | $ | 338,000.00 | GK31 |
| Critical | $ | 414,000.00 | GK8 |
| Critical | $ | 143,000.00 | GK13 |
| Critical | $ | 88,000.00 | GK36 |
| 2015 | $ | 876,000.00 | GK16 |
| 2017 | $ | 1,029,000.00 | GK21 |
| 2022 | $ | 498,000.00 | GK30 |
| 2023 | $ | 889,000.00 | GK25 |
| 2024 | $ | 103,000.00 | GK12 |
| 2024 | $ | 74,000.00 | GK17 |
| 2025 | $ | 139,000.00 | GK14 |
| 2025 | $ | 139,000.00 | GK15 |
| 2028 | $ | 625,000.00 | GK19 |
| 2031 | $ | 163,000.00 | GK1 |
| 2033 | $ | 178,000.00 | W5 |
| 2033 | $ | 679,000.00 | GK23 |
| 2033 | $ | 103,000.00 | GK37 |
| 2035 | $ | 99,000.00 | GK4 |
| 2036 | $ | 921,000.00 | W3 |
| 2043 | $ | 1,402,000.00 | W1 |
| 2043 | $ | 84,000.00 | GK5 |
| 2043 | $ | 96,000.00 | GK11 |
| 2043 | $ | 476,000.00 | GK34 |
| 2045 | $ | 402,000.00 | GK33 |
| 2050 | $ | 506,000.00 | GK9 |
| 2051 | $ | 768,000.00 | GK32 |
| 2052 | $ | 479,000.00 | GK26 |
| 2055 | $ | 443,000.00 | W10 |
| 2058 | $ | 60,000.00 | W7 |
| 2058 | $ | 60,000.00 | W8 |
| 2060 | $ | 315,000.00 | GK35 |
| 2061 | $ | 462,000.00 | W6 |
| 2062 | $ | 512,000.00 | W2 |
| 2063 | $ | 202,000.00 | GK29 |
| 2066 | $ | 107,000.00 | GK24 |
| 2068 | $ | 457,000.00 | GK6 |
| 2072 | $ | 230,000.00 | GK38 |
| 2074 | $ | 571,000.00 | GK2 |
| 2076 | $ | 531,000.00 | W9 |
| 2077 | $ | 407,000.00 | GK20 |
| 2078 | $ | 367,000.00 | GK27 |

WANNEROO HOUSE PRECINCT - WATER

| Catchment | Quantities (m) DN63 | DN100 | DN150 | DN250 | Trigger Dates Exist lots | Estimated lots | Exist Capacity | Trigger date |
|---|---|---|---|---|---|---|---|---|
| W1 | | | 1198 | 481 | 175 | 516 | 330 | 2043 |
| W2 | | | 613 | | 57 | 172 | 140 | 2062 |
| W3 | | | 706 | 375 | 70 | 184 | 110 | 2036 |
| W4 | | | 1054 | 593 | 161 | 432 | 160 | Critical |
| W5 | | | 188 | | 77 | 188 | 110 | 2033 |
| W6 | 52 | 46 | 460 | | 73 | 194 | 160 | 2061 |
| W7 | | 40 | | | 6 | 12 | 10 | 2058 |
| W8 | | 40 | | | 6 | 12 | 10 | 2058 |
| W9 | | 112 | 532 | | 65 | 178 | 170 | 2076 |
| W10 | | | 525 | | 52 | 144 | 110 | 2055 |
| Sub-Total | 52 | 238 | 5276 | 1449 | | | | |
| | | | Total | 7015 | | | | |

GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS - WATER

| Catchment | Quantities (m) DN63 | DN100 | DN150 | DN200 | Trigger Dates Exist lots | Estimated lots | Exist Capacity | Trigger date |
|---|---|---|---|---|---|---|---|---|
| GK1 | 60 | 123 | | | 7 | 18 | 10 | 2031 |
| GK2 | | | 688 | | 195 | 530 | 500 | 2074 |
| GK3 | | | 191 | | 80 | 179 | 50 | Critical |
| GK4 | | | 87 | | 34 | 82 | 50 | 2035 |
| GK5 | | 72 | | | 5 | 16 | 10 | 2043 |
| GK6 | | | 396 | 129 | 43 | 125 | 110 | 2068 |
| GK7 | | | 370 | | 61 | 154 | 50 | Critical |
| GK8 | | | 175 | 275 | 49 | 178 | 50 | Critical |
| GK9 | | | 605 | | 83 | 221 | 160 | 2050 |
| GK10 | | | 677 | | 51 | 147 | 50 | Critical |
| GK11 | 57 | 36 | | | 6 | 15 | 10 | 2043 |
| GK12 | 69 | 34 | | | 8 | 20 | 10 | 2024 |
| GK13 | 52 | 104 | | | 10 | 23 | 10 | Critical |
| GK14 | 51 | 99 | | | 8 | 19 | 10 | 2025 |
| GK15 | 53 | 97 | | | 8 | 19 | 10 | 2025 |
| GK16 | | | 1076 | | 151 | 387 | 160 | 2015 |
| GK17 | | 59 | | | 8 | 20 | 10 | 2024 |
| GK18 | | | 314 | | 79 | 178 | 50 | Critical |
| GK19 | 47 | 96 | 625 | | 83 | 203 | 110 | 2028 |
| GK20 | | | 387 | 81 | 59 | 165 | 160 | 2077 |
| GK21 | | | 271 | 879 | 101 | 246 | 110 | 2017 |
| GK22 | 27 | 67 | | | 13 | 32 | 10 | Critical |
| GK23 | | | 716 | 96 | 70 | 204 | 110 | 2033 |
| GK24 | | | 97 | | 77 | 208 | 180 | 2066 |
| GK25 | | 33 | 678 | 337 | 127 | 338 | 160 | 2023 |
| GK26 | | | 571 | | 58 | 148 | 110 | 2052 |
| GK27 | | | 428 | | 62 | 163 | 160 | 2078 |
| GK28 | | | 186 | | 63 | 152 | 50 | Critical |
| GK29 | | | 218 | | 109 | 433 | 350 | 2063 |
| GK30 | | | 595 | | 91 | 233 | 110 | 2022 |
| GK31 | | | | 344 | 108 | 259 | 50 | Critical |
| GK32 | | | 68 | 765 | 311 | 664 | 510 | 2051 |
| GK33 | | | 473 | | 94 | 233 | 160 | 2045 |
| GK34 | | 35 | 534 | | 61 | 169 | 110 | 2043 |
| GK35 | | | 362 | | 53 | 135 | 110 | 2060 |
| GK36 | 29 | 51 | | | 4 | 15 | 4 | Critical |
| GK37 | 28 | 72 | | | 6 | 19 | 10 | 2033 |
| GK38 | | 65 | 193 | | 238 | 603 | 560 | 2072 |
| Sub-Total | 473 | 1043 | 10981 | 2906 | | | | |
| | | | Total | 15403 | | | | |

WANNEROO HOUSE PRECINCT - WATER

| | Cost Estimate | | | | |
|---|---|---|---|---|---|
| Catchment | Prelims | Water Main | Reinstatement | Fees/Contingency | Total |
| W1 | $ 25,000.00 | $ 815,630.00 | $ 327,405.00 | $233,607.00 | $ 1,401,642.00 |
| W2 | $ 25,000.00 | $ 281,980.00 | $ 119,535.00 | $85,303.00 | $ 511,818.00 |
| W3 | $ 25,000.00 | $ 531,010.00 | $ 210,795.00 | $153,361.00 | $ 920,166.00 |
| W4 | $ 25,000.00 | $ 810,990.00 | $ 321,165.00 | $231,431.00 | $ 1,388,586.00 |
| W5 | $ 25,000.00 | $ 86,480.00 | $ 36,660.00 | $29,628.00 | $ 177,768.00 |
| W6 | $ 25,000.00 | $ 250,680.00 | $ 108,810.00 | $76,898.00 | $ 461,388.00 |
| W7 | $ 25,000.00 | $ 16,800.00 | $ 7,800.00 | $9,920.00 | $ 59,520.00 |
| W8 | $ 25,000.00 | $ 16,800.00 | $ 7,800.00 | $9,920.00 | $ 59,520.00 |
| W9 | $ 25,000.00 | $ 291,760.00 | $ 125,580.00 | $88,468.00 | $ 530,808.00 |
| W10 | $ 25,000.00 | $ 241,500.00 | $ 102,375.00 | $73,775.00 | $ 442,650.00 |
| | | | | Sub-Total | $ 5,953,866.00 |

GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS - WATER

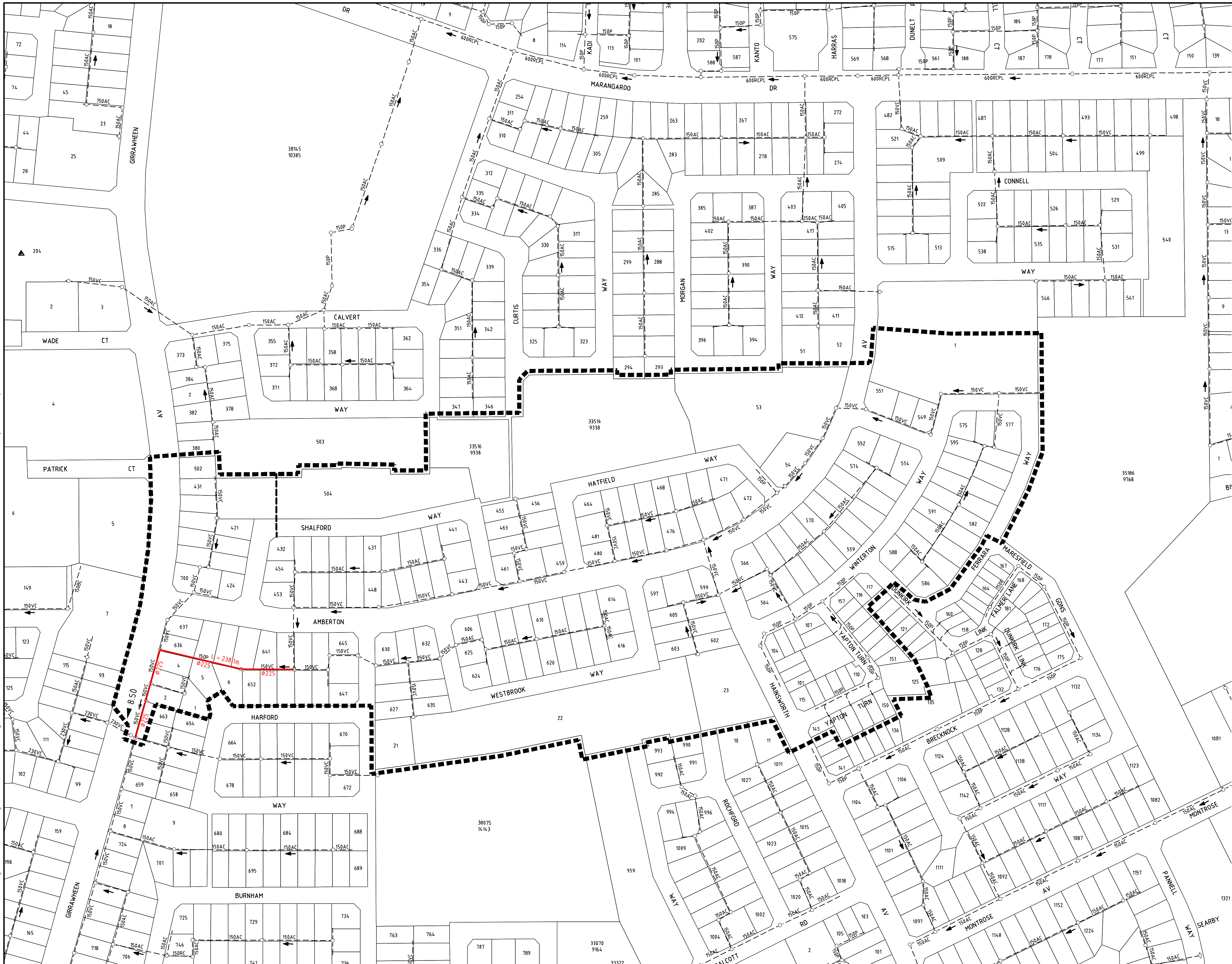
| | Cost Estimate | | | | |
|---|---|---|---|---|---|
| Catchment | Prelims | Water Main | Reinstatement | Fees/Contingency | Total |
| GK1 | $ 25,000.00 | $ 74,460.00 | $ 35,685.00 | $27,029.00 | $ 162,174.00 |
| GK2 | $ 25,000.00 | $ 316,480.00 | $ 134,160.00 | $95,128.00 | $ 570,768.00 |
| GK3 | $ 25,000.00 | $ 87,860.00 | $ 37,245.00 | $30,021.00 | $ 180,126.00 |
| GK4 | $ 25,000.00 | $ 40,020.00 | $ 16,965.00 | $16,397.00 | $ 98,382.00 |
| GK5 | $ 25,000.00 | $ 30,240.00 | $ 14,040.00 | $13,856.00 | $ 83,136.00 |
| GK6 | $ 25,000.00 | $ 253,110.00 | $ 102,375.00 | $76,097.00 | $ 456,582.00 |
| GK7 | $ 25,000.00 | $ 170,200.00 | $ 72,150.00 | $53,470.00 | $ 320,820.00 |
| GK8 | $ 25,000.00 | $ 231,750.00 | $ 87,750.00 | $68,900.00 | $ 413,400.00 |
| GK9 | $ 25,000.00 | $ 278,300.00 | $ 117,975.00 | $84,255.00 | $ 505,530.00 |
| GK10 | $ 25,000.00 | $ 311,420.00 | $ 132,015.00 | $93,687.00 | $ 562,122.00 |
| GK11 | $ 25,000.00 | $ 36,780.00 | $ 18,135.00 | $15,983.00 | $ 95,898.00 |
| GK12 | $ 25,000.00 | $ 40,500.00 | $ 20,085.00 | $17,117.00 | $ 102,702.00 |
| GK13 | $ 25,000.00 | $ 63,440.00 | $ 30,420.00 | $23,772.00 | $ 142,632.00 |
| GK14 | $ 25,000.00 | $ 60,960.00 | $ 29,250.00 | $23,042.00 | $ 138,252.00 |
| GK15 | $ 25,000.00 | $ 60,880.00 | $ 29,250.00 | $23,026.00 | $ 138,156.00 |
| GK16 | $ 25,000.00 | $ 494,960.00 | $ 209,820.00 | $145,956.00 | $ 875,736.00 |
| GK17 | $ 25,000.00 | $ 24,780.00 | $ 11,505.00 | $12,257.00 | $ 73,542.00 |
| GK18 | $ 25,000.00 | $ 144,440.00 | $ 61,230.00 | $46,134.00 | $ 276,804.00 |
| GK19 | $ 25,000.00 | $ 345,680.00 | $ 149,760.00 | $104,088.00 | $ 624,528.00 |
| GK20 | $ 25,000.00 | $ 222,570.00 | $ 91,260.00 | $67,766.00 | $ 406,596.00 |
| GK21 | $ 25,000.00 | $ 608,110.00 | $ 224,250.00 | $171,472.00 | $ 1,028,832.00 |
| GK22 | $ 25,000.00 | $ 38,400.00 | $ 18,330.00 | $16,346.00 | $ 98,076.00 |
| GK23 | $ 25,000.00 | $ 382,160.00 | $ 158,340.00 | $113,100.00 | $ 678,600.00 |
| GK24 | $ 25,000.00 | $ 44,620.00 | $ 18,915.00 | $17,707.00 | $ 106,242.00 |
| GK25 | $ 25,000.00 | $ 511,090.00 | $ 204,360.00 | $148,090.00 | $ 888,540.00 |
| GK26 | $ 25,000.00 | $ 262,660.00 | $ 111,345.00 | $79,801.00 | $ 478,806.00 |
| GK27 | $ 25,000.00 | $ 196,880.00 | $ 83,460.00 | $61,068.00 | $ 366,408.00 |
| GK28 | $ 25,000.00 | $ 85,560.00 | $ 36,270.00 | $29,366.00 | $ 176,196.00 |
| GK29 | $ 25,000.00 | $ 100,280.00 | $ 42,510.00 | $33,558.00 | $ 201,348.00 |
| GK30 | $ 25,000.00 | $ 273,700.00 | $ 116,025.00 | $82,945.00 | $ 497,670.00 |
| GK31 | $ 25,000.00 | $ 189,200.00 | $ 67,080.00 | $56,256.00 | $ 337,536.00 |
| GK32 | $ 25,000.00 | $ 452,030.00 | $ 162,435.00 | $127,893.00 | $ 767,358.00 |
| GK33 | $ 25,000.00 | $ 217,580.00 | $ 92,235.00 | $66,963.00 | $ 401,778.00 |
| GK34 | $ 25,000.00 | $ 260,340.00 | $ 110,955.00 | $79,259.00 | $ 475,554.00 |
| GK35 | $ 25,000.00 | $ 166,520.00 | $ 70,590.00 | $52,422.00 | $ 314,532.00 |
| GK36 | $ 25,000.00 | $ 32,440.00 | $ 15,600.00 | $14,608.00 | $ 87,648.00 |
| GK37 | $ 25,000.00 | $ 40,880.00 | $ 19,500.00 | $17,076.00 | $ 102,456.00 |
| GK38 | $ 25,000.00 | $ 116,080.00 | $ 50,310.00 | $38,278.00 | $ 229,668.00 |
| | | | | Sub-Total | $ 13,465,134.00 |
| | | | | Total | $ 19,419,000.00 |

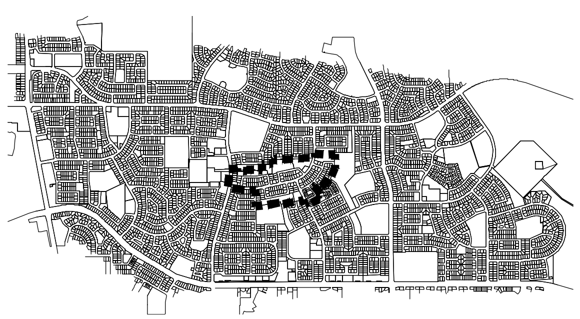
Wanneroo & Girrawheen-Koondoola Precincts

# APPENDIX E

## SEWER RETICULATION – CONCEPT DESIGN

Cardno
Shaping the Future



## LOCALITY PLAN
N.T.S

## LEGEND:

CATCHMENT BOUNDARY

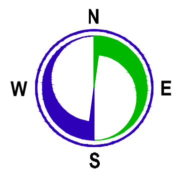
UPGRADED SEWER & DIA (Ø225)

EXISTING SEWER & DIA (150P)

EXISTING SEWER PRESSURE MAIN (SPM)

1:2000 0 20m 40 60 80 100 120 140 160 180 200

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| A | 22.01.2012 | PRELIMINARY ISSUE | JYY | |






Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn: JYY — Date: 22.01.2012
Designed — Date
Checked — Date
Reviewed — Date
Approved — Date

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES
WANNEROO AND
GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS
SEWER RETIC UPGRADE PLAN
SHT 1 OF 3

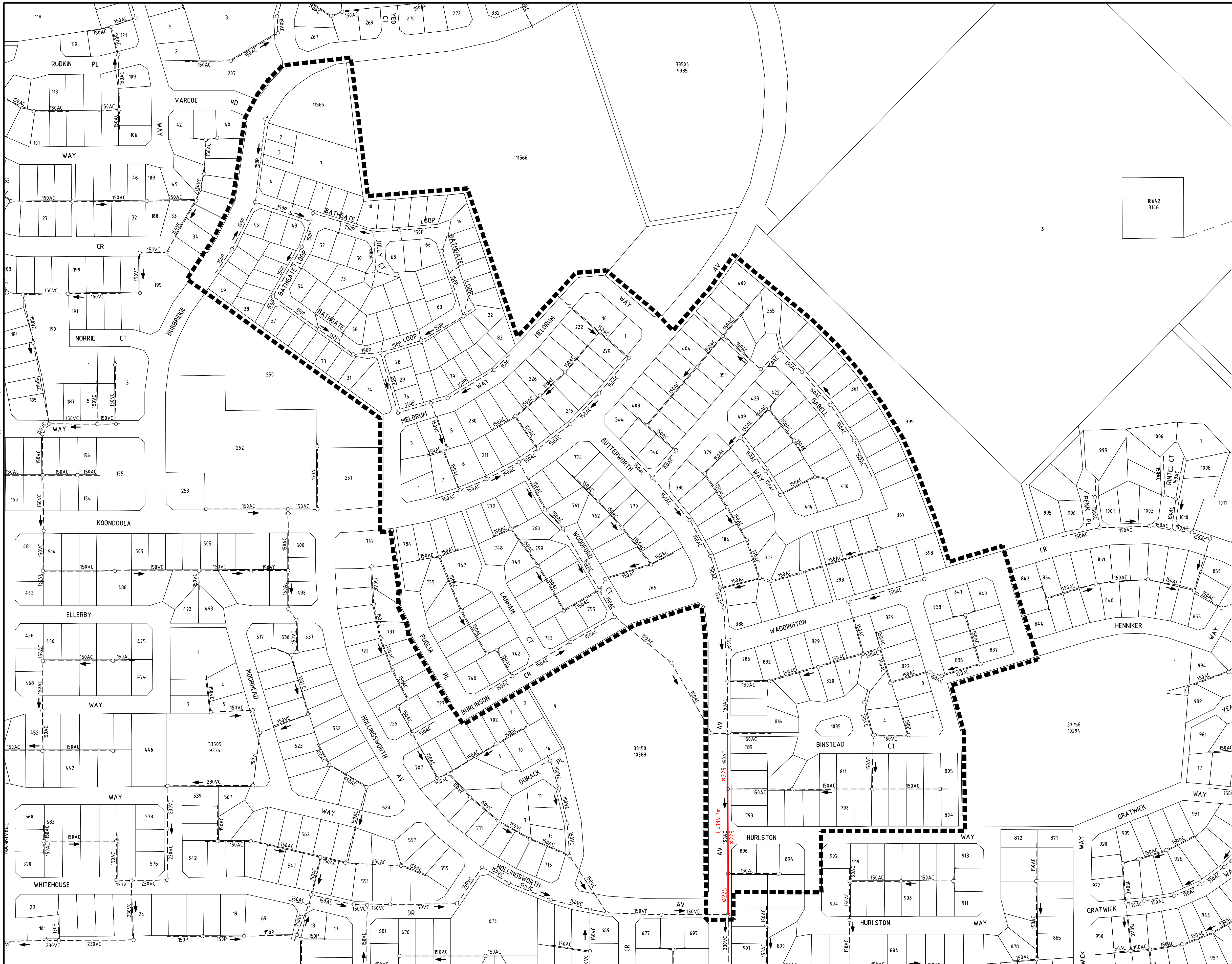
Status: PRELIMINARY

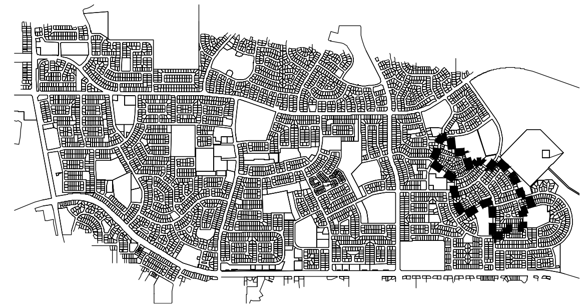
| Date | Datum | Scale | Size |
|---|---|---|---|
| 22.01.2012 | A.H.D | 1:2000 | A1 |

Drawing Number: E11042-001-GSU1 — Revision: A

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

DATE PLOTTED: 25 January, 2013 - 3:02pm
XREF's: Xref_0A(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GSU1.dwg



## LOCALITY PLAN
N.T.S

## LEGEND:

CATCHMENT BOUNDARY
Ø225 UPGRADED SEWER & DIA
150P EXISTING SEWER & DIA
SPM EXISTING SEWER PRESSURE MAIN

1:2000 0 20m 40 60 80 100 120 140 160 180 200

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| A | 22.01.2012 | PRELIMINARY ISSUE | JYY | |

N W E S



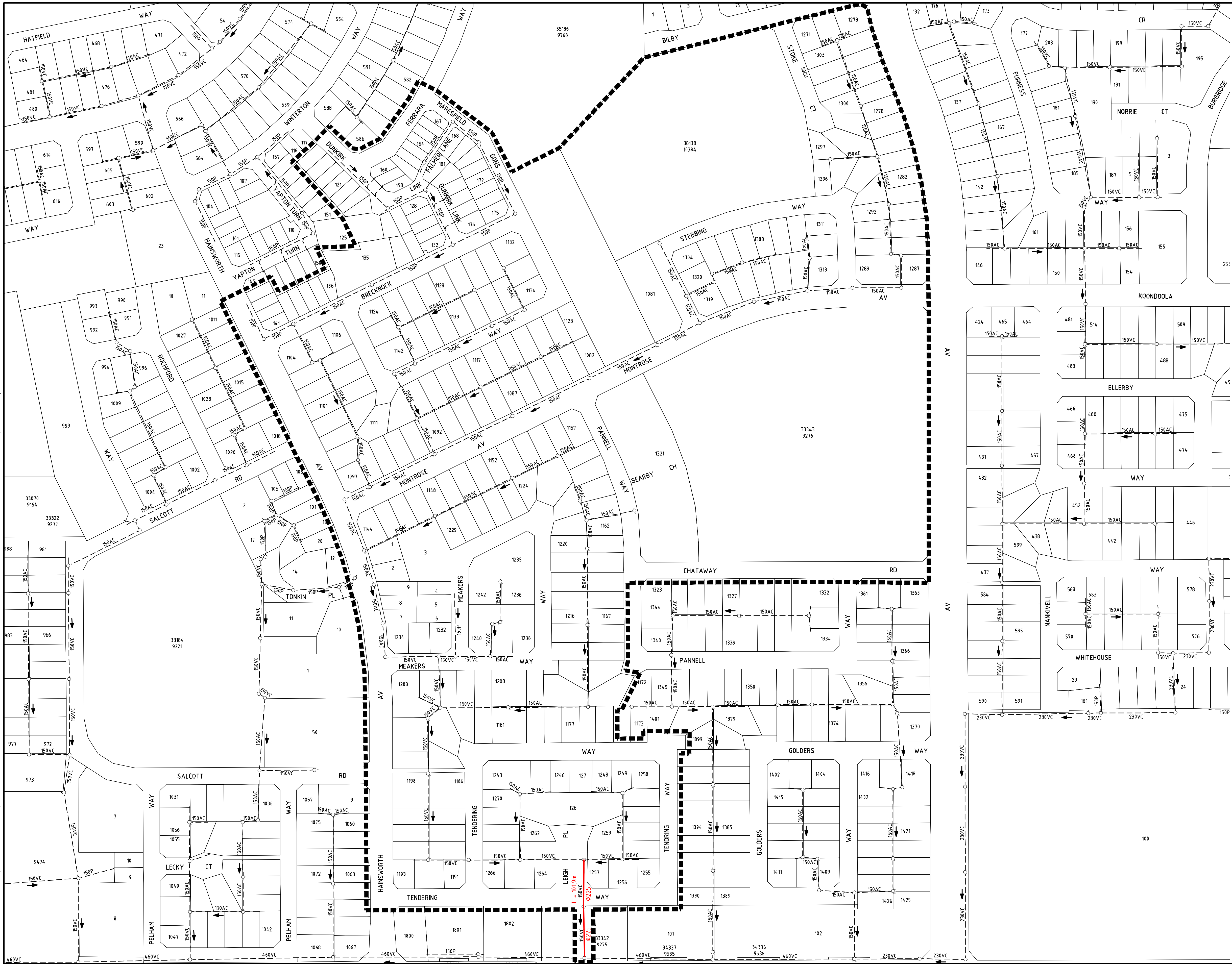
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

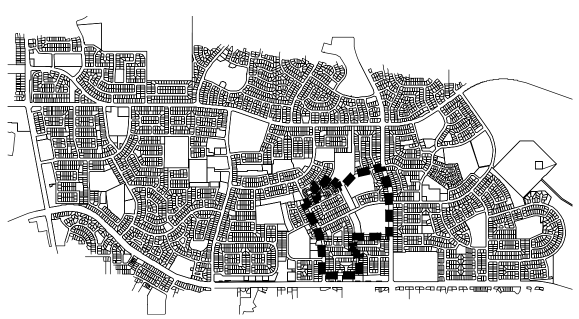
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

| | |
|---|---|
| Drawn | JYY |
| Date | 22.01.2012 |
| Designed | |
| Checked | |
| Reviewed | |
| Approved | |
| Client | CITY OF WANNEROO |
| Project | WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS |
| Title | GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS SEWER RETIC UPGRADE PLAN SHT 2 OF 3 |
| Status | PRELIMINARY |
| Date | 22.01.2012 |
| Datum | A.H.D |
| Scale | 1:2000 |
| Size | A1 |
| Drawing Number | E11042-001-GSU2 |
| Revision | A |

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

DATE PLOTTED: 29 January, 2013 - 12:21pm
XREF's: Xref_GA(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GSU2.dwg



LOCALITY PLAN
N.T.S.

## LEGEND:

- CATCHMENT BOUNDARY
- UPGRADED SEWER & DIA
- EXISTING SEWER & DIA
- EXISTING SEWER PRESSURE MAIN

1:2000

0 20m 40 60 80 100 120 140 160 180 200

DATE PLOTTED: 25 January, 2013 - 3:03pm

XREF's: Xref _0A(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GSU3.dwg

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| A | 22.01.2012 | PRELIMINARY ISSUE | JYY | |



Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn: JYY — Date: 22.01.2012
Designed — Date
Checked — Date
Reviewed — Date
Approved — Date

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

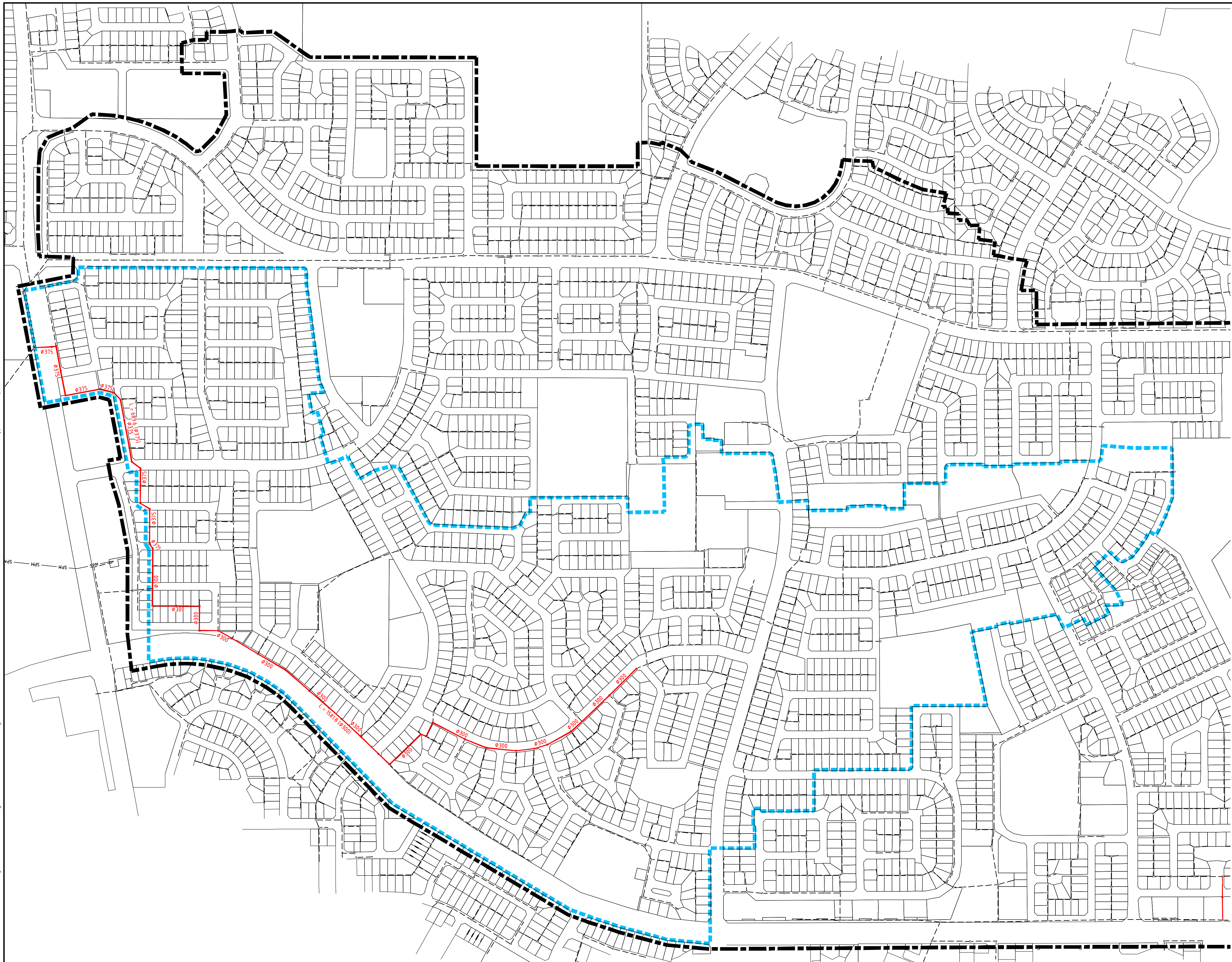
Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS SEWER RETIC UPGRADE PLAN SHT 3 OF 3

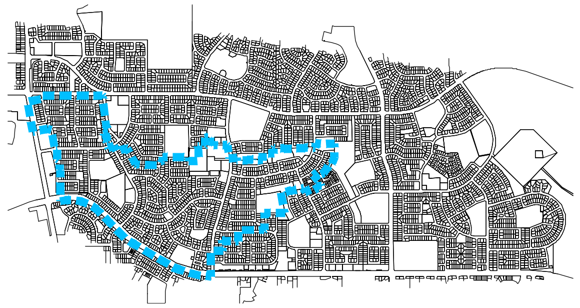
Status: PRELIMINARY

| Date | Datum | Scale | Size |
|---|---|---|---|
| 22.01.2012 | A.H.D | 1:2000 | A1 |

Drawing Number: E11042-001-GSU3 — Revision: A

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



LOCALITY PLAN
N.T.S

## LEGEND:

PRECINCT BOUNDARY
CATCHMENT BOUNDARY
ϕ225 UPGRADED SEWER & DIA
EXISTING SEWER
SPM EXISTING SEWER PRESSURE MAIN

1:4500 0 100m 200 300 400

N W E S

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| A | 22.01.2012 | PRELIMINARY ISSUE | JYY | |



Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

| Drawn | JYY | Date | 22.01.2012 |
|---|---|---|---|
| Designed | | Date | |
| Checked | | Date | |
| Reviewed | | Date | |
| Approved | | Date | |

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS SEWER HEADWORKS UPGRADE PLAN

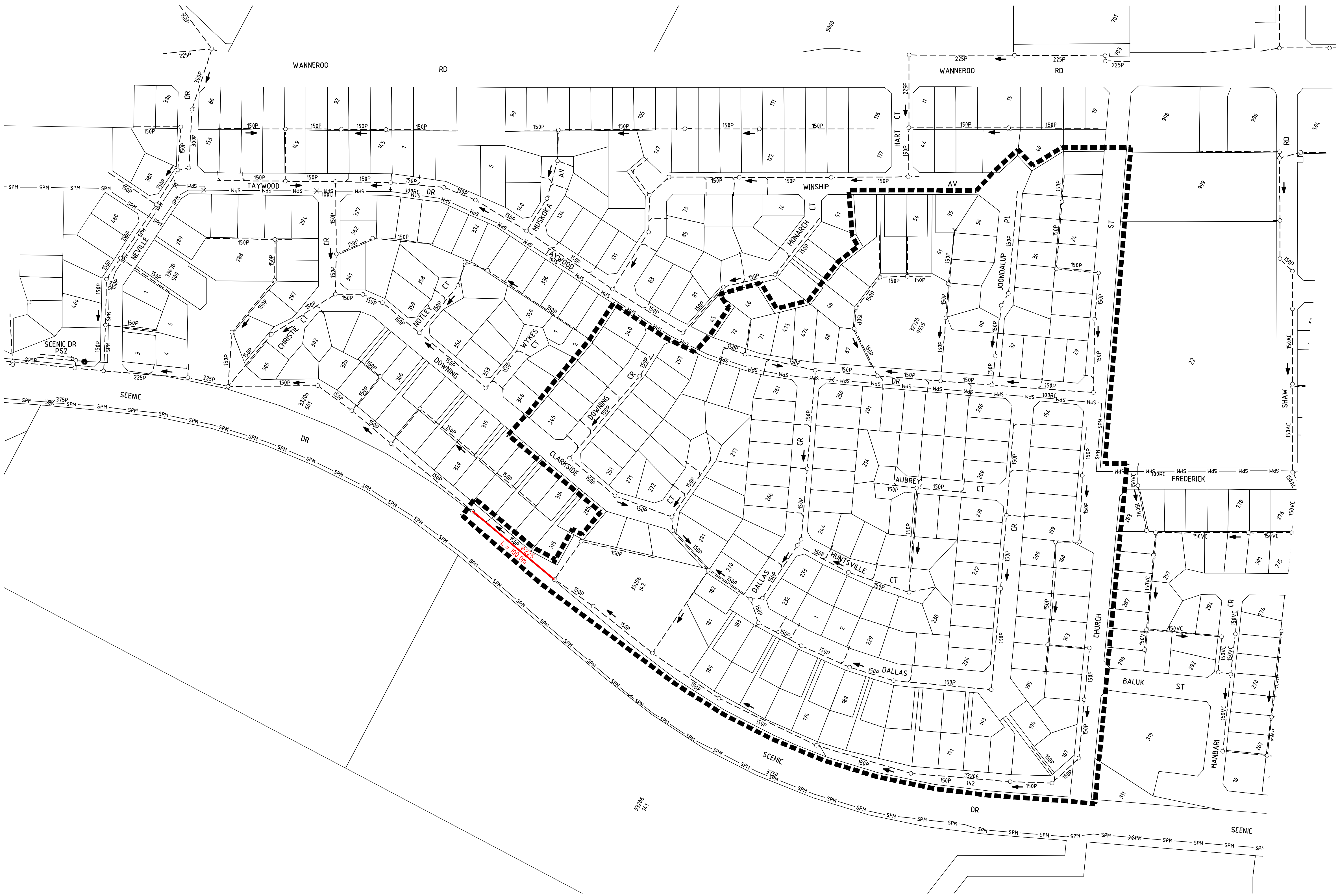
Status: PRELIMINARY

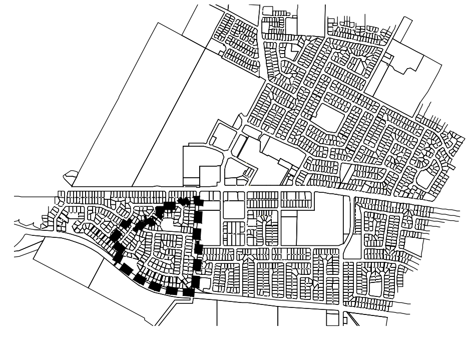
| Date | Datum | Scale | Size |
|---|---|---|---|
| 22.01.2012 | A.H.D | 1:4500 | A1 |

| Drawing Number | Revision |
|---|---|
| E11042-001-GSU4 | A |

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

DATE PLOTTED: 25 January, 2013 - 5:07pm
XREF's: Xref_GA(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GSU4.dwg



LOCALITY PLAN
N.T.S

LEGEND:

- CATCHMENT BOUNDARY
- UPGRADED SEWER & DIA
- EXISTING SEWER & DIA
- EXISTING SEWER PRESSURE MAIN

1:2000 0 20m 40 60 80 100 120 140 160 180 200

DATE PLOTTED: 25 January, 2013 - 3:02pm

XREF's: Xref_GA(Wanneroo Precint), Xref_GW(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-WSU1.dwg

| Rev | Date | Description | Drawn | Appr. |
|---|---|---|---|---|
| A | 22.01.2012 | PRELIMINARY ISSUE | JYY | |



Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

| | | |
|---|---|---|
| Drawn | JYY | Date 22.01.2012 |
| Designed | | Date |
| Checked | | Date |
| Reviewed | | Date |
| Approved | | Date |

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Title: WANNEROO HOUSING PRECINCT SEWER RETIC UPGRADE PLAN

Status: PRELIMINARY

| Date | Datum | Scale | Size |
|---|---|---|---|
| 22.01.2012 | A.H.D | 1:2000 | A1 |

Drawing Number: E11042-001-WSU1 | Revision: A

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

Wanneroo & Girrawheen-Koondoola Precincts

# APPENDIX F

## SEWER RETICULATION – COST ESTIMATES & TRIGGER DATES

Cardno
Shaping the Future

GIRRAWHEEN-KOONDOOLA/WANNEROO HOUSING PRECINCTS - SEWER

| | Quantities (m) | | | | Flow (L/s) | | | |
|---|---|---|---|---|---|---|---|---|
| Catchment | DN150 | DN225 | | | Exist flow | Estimated flow | Exist Capacity | Trigger date |
| WSU1 | | 100 | | | 3.79 | 6.9 | 5 | 2039 |
| GSU1 | | 238 | | | 4.67 | 8.5 | 6 | 2036 |
| GSU2 | | 189 | | | 5.77 | 10.5 | 6 | 2016 |
| GSU3 | | 102 | | | 5.11 | 9.3 | 6 | 2027 |
| Total | | 629 | | | | | | |

GIRRAWHEEN-KOONDOOLA/WANNEROO HOUSING PRECINCTS - SEWER

| | Cost Estimate | | | | |
|---|---|---|---|---|---|
| Catchment | Prelims | Sewer Main | Reinstatement | Fees/Contingency | Total |
| WSU1 | $ 25,000.00 | $ 60,000.00 | $ 19,500.00 | $20,900.00 | $ 125,400.00 |
| GSU1 | $ 25,000.00 | $ 142,800.00 | $ 46,410.00 | $42,842.00 | $ 257,052.00 |
| GSU2 | $ 25,000.00 | $ 113,400.00 | $ 36,855.00 | $35,051.00 | $ 210,306.00 |
| GSU3 | $ 25,000.00 | $ 61,200.00 | $ 19,890.00 | $21,218.00 | $ 127,308.00 |
| | | | | Total | $ 720,066.00 |

# ATTACHMENT 3 – ROAD NETWORK CAPACITY STUDY

# City of Wanneroo

## Girrawheen - Koondoola Housing Strategy
## Traffic Impact Assessment

January 2013

# Table of contents



# Table index

# Figure index

# Appendices

# 1. Introduction

The City of Wanneroo is proposing increases to R Coding in the Girrawheen-Koondoola Housing Precinct. This will result in a significant increase in the number of dwellings and population in this area, which will impact on the number of trips generated.

A plan showing the location of the Girrawheen - Koondoola Housing Precinct is shown overleaf in Figure 1-1 and Figure 1-2.

As a result, a traffic impact assessment (TIA) is required for the road network to satisfy MRWA and Department of Planning and for the local road network which is the City's responsibility. The broad requirements of the TIA are identified as follows:

- Assess impacts of this additional traffic on the immediate regional road network as well as the local road network
- Recommend improvements which may be required to those road networks to address the impacts
- Estimate for each of these improvements, the proportion of that improvement which can be considered attributable to the density increases in the Girrawheen-Koondoola Precinct, as distinct from population and traffic increases occurring in the wider region.
- Estimate costs for the undertaking of each of the recommended road network improvements and then applying the proportions estimated to each cost estimate.

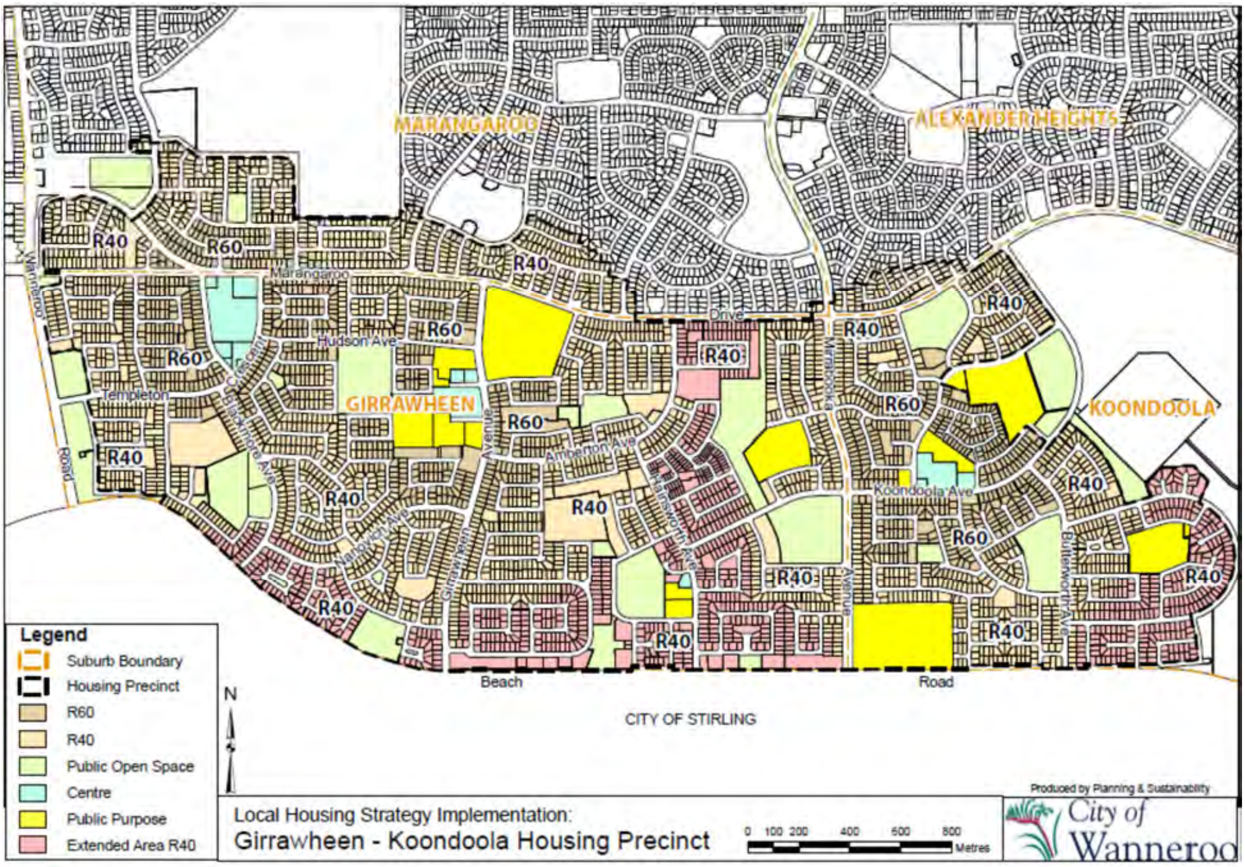
## 1.1 Scope of work

The following scope of work has been undertaken:

- Land use input to Main Roads Regional Operations Model (ROM) to allow Main Roads to model the increased densities.
- Undertake localised modelling.
- Undertake Sidra intersection analysis for the following scenarios:
  – Existing layout to 2031, no local housing strategy (LHS) forecast traffic volumes.
  – Proposed layout using future traffic volumes 2031 with LHS.
- Make recommendations for road network improvements.
- Prepare concept designs for improvements.
- Prepare cost estimates.
- Apportion costs based on ROM modelling.
- Prepare final report.

Figure 1-1 Study area


Figure 1-2 Housing strategy area



# 2. Stakeholder liaison

## 2.1 City of Wanneroo

The following summarises the consultation with the City of Wanneroo.

- An inception meeting was held with Planning Officers at the City of Wanneroo. The following was discussed.
  - Base aerial photo, high resolution - Council will arrange.
  - Traffic data - Planners were liaising with Council's engineers and will provide any available information.
  - Intersection Counts – Main Roads have been asked for SCATS info at all relevant signals. GHD will need to arrange others up to the PS value.
  - Council were asked for their construction rates for our subsequent costing of measures.
  - Council can provide suitable base for any conceptual design.
  - Shawmac report for Wanneroo TC has been provided.
  - GHD's Planning staff to follow up with Council regarding Structure Plans.
  - Council were advised GHD can provide estimate of costs for land acquisition (based on Council advice regarding land costs), design costs and survey costs. However we cannot provide costs for services implications only flag issues. Council were advised that costing for relocation, protection etc is impossible at this stage. GHD will flag issues based on One Call Info and allow a contingency based on experience elsewhere (subject to exclusions and qualifications).
  - Council advised that the contact for liaison with DoT is Mohsin Mutaqui.
  - Council advised that the contacts at Main Roads are John Van Luen, David van Den Dries, Wes Soet (modelling)

Council advised recent road upgrades include:

  - Pinjar Rd/Wanneroo Rd signals
  - Dundebar Rd/Wanneroo Rd, double right turn from Dundebar Road is underway.
  - There are plans for Wanneroo Rd north of Dundebar Rd (need to speak to Main Roads)
  - Wanneroo Rd (Ashby to Tapping recently upgraded)
  - Grade separation of Ocean Reef Rd/Wanneroo Rd long term plan (discuss timing with Main Roads)
  - Ocean Reef Road now connects with Gnangara Road.

Council confirmed:

  - Important to look specifically at traffic volume increase within the precincts of Wanneroo and Girrawheen - Koondoola and their impacts.
  - Keep client advised of progress and any issues.
  - Council were advised of likely delays in ROM modelling turnaround in view of Main Roads commitments in this area.

- The City were consulted regarding the content of the land use input to the ROM model and asked for acceptance of the results prior to asking Main Roads to run the ROM model.

## 2.2 Main Roads Western Australia (MRWA)

Contact was made with Main Roads as follows:

- Main Roads WA were contacted for base traffic data including:
  - SCATS information
  - ROM model traffic zones for land use input
  - Traffic signal information
- Main Roads were also consulted regarding confirmation of the extent of Paramics modelling and ROM areas to be modelled.
- Main Roads were asked to advise of any road upgrades planned in the future and GHD were advised that no works were planned that would impact on this study.
- Regular contact was made with Main Roads modelling section (Dr Wes Soet) to confirm the modelling requirements and inputs for the study in May July and August 2012. Discussion was also held with David Van Den Dries at Main Roads on 19 June 2012 regarding the extent of the modelling and confirmation of the area of influence.
- Responses to comments made by Main Roads on the draft report are shown in Appendix G.

## 2.3 Department of Transport (DoT)

Contact was made with the DoT regarding the East Wanneroo North-South Road (EWNSR) and the following provides a summary of the current status:

- Department of Planning has completed a route alignment study for the East Wanneroo N-S Road between East Wanneroo and Tonkin Highway. There is more work to be done.
- The route will be a freight route and Primary Regional Road.
- The route is justified within the study.
- This has now been handed over to Main Roads. (Lindsay Broadhurst/Justin McKirdy)
- The N-S route will connect with Tonkin Highway along the new section of Hepburn Avenue.
- There will be no connection to Marshall Road; this will be a fly over.
- EWNSR joins Perth Darwin National Highway north of Reid Highway. There will be an interchange at Hepburn Ave.
- There will be an interchange at N-S Road/Reid Highway/Tonkin Highway
- The treatment and intersections of Beechboro Road is uncertain at this stage.
- The N-S road is likely within 20 years and may or may not include grade separation in the first stage.
- The will be no connection to Hepburn Avenue (new N-S Route) permitted.
- Main Roads will probably commence their Planning Study in 2012 and anticipate this will take 12-18 months to complete.

# 3. Literature review

## 3.1 Planning documents

GHD have reviewed planning documents as follows:

- Mirrabooka Local Area Plan.
- City of Wanneroo Local Housing Strategy, Estimated Rates of Development of New Dwellings in Wanneroo and Girrawheen-Koondoola Precincts.
- Wanneroo Local Area Strategy Plan, Planning and Sustainability, Local Planning Policy Framework, Local Planning Policy 3.1: Local Housing Strategy Implementation.

# 4. Land use update

## 4.1 Planning investigation

Main Roads WA has provided GHD with details of the traffic zones within the ROM model for the study area including a 1km buffer around the Girawheen – Koondoola  Housing Precinct.

GHD's Planners have updated the landuse for each of the traffic zones following a review of local structure plans, relevant planning documents, liaison with the City of Wanneroo and Main Roads WA. The City of Wanneroo have reviewed and agreed the planned landuse inputs and assumptions.

A spreadsheet showing the content of the ROM traffic zones for 2031 with and without the R Code Increases is shown in Appendix A.

Main Roads WA has subsequently run the ROM model incorporating the increased R Code for use in the transport assessment for the Girawheen – Koondoola Housing Precinct.

The land use inputs include:

- Population
- Occupied dwellings
- Households
- Manufacturing, commercial and retail employment numbers
- School attendee numbers

The Paramics model also includes the increased R codes and ROM output and is discussed further in Section 5.

# 5. Network modelling

A localised network model of the precinct was required in order to assess the impacts of forecast traffic volumes.  The development of models simulating both 'with density increase' (with LHS) and 'without density increase' (without LHS) scenarios was undertaken to allow a clear comparison to be drawn that isolates the traffic impacts attributable to the changes in R-coding in each area.

Paramics microsimulation traffic modelling software has been used in conjunction with Azalient Ceejazz plugins.

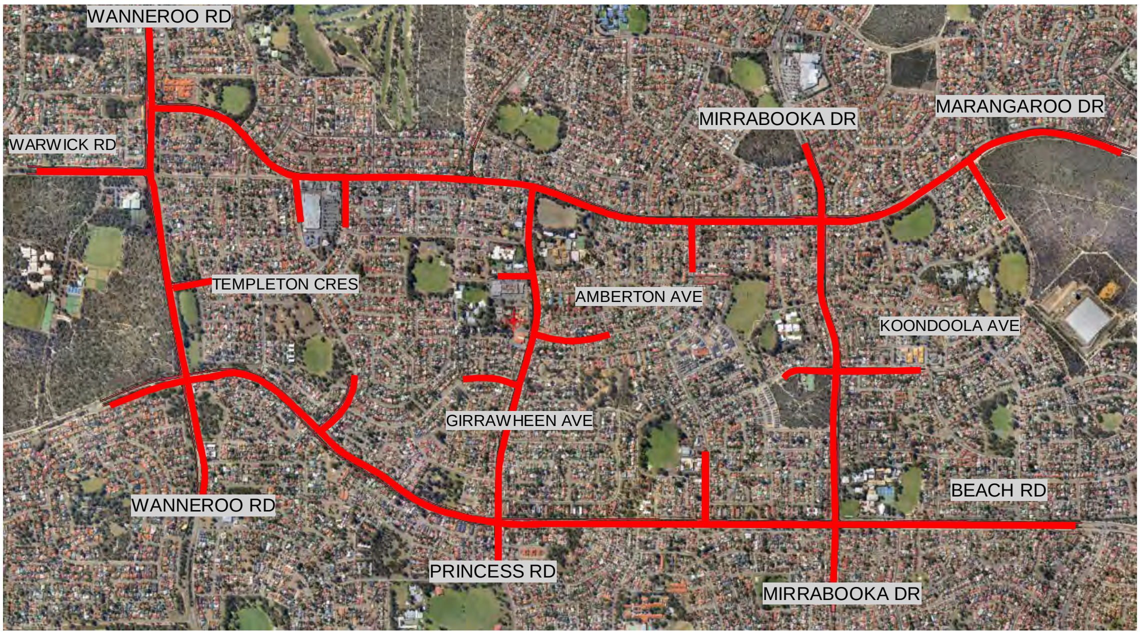
## 5.1 Localised network modelling study area

GHD have developed models that include the key network extents and intersections for the Girrawheen-Koondoola precinct as follows:

- Marangaroo Road;
- Wanneroo Road;
- Beach Road;
- Mirrabooka Avenue; and
- Girrawheen Avenue.

The modelled network is displayed in Figure 5-1.

Figure 5-1 Simulation model network




## 5.2 Base models

Base models were initially developed to represent the current on-site conditions through the study area. These AM and PM peak models were calibrated to traffic volume data and validated against recorded on-site sectional travel times to ensure they provided a comprehensive representation of the existing conditions.

A detailed model validation report has been prepared which documents the inputs, methodology, and results of the Base model development and calibration. This validation report is attached as Appendix B. The key elements of the validation process are summarised below.

### 5.2.1 Data inputs

The key data sources and inputs into the Base model included the following:

- Traffic volume data: Data included manual turning movement surveys, SCATS detector loop counts and historical tube counts;
- Traffic signal information: SCATS data was sourced from Main Roads (including Intersection Diagnostic Monitor files, Traffic Control Signal graphics and intersection timing charts);

- Travel time data: Sectional travel times were recorded for the key routes through the study area network; and
- ROM outputs: Main Roads provided strategic model sub-area trip matrices from the ROM.

Public transport data i.e. bus routes, were not coded into the model network as operationally they were not considered critical to the traffic modelling component.

### 5.2.2 Base trip matrices

Trip matrices for both the AM and PM periods were developed by combining the known turning movement volumes (from recent surveys) with the routing patterns and trip distributions obtained from the ROM sub-area cordon outputs. These trip matrices were refined and entered into the simulation model as demand inputs. (Further information regarding the trip matrix developed is provided in Appendix B).

### 5.2.3 Calibration/validation results

Each recorded turning movement count was compared against the equivalent model output to assess whether the model was representing on-site conditions. The statistical GEH measure was used as the primary acceptance criteria (the GEH statistic is explained in detail in Appendix B), whereby comparisons should produce a GEH value less than 5 to be considered a reasonable fit. The following tables summarises the AM and PM Base model calibration results. Modelled results are the average of five seed runs.

Table 5-1 Base model turning volume calibration results survey

| Time Period | Number of Observations | Observations with GEH < 5 | Average GEH | R2 and Slope | Exceeds Criteria? |
|---|---|---|---|---|---|
| AM Peak | 92 | 92 (100%) | 1.56 | 0.99, 1.009 | Yes |
| PM Peak | 92 | 92 (100%) | 1.66 | 0.99, 0.978 | Yes |

Travel time recordings were also compared against the modelled equivalent as a validation check following the traffic volume calibration process. Modelled travel times within 15% or 1 minute of the recorded time were considered to represent a reasonable fit. This validation criteria is adopted from the Design Manual for Roads and Bridges (DMRB) (and is also stated within the latest RMS NSW Traffic Modelling Guidelines, to be release shortly). Table 5-2 summarises the AM and PM base model travel time validation results.

Table 5-2 Base model travel time validation results summary

| Time Period | Number of recorded travel time sections | Observations within 15% or 1-minute | Exceeds Criteria? |
|---|---|---|---|
| AM Peak | 14 | 14 (100%) | Yes |
| PM Peak | 14 | 14 (100%) | Yes |

Both the AM and PM base models were found to present observed on-site conditions closely, and were hence considered a robust platform against which to assess the future year scenarios.

***Shared model space: Wanneroo and Girrawheen***

It should be noted that this Girrawheen-Koondoola model network has been developed at the same time as a Wanneroo study area model has been developed also for City of Wanneroo. Given the close proximity of these two areas, the two models have been developed within the same Paramics model space. The models can be run together (although the two networks do not interact with each other) or separately (by specifying demands for an individual network).

## 5.3 Forecast traffic volumes

### 5.3.1 Trip matrix

The calibrated base model trip matrices were taken as the starting point for determining the forecast 2031 demand matrices. AM and PM peak hour periods were analysed separately. The methodology implemented was as follows:

- The base model (2012) demand matrices were factored based upon the updated ROM outputs;
- Trip attractions and productions for individual zones based upon the existing, and proposed, land uses were assessed and applied to the corresponding zones within the simulation model network;
- The movements to/from zones within the Paramics model (which represent roads connecting into the study area) were consequently scaled based upon the revised land uses of the areas feeding these road connections.
- The escalation of trip attractions and trip productions were applied separately and the resulting demand matrix balanced to ensure any changes to distributions were incorporated into the 2031 matrices.

The above process was applied for the AM and PM peak hour matrices for the ’with LHS’ and ‘without LHS’ scenarios.

***ROM outputs***

Main Roads’ Regional Operations Model (ROM) data was provided as a sub-area cordon trip matrix for the alternate scenarios. The coarseness of the zone structure as well as the 24-hour time period which ROM operates meant that the outputs were not used as a direct input into the simulation model. Instead the ROM outputs were used to evaluate the magnitude of forecast trip volume escalations as well as providing an initial distribution of trips across the study area.

Main Roads incorporated the revised and updated lane use figures (discussed in Section 4) for the alternate scenarios into ROM, and subsequently provided the corresponding 2031 trip matrices for the with and without LHS options. These outputs were then used as described above.

### 5.3.2 Turning movement volumes

Following the determination of trip matrices, the corresponding forecast turning movement volumes were then analysed. The 2031 turning movement volumes were determined by applying the demand files (trip matrices) to the simulation network and recording the resulting turning movements. It is noted that there are a number of alternate route choices within the network, as such, not all forecast turning volumes could be determined directly from inspection of the trip matrix alone.

The resulting 2031 forecast turning movement volumes for key intersections within the study network are presented in Appendix C. These display the forecast AM and PM volumes for both the ‘with LHS’ and ‘without LHS’ scenarios.

## 5.4 Scenario testing

A sequential and staged approach was implemented for the various scenario tests to assess the impact to the road network with, and without, the increased R-coding ratings i.e. with/without the local housing strategy (LHS) in place. Consequently the following scenarios were assessed within the simulation model (note, all scenarios consisted of a 2031 horizon year):

- Existing network 'without LHS' volumes;
- Existing network 'with LHS' volumes;
- Suggested network upgrades to facilitate 'without LHS' volumes;
- Suggested network upgrades for 'without LHS' with 'with LHS' volumes; and
- Suggested network upgrades to facilitate 'with LHS' volumes.

***Known and committed network upgrades***

GHD liased with council and Main Roads to ascertain whether any known network upgrades are to occur within the study area. Both council and Main Roads indicated no upgrades or capacity enhancements are currently planned. Had any upgrades been planned to occur, these would have been included into the base network for the purposes of testing the 2031 status quo scenario.

### 5.4.1 Methodology for capacity enhancements

The process adopted to determine the network upgrades necessary to provide an acceptable level of service under the various scenarios, was as follows:

- Forecast traffic volumes were initially applied to the existing network model without any upgrades or capacity enhancements;
- The models were visually observed in operation to assess performance;
- Key areas of deficiencies within the network were identified, i.e. areas exhibiting substantial congestion or oversaturated conditions;
- Signal operation adjustments or refinements were implemented to improve the efficiency of the network. That is, congested conditions within the network were initially attempted to be resolved through the refinement of signal operations in the first instance. The dynamic nature of the SCATS signalling functionality on-site would attempt to optimise signal operations in a similar manner. Furthermore, adjustments to signal operations were preferable over capacity increases requiring infrastructure works;
- The performance of the network was evaluated through quantitative model outputs and qualitative model observations to determine where network capacity increases were required;
- Network upgrades were implemented into model network and then the assessment process repeated. That is, visual observations of the simulation model combined with quantitative outputs were used to evaluate the proposed intersection and mid-block modifications. Throughout the iterative process of determining required intersection upgrades, a level of service (LOS) D was targeted as the junction performance measure.

During this process, a number of Sidra models were developed to assist with determining suggested upgrades. These Sidra models were used to determine board capacity requirements and suggested signal operations, which were then taken into the Paramics microsimulation model and assessed as part of an integrated and connected road network.

The process described above was undertaken in an iterative manner to account for the fact that deficiencies within the network were not always initially identifiable. Due to the integrated network of intersections within the simulation model, congestion at neighbouring intersections can obscure or mask the actual performance of a given site. As such, the process above was conducted iteratively do address the most critical areas of concern first.

Following the simulation model scenario testing, and identification of broad network upgrade requirements, comprehensive Sidra models were run and analysed for the key sites throughout the network. These are discussed and presented in detail in Section 6.

The modelling process outlined above was undertaken to determine the following;

- The upgrades likely to be required by 2031 assuming no change to current R-code ratings or density levels i.e. without implementation of the local housing strategy; and
- The further upgrades likely to be required if the local housing strategy is implemented and R-coding designations are increased to allow higher density developments.

The resulting suggested upgrade requirements from the modelling assessment were as follows for the scenario ***without LHS***:

- Wanneroo Road: Additional lane in each direction i.e. three lanes northbound and southbound;
- Wanneroo Road /Warwick Road: Double right turn and double departure lanes for north-to-west movement;
- Wanneroo Road/Beach Road: Double right turns east-to-north, west-to-south, and north-to-west;
- Beach Road /Girrawheen Road: two lane approach from Princess Street with two through lanes and a flared right turn lane onto Beach Road (i.e. south-to-east), two lane departure on north leg (Girrawheen Avenue);
- Signal adjustments as required, i.e. phase times and some cycle times, to cater for changed traffic volumes/movements. Note, no infrastructure changes.

Additional upgrades required to facilitate the 2031 ***with LHS***:

- Girrawheen Avenue: additional lane in each direction, i.e. two lanes northbound and southbound, between Beach Road and Marangaroo Drive;
- Beach Road /Girrawheen Road: double right turn from Princess Street to Beach Road (i.e.south-to-east), left turn lane from Beach Road to Princess Street (east-to-south), right turn lane from Girrawheen Avenue to Beach Road (north-to-west);
- Signalisation of Beach Road /Hainsworth Avenue, Wanneroo Road /Templeton Crescent, Mirrabooka Avenue /Koondoola Avenue, and Mirrabooka Avenue /Girrawheen Avenue; (Main Roads response to these suggestions is discussed in Section 6);.
- Beach Road/Mirrabooka Avenue: Double right turns east-to-north, west-to-south, and north-to-west;
- Marangaroo Avenue /Mirrabooka Avenue: Flared northbound/southbound (Mirrabooka Avenue) approaches and departures to 3-lanes, double right turns east-to-north and west-to-south, left turn lanes east-to-south and west-to-north;
- Girrawheen Avenue /Amberton Avenue: Amberton Avenue two lane approach to Girrawheen Avenue;
- Signal adjustments as required i.e. signal operation changes without any infrastructure changes.

It should be noted that the suggested upgrades above did not consider the available land on-site at these locations. The proposed configurations represent the ultimate junction layouts which would provide an acceptable level of service based upon the forecast traffic volumes. Consideration has been given to site constraints during the detailed intersection assessments discussed in Section 6.

The modelled intersection configurations of the three scenarios (i.e. base, upgrades without LHS and upgrades with LHS) are presented in Appendix D.

## 5.5 Model results

Each scenario model was run five times with different seed values and the results extracted from each model. Statistical outputs were then averaged across the five seed value runs.

Results are presented in the sections below and show comparisons across the different scenarios for the following statistical outputs and performance measures:

- Intersection levels of service (LOS);
- Blocked (unreleased) vehicle summary for each zone; and
- Modelled travel time recordings for key routes through the network.

In addition to the quantitative results listed above, video files of the simulation models in operation have also been produced.

The result summary tables in the sections below display the following abbreviated scenario names:

- **BASE**: Existing conditions as per the calibrated base model (current 2012 volumes);
- **DN w/o LHS**: Existing network i.e. Do-Nothing (DN), 'without LHS' volumes;
- **DN w/ LHS**: Existing network i.e. Do-Nothing (DN), 'with LHS' volumes;
- **NU w/o LHS**: Suggested network upgrades (NU) necessary to facilitate 'without LHS' volumes;
- **NU w/o LHS, w/ LHS vols**: Suggested network upgrades (NU) for 'without LHS', but modelled with 'with LHS' volumes;
- **NU w/ LHS**: Suggested network upgrades (NU) to facilitate 'with LHS' volumes.

### 5.5.1 Level of service

The key statistical performance measure which has been used to evaluate the network and individual junctions is delay, which has subsequently been converted into a level of service (LOS). The intersections which have been analysed using the simulation model include a mixture of signalised sites, priority control, and roundabouts. The average approach delay thresholds and corresponding LOS categories which have been utilised are as shown in Table 5-3.

Table 5-3 Level of service/delay categories

| Level of Service | Signals | Roundabout | Priority Control |
|---|---|---|---|
| A | 0s – 10s | 0s – 10s | 0s – 10s |
| B | 10s – 20s | 10s – 20s | 10s – 15s |
| C | 20s – 35s | 20s – 35s | 15s – 25s |
| D | 35s – 55s | 35s – 50s | 25s – 35s |
| E | 55s – 80s | 50s – 70s | 35s – 50s |
| F | 80s+ | 70s+ | 50s+ |

Table 5-4 outlines the recorded LOS for the AM peak scenario tests.

### Table 5-4 Intersection level of service results: AM peak

| | BASE | DN w/o LHS | DN w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| Wanneroo Rd / Beach Rd | E | F | F | D | E | E |
| Wanneroo Rd / Marangaroo Dr | B | E | F | C | C | D |
| Wanneroo Rd / Warwick Rd | C | E | E | C | C | C |
| Beach Rd / Princess Rd / Girrawheen Ave | C | E | F | D | F | D |
| Beach Rd / Mirrabooka Ave | C | D | F | D | F | D |
| Marangaroo Dr / Mirrabooka Ave | D | E | E | D | E | D |
| Marangaroo Dr / Highclere Blvd | B | B | C | B | B | B |
| Marangaroo Dr / Templeton Cres | B | B | F | B | B | B |
| Girrawheen Ave / Amberton Ave | A | A | C | A | D | B |
| Girrawheen Ave / Wade Ct | A | A | D | A | E | A |
| Mirrabooka Ave / Koondoola Ave | A | A | D | A | E | D |
| Girrawheen Ave / Marangaroo Dr | A | A | D | A | F | B |
| Beach Rd / Hainsworth Ave | A | A | D | A | E | B |
| Wanneroo Rd / Templeton Cres | E | F | F | B | F | D |

Table 5-5 outlines the recorded LOS for the PM peak scenario tests.

### Table 5-5 Intersection level of service results: PM peak

| | BASE | DN w/o LHS | DN w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| Wanneroo Rd / Beach Rd | E | F | F | D | E | E |
| Wanneroo Rd / Marangaroo Dr | B | B | C | B | C | C |
| Wanneroo Rd / Warwick Rd | C | F | E | C | D | D |
| Beach Rd / Princess Rd / Girrawheen Ave | C | E | F | D | F | C |
| Beach Rd / Mirrabooka Ave | C | D | F | D | E | D |
| Marangaroo Dr / Mirrabooka Ave | D | E | E | D | E | C |
| Marangaroo Dr / Highclere Blvd | A | B | B | B | B | B |
| Marangaroo Dr / Templeton Cres | B | B | C | B | C | C |
| Girrawheen Ave / Amberton Ave | A | A | A | A | D | A |
| Girrawheen Ave / Wade Ct | A | A | A | A | C | A |
| Mirrabooka Ave / Koondoola | A | A | B | A | B | D |

| | BASE | DN w/o LHS | DN w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| Ave | | | | | | |
| Girrawheen Ave / Marangaroo Dr | A | A | C | A | D | B |
| Beach Rd / Hainsworth Ave | A | A | A | A | A | B |
| Wanneroo Rd / Templeton Cres | A | D | F | A | C | C |

It can be seen from Table 5-4 and Table 5-5 that the anticipated performance of the network without any intersection upgrades (i.e. the Do-Nothing scenarios) is expected to be poor with numerous sites exhibiting LOS E and F. Similarly, if the suggested network upgrades to facilitate the 2031 traffic volumes 'without LHS' are adopted, and then the LHS is implemented then many sites would be expected to operate at LOS E and F. Applying the recommended network upgrades results in acceptable levels of service for both the with/without LHS scenarios.

It is noted that the intersection of Wanneroo Road and Beach Road is shown in Table 5-4 and Table 5-5 to operate at LOS E under both the current conditions as well as the upgraded scenarios. This result is partially attributable to the 190 second cycle time which is currently in operation at this site (and has been maintained for the scenario testing).

### 5.5.2 Blocked vehicle summary

Blocked (or 'unreleased') vehicles occur within the simulation when the full extent of the traffic demand cannot be loaded onto the model network. These blocked vehicles occur due to downstream network congestion or insufficient capacity on the link which connects the zone onto the model network. Blocked vehicles essentially represent the length of queue (in terms of number of vehicles) extending off the study area network.

Table 5-6 displays the modelled blocked vehicle summary for each zone across the various scenarios for the AM period. Note; only zones which exhibited blocked vehicles in at least one scenario have been included in Table 5-6.

Table 5-6 Blocked vehicle summary: AM peak

| Model Entry Zone | BASE | DN w/o LHS | DN w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| Warwick Rd | 0 | 16 | 49 | 0 | 0 | 0 |
| Beach Rd west | 0 | 30 | 26 | 0 | 0 | 0 |
| Princess Rd | 0 | 0 | 361 | 0 | 0 | 0 |
| Mirrabooka Ave north | 0 | 68 | 50 | 0 | 0 | 0 |
| Highclere Blvd | 0 | 0 | 50 | 0 | 0 | 0 |
| Giralt Rd | 0 | 63 | 195 | 0 | 0 | 0 |
| Wanneroo Rd north | 0 | 0 | 29 | 0 | 0 | 0 |
| Hainsworth Ave | 0 | 0 | 8 | 0 | 33 | 0 |
| Koondoola Ave (@ Mirrabooka) | 0 | 0 | 188 | 0 | 224 | 0 |
| Amberton Ave (@ Marangaroo) | 0 | 0 | 0 | 0 | 68 | 0 |
| Amberton Ave (@ Girrawheen) | 0 | 0 | 88 | 0 | 75 | 0 |
| Nanovich Ave | 0 | 0 | 0 | 0 | 11 | 0 |
| Balgonie Ave | 0 | 0 | 73 | 0 | 0 | 0 |

| Model Entry Zone | BASE | DN w/o LHS | DN w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| Templeton Cres (@ Wanneroo Rd) | 0 | 120 | 427 | 0 | 26 | 0 |
| Wade Ct (or Hudson Ave) | 0 | 0 | 7 | 0 | 15 | 0 |
| Total | 0 | 297 | 1549 | 0 | 451 | 0 |

Table 5-7 displays the blocked vehicle summaries for the various scenarios for the PM period. Note; only zones which exhibited blocked vehicles in at least one scenario have been included in Table 5-7.

Table 5-7 Blocked vehicle summary: PM peak

| Model Entry Zone | BASE | DN w/o LHS | DN w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| Wanneroo Rd south | 0 | 118 | 711 | 0 | 0 | 0 |
| Princess Rd | 0 | 231 | 1038 | 0 | 263 | 0 |
| Amberton Ave (@ Girrawheen Ave) | 0 | 0 | 0 | 0 | 99 | 0 |
| Templeton Cres (@ Wanneroo Rd) | 0 | 0 | 123 | 0 | 0 | 0 |
| Wade Ct (or Hudson Ave) | 0 | 0 | 0 | 0 | 78 | 0 |
| Total | 0 | 349 | 1872 | 0 | 440 | 0 |

It can be seen from Table 5-6 and Table 5-7 that the anticipated performance of the network without any intersection upgrades (i.e. the Do-Nothing scenarios) is expected to be poor with substantial numbers of trips unable to be access the network due to congestion. Similarly, if the suggested network upgrades to facilitate the 2031 traffic volumes 'without LHS' are adopted, and then the LHS is implemented then the network would still be unable to service the full extent of the forecast trips. These results are consistent with the LOS results presented in Table 5-4 and Table 5-5.

### 5.5.3 Travel times

Modelled travel times for key sections of the network have been extracted from each of the scenarios. The recorded sections are consistent with the sections recorded (and validated against) during the base model development. The recorded sections are highlighted in Table 5-2.

Figure 5-2 Recorded travel time sections

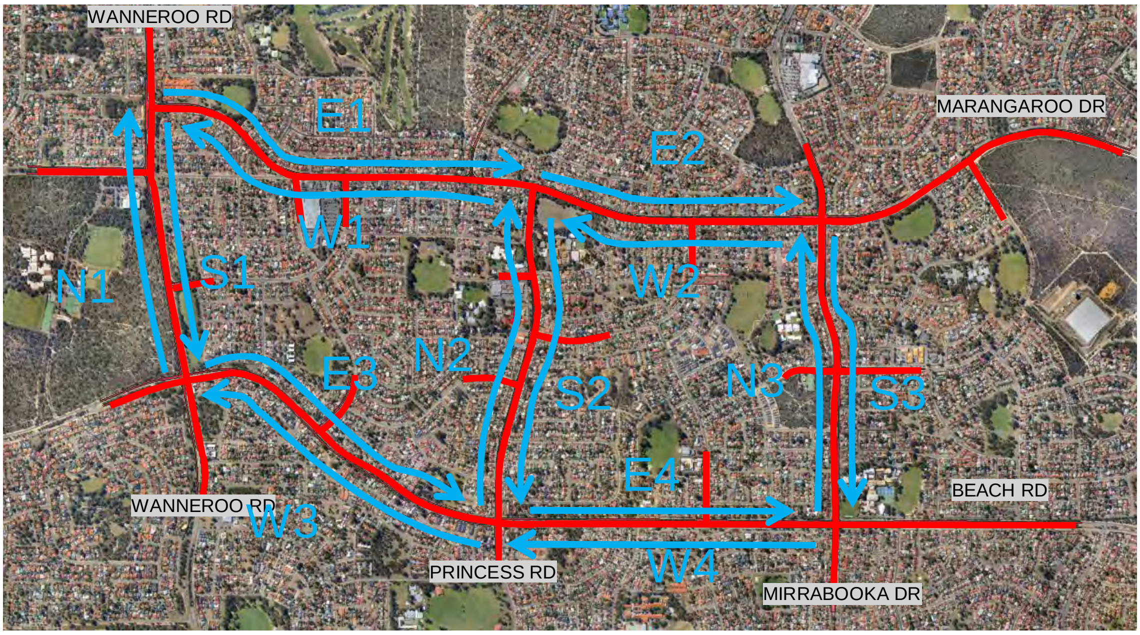



Table 5-9 shows the modelled travel time comparisons between each scenario for the AM period.

Table 5-8 Modelled travel time result (seconds): AM peak

| Location | BASE | DN w/o LHS | DN w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| N1 | 231 | 257 | 266 | 249 | 254 | 263 |
| N2 | 161 | 171 | 244 | 168 | 410 | 194 |
| N3 | 128 | 133 | 131 | 115 | 140 | 186 |
| S1 | 195 | 333 | 348 | 143 | 173 | 215 |
| S2 | 189 | 331 | 274 | 242 | 289 | 184 |
| S3 | 138 | 175 | 238 | 130 | 229 | 212 |
| E1 | 137 | 126 | 143 | 133 | 155 | 153 |
| E2 | 109 | 117 | 128 | 119 | 147 | 118 |
| E3 | 117 | 120 | 128 | 125 | 281 | 141 |
| E4 | 111 | 126 | 282 | 142 | 234 | 145 |
| W1 | 195 | 509 | 612 | 187 | 198 | 223 |
| W2 | 68 | 68 | 169 | 68 | 343 | 101 |
| W3 | 151 | 163 | 167 | 147 | 146 | 150 |
| W4 | 112 | 126 | 264 | 132 | 465 | 121 |

Table 5-9 shows the modelled travel time comparisons between each scenario for the PM period.

Table 5-9 Modelled travel time results (seconds): PM peak

| Location | BASE | DN w/o LHS | DN w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| N1 | 177 | 269 | 221 | 181 | 203 | 199 |
| N2 | 151 | 153 | 199 | 161 | 242 | 159 |
| N3 | 137 | 204 | 168 | 144 | 197 | 166 |
| S1 | 87 | 100 | 169 | 120 | 118 | 181 |

| Location | BASE | DN w/o LHS | DN w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| S2 | 174 | 181 | 205 | 229 | 512 | 166 |
| S3 | 129 | 134 | 139 | 135 | 158 | 173 |
| E1 | 126 | 128 | 146 | 132 | 151 | 175 |
| E2 | 111 | 113 | 224 | 116 | 127 | 107 |
| E3 | 115 | 128 | 126 | 138 | 132 | 126 |
| E4 | 107 | 115 | 114 | 112 | 116 | 121 |
| W1 | 119 | 124 | 153 | 198 | 222 | 247 |
| W2 | 68 | 68 | 68 | 68 | 77 | 99 |
| W3 | 184 | 340 | 361 | 161 | 163 | 176 |
| W4 | 113 | 222 | 414 | 129 | 324 | 122 |

Observations of the travel time results presented in Table 5-8 and Table 5-9 generally reveal the following trends:

- All sections are expected to experience increased vehicle journey times if no network modifications are applied, particularly if the LHS is introduced; and
- Adoption of the suggested network upgrades would provide the least variation from current travel times through the study area.

## 5.6 Trigger Points

A number of horizon year sensitivity tests were undertaken to determine the required staging of the suggested upgrades. Five and ten year horizons were adopted to determine the intersections requiring treatment within the short/medium term. The trigger/threshold assessments were undertaken separately for the scenarios with and without the proposed LHS. The following methodology was employed for this assessment:

- The escalation of traffic between the current (2012 Base) scenario and 2031 forecast year (i.e. 20 year horizon) was determined for without and with LHS scenarios;
- A linear escalation of the forecast traffic volume increases was assumed, such that 25% of the increase would occur over the next 5 years, and similarly 50% of the forecast increase would occur over ten years;
- The traffic demands corresponding to 5 and 10 year horizons were calculated separately for AM and PM peak periods.
- The calculated interim year traffic volumes were applied to the simulation model with the current road configuration to assess the anticipated network performance.

Table 5-10 and Table 5-11 present the modelled intersection performance results of the scenario testing without LHS and with LHS respectively.

The recommended staging of intersection treatments is discussed in Section 7.

### Table 5-10 Intersection performance – without LHS

| | 5 year | | 10 year | |
|---|---|---|---|---|
| | AM peak | PM peak | AM peak | PM peak |
| Wanneroo Rd / Beach Rd | E | E | E | F |
| Wanneroo Rd / Warwick Rd | C | C | C | D |
| Beach Rd / Princess Rd / Girrawheen Ave | C | C | D | D |

| | 5 year | | 10 year | |
|---|---|---|---|---|
| Beach Rd / Mirrabooka Ave | C | C | D | D |
| Marangaroo Dr / Mirrabooka Ave | D | D | D | D |
| Girrawheen Ave / Amberton Ave | A | A | A | A |
| Mirrabooka Ave / Koondoola Ave | A | A | A | A |
| Girrawheen Ave / Marangaroo Dr | A | A | A | A |
| Beach Rd / Hainsworth Ave | A | A | A | A |
| Wanneroo Rd / Templeton Cres | E | A | F | A |

Table 5-11 Intersection performance – with LHS

| | 5 year | | 10 year | |
|---|---|---|---|---|
| | AM peak | PM peak | AM peak | PM peak |
| Wanneroo Rd / Beach Rd | E | E | F | F |
| Wanneroo Rd / Warwick Rd | C | C | C | D |
| Beach Rd / Princess Rd / Girrawheen Ave | D | D | E | F |
| Beach Rd / Mirrabooka Ave | E | C | E | D |
| Marangaroo Dr / Mirrabooka Ave | D | D | E | D |
| Girrawheen Ave / Amberton Ave | A | A | A | A |
| Mirrabooka Ave / Koondoola Ave | A | A | B | A |
| Girrawheen Ave / Marangaroo Dr | A | A | A | A |
| Beach Rd / Hainsworth Ave | A | A | A | A |
| Wanneroo Rd / Templeton Cres | F | A | F | B |

# 6. Intersection analysis and road network improvements

The following section considers the intersection requirements based on the forecast traffic volumes from both the Paramics modelling and ROM modelling and subsequent Sidra modelling.

The following Sidra analysis has been undertaken

- Undertake Sidra intersection analysis for two scenarios:
  - Existing layout to 2031, no LHS forecast traffic volumes
  - Proposed layout using future traffic volumes 2031 with increased R Code

A summary of all Sidra analysis for scenarios with and without LHS to 2031 is shown in Appendix D and Appendix E.

The following intersections have been analysed:

- Mirrabooka/Koondoola Intersection 2031.
- Beach Road/Mirrabooka Road Intersection 2031.
- Girrawheen/Beach Road Intersection 2031.
- Mirabooka/Marangaroo Ave Intersection 2031.
- Marangaroo Drive/Girawheen Ave Intersection 2031.
- Beach Road/Wanneroo Road Intersection 2031.

- Wanneroo Road/Templeton Road Intersection 2031.
- Marangaroo Dr/Templeton Crescent Intersection 2031.

## 6.1 Wanneroo Road Cross Section

Main Roads have provided the following comment regarding the cross section of Wanneroo Road.

*"It is acknowledged that future predicted volumes, especially on Wanneroo Rd, suggest the need to consider upgrading this road to six lanes, however current ultimate planning is for four lanes. Current thinking would suggest, if any additional lanes are introduced then they would be for public transport purposes, such as bus lanes. Additionally, the extra demand predicted may actually result in peak spreading with the demand being forced to utilise the infrastructure available. Reference to ARRB's North West Corridor Structure Plan Review – Strategic Assessment of Regional Transport Requirements – October 2009 concluded /recommended that four lanes for Wanneroo Rd through the Girrawheen area will be required by 2031 but accepting it will be operating at a level of service F during peak periods"*

Modelling for this project confirms these findings in relation to capacity and operation.

## 6.2 Intersection analysis 2031 (existing layout with no LHS)

This section summarises the analysis of the current geometry at key intersections to 2031 with No LHS. It indicates whether the existing geometry needs to be upgraded. Full analysis and intersection layouts are shown in Appendix D. Intersection layouts are not repeated here.

*It should be noted that most intersections considered are forecast to require upgrade based on the surrounding traffic growth **without** the increased traffic generation due to the planned increased housing density.*

### 6.2.1 Mirrabooka/Koondoola intersection 2031

The analysis with NO LHS indicates that the existing roundabout will accommodate forecast traffic volumes to 2031. A LoS of A/B is forecast.

### 6.2.2 Beach Road/Mirrabooka Road intersection 2031

The analysis with NO LHS indicates an intersection LoS of D/E to 2031 for the current geometry. Stop rates for some movements are greater than 1 and the degree of saturation is 1. The analysis indicates that upgrade is required to improve the performance.

### 6.2.3 Girrawheen/Beach Road intersection 2031

The analysis with NO LHS indicates an intersection LoS of E/F to 2031 for the current geometry. Stop rates for most movements are greater than 1 and the degree of saturation is greater than 1 in the pm peak hour 1. The analysis indicates that upgrade is required to improve the performance.

### 6.2.4 Mirabooka/Marangaroo Avenue intersection 2031

The analysis with NO LHS indicates an intersection LoS of E to 2031 for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 0.9. Queues in excess of 400m are forecast in Mirrabooka Drive. The analysis indicates that upgrade is required to improve the performance.

### 6.2.5 Marangaroo Drive/Girawheen Avenue intersection 2031

The analysis with NO LHS indicates an intersection LoS of F for the right turn from Girrawheen Ave to 2031 for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 1. Queues in excess of 400m are forecast in Girrawheen Ave. The analysis indicates that upgrade is required to improve the performance

### 6.2.6 Beach Road/Wanneroo Road intersection 2031

The analysis with NO LHS indicates an intersection LoS of F to 2031 for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 1. Queues in excess of 1km are forecast in Wanneroo Road. The analysis indicates that upgrade is required to improve the performance.

### 6.2.7 Wanneroo Road/Templeton Road intersection 2031

The analysis with NO LHS indicates a LoS of F for right turn movements to 2031 with no LHS, for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 1. Queues in excess of 400m are forecast in Templeton Crescent. The analysis indicates that upgrade is required to improve the performance.

### 6.2.8 Marangaroo Dr/Templeton Crescent intersection 2031

The analysis with NO LHS indicates a LoS of A to D for most movements to 2031 for the current geometry. Stop rates for all movements are less than 1 and the degree of saturation is 0.395 and 0.573. Queues in excess of 60m are forecast in Templeton Crescent during the pm peak hour indicating this short two lane approach should be extended. The analysis indicates that minor upgrade is required to improve the performance.

### 6.2.9 Wanneroo Road/Marangaroo Drive intersection 2031

The analysis with no LHS indicates a LoS of E and F for some movements to 2031, for the current geometry. Stop rates for all movements during the pm peak hour are less than 1 however some are greater than 1 during the am peak hour. The degree of saturation is 1 and 0.896. Queues in excess of 700m are forecast on Wanneroo Road north during the am peak hour. The analysis indicates upgrade is required to improve the performance.

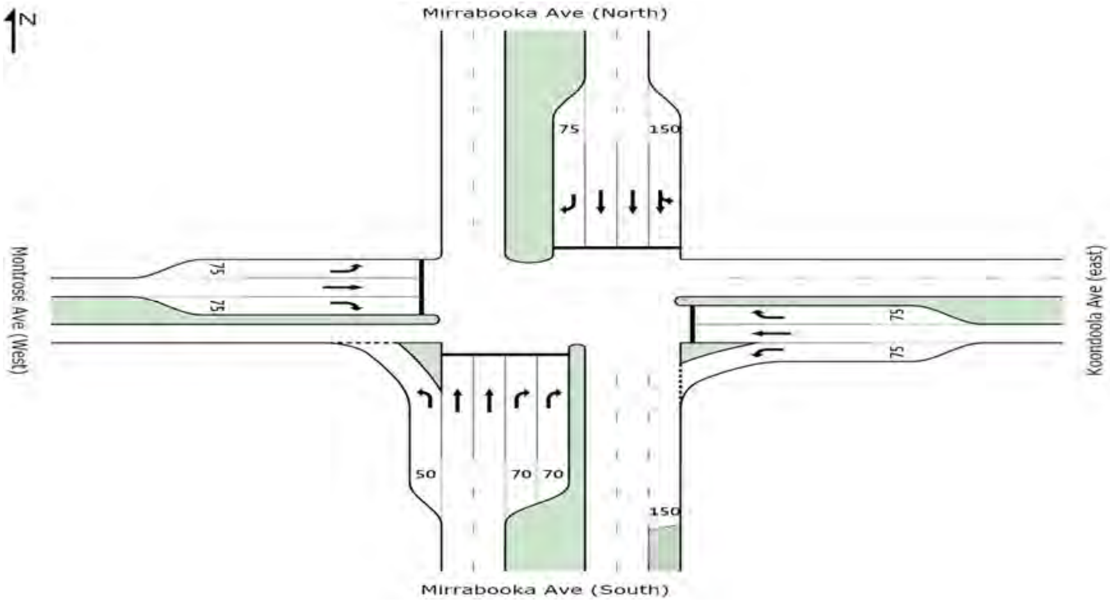
## 6.3 Intersection analysis 2031 (proposed layout with LHS)

Analysis has been undertaken of a modified intersection to determine the ultimate requirement to achieve a good level of service, however in view of the fact that some sites are constrained a compromise layout is provided to avoid land acquisition. All layouts are shown in Appendix E and are not repeated here, only the recommended layouts.

### 6.3.1 Mirrabooka Ave/Koondoola Ave intersection 2031

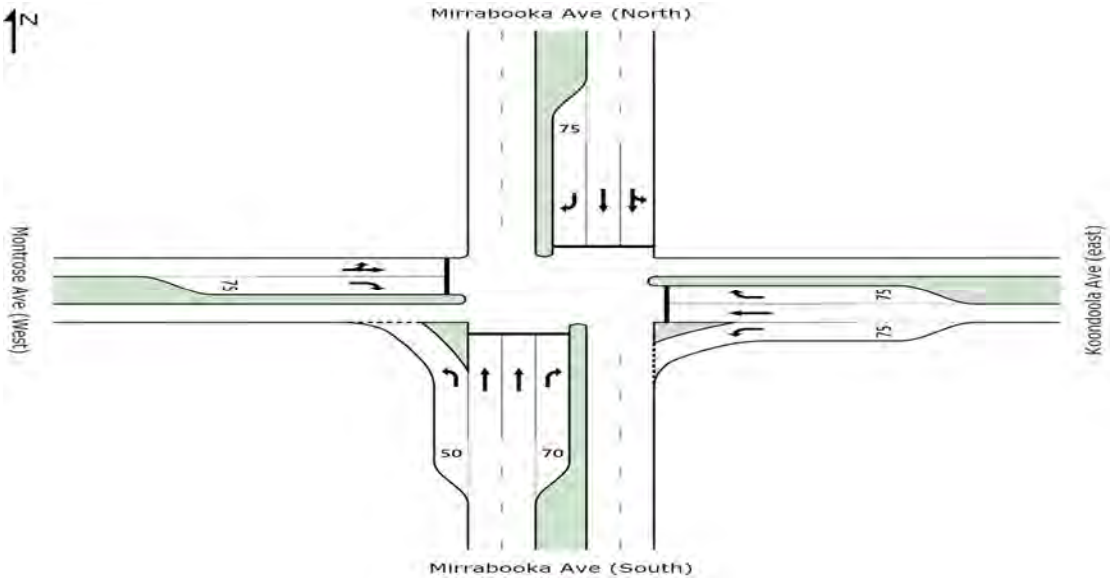
The analysis with LHS indicates that an upgraded intersection which includes replacing the roundabout with a signalised intersection as shown in Appendix F is likely to accommodate forecast traffic volumes to 2031. Degree of saturation is 0.883 to 0.887, LoS is C/D, queue length on Mirrabooka Ave North is 214m and the stop rate is 0.9. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required. Figure 6-1 refers.

Figure 6-1 Mirrabooka Ave/Koondoola Ave – Ultimate Design




A compromise design is therefore indicated as follows. The performance is not as good as the optimal upgrade however the site is constrained. The intersection LoS is C/D. The degree of saturation is 0.882/0.887 and queue length on Mirrabooka Ave North is 407m. The average stop rate is 0.86/0.92. Figure 6-2 refers.

Figure 6-2 Mirrabooka Ave/Koondoola Ave - Compromise Design



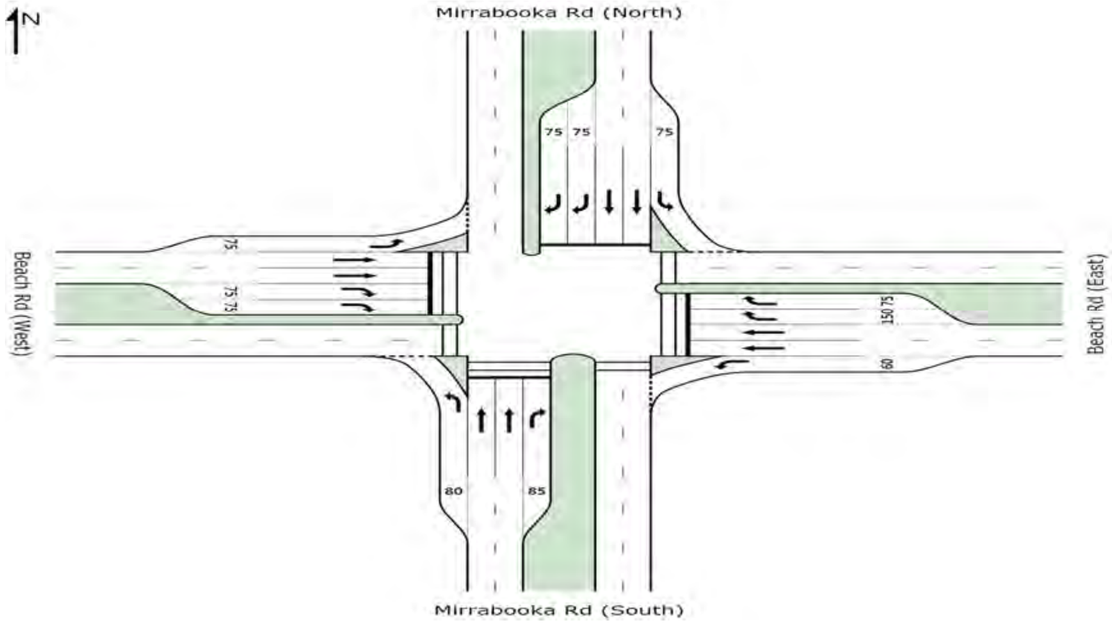

### Recommendation

In order to accommodate increased traffic volumes due to the LHS an option is to replace the existing roundabout with a signalised intersection as indicated in Figure 6-2. However following Main Roads review of the proposed measures, indicate they are not supportive of signals at this location, a preferred option is therefore to convert the Koondoola Ave and Montrose Ave approaches to left in/out at a future date when the intersection is at capacity and promote distribution of traffic to the existing east west regional roads.

### 6.3.2 Beach Road/Mirrabooka Road Intersection 2031

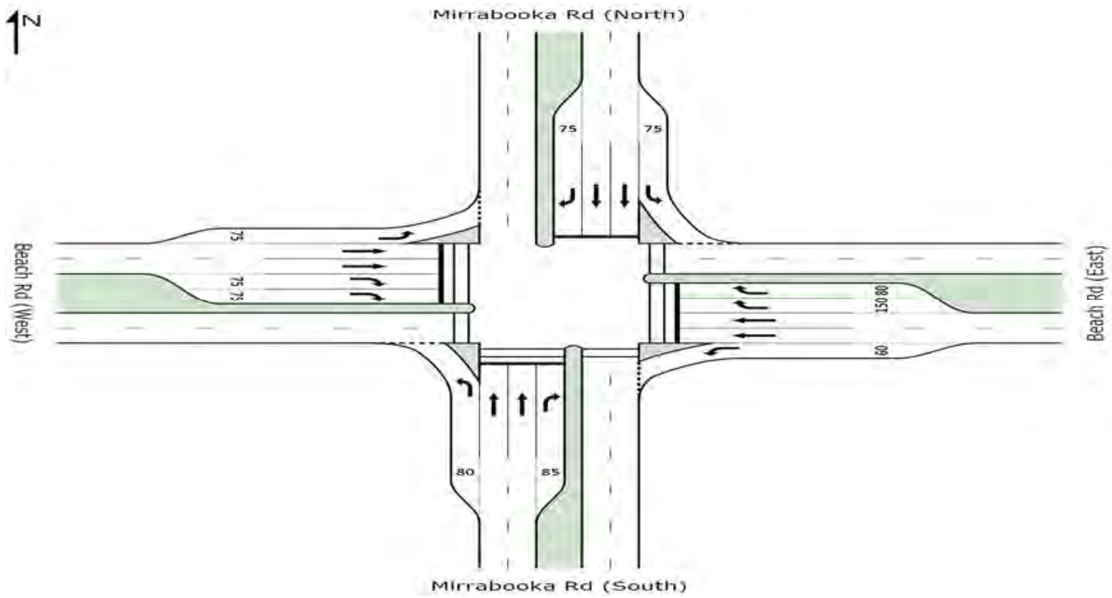
The analysis with LHS indicates that an upgraded signalised intersection is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include double turn lanes on the eastern, western and northern approaches. Degree of saturation is 0.889, LoS is D, queue length on Mirrabooka Ave North is 230m and the stop rate is 0.88- 0.9. It is noted that the reserve on Mirrabooka Road north would not appear to be wide enough to accommodate a double right turn and significant land acquisition would likely be required. Figure 6-3 refers.

Figure 6-3 Mirrabooka Ave/Beach Road – Ultimate Design




A compromise design with a reduced performance is therefore considered as follows. The intersection LoS is E/F. The degree of saturation is 1-1.022. The average stop rate is 0.92/1.05. Figure 6-4 refers.

Figure 6-4 Mirabooka Ave/Beach Road – Compromise Design



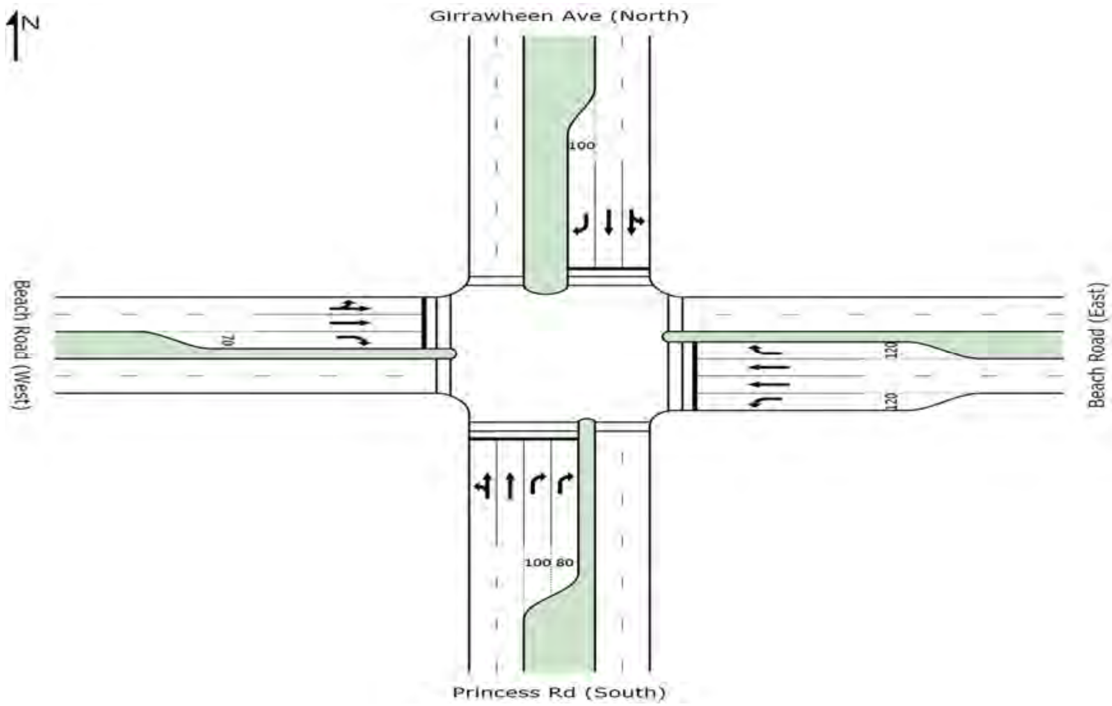

### Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded as indicated in Figure 6.3 however if land resumption is not possible the layout in Figure 6-4 could be considered.

### 6.3.3 Girrawheen Ave/Beach Road Intersection 2031

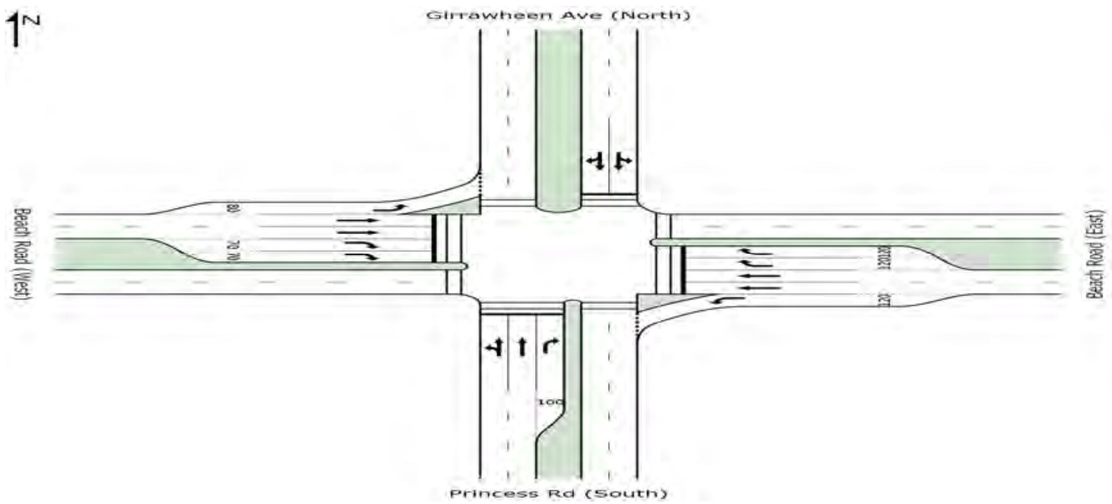
The analysis with LHS indicates that the modified signalised intersection is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include double turn lanes on the southern approach and additional through and turn lanes. Degree of saturation is 0.909 to 0.925, LoS is D/E, queue length on Princess Rd South is 269m and the stop rate is 0.94 - 0.95. It is noted that the reserve on Girrawheen Ave north would not appear to be wide enough to accommodate the proposed modifications and significant land acquisition would likely be required. Figure 6-5 refers.

Figure 6-5 Girrawheen Ave/Beach Road – Ultimate Design




A compromise is therefore considered as follows, the performance is poor in comparison but the site is constrained. The intersection LoS is D/E. The degree of saturation is 0.9-1, the queue on Princess Road south is 326m. The average stop rate is 0.94/1.1. Figure 6-6 refers.

Figure 6-6 Girrawheen Ave/Beach Road – Compromise Design



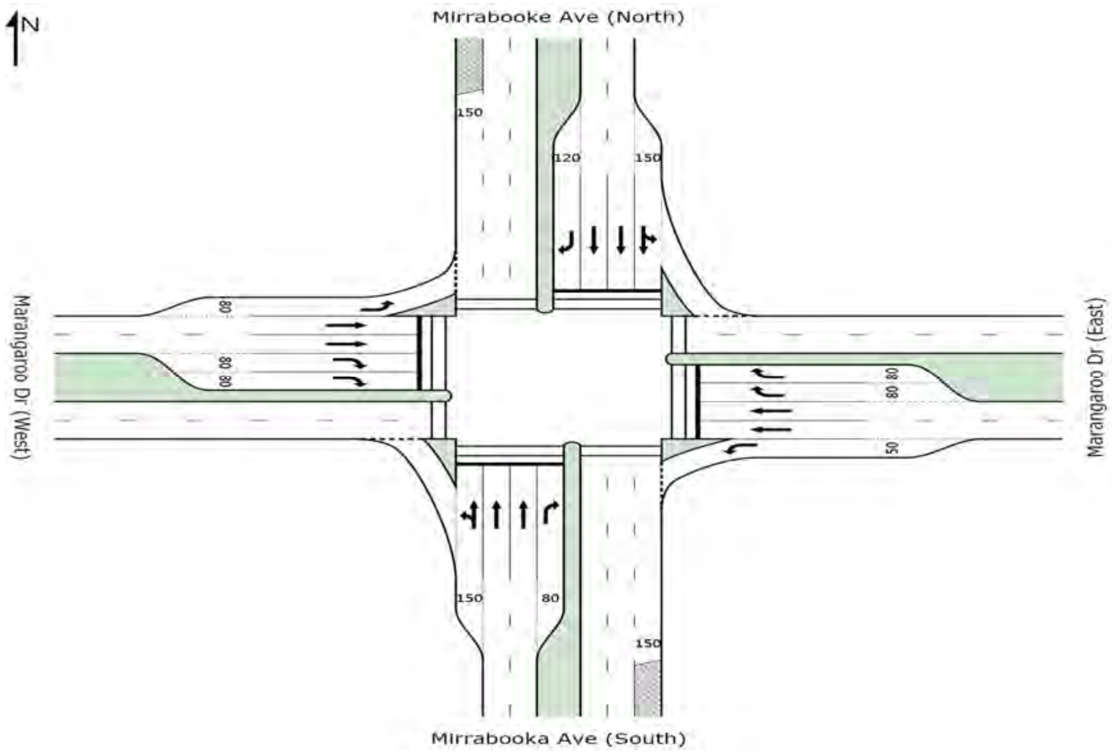
### Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded as indicated in Figure 6-5 however if land resumption is not possible the layout in Figure 6-6 could be considered.

#### 6.3.4 Mirabooka Ave/Marangaroo Ave intersection 2031

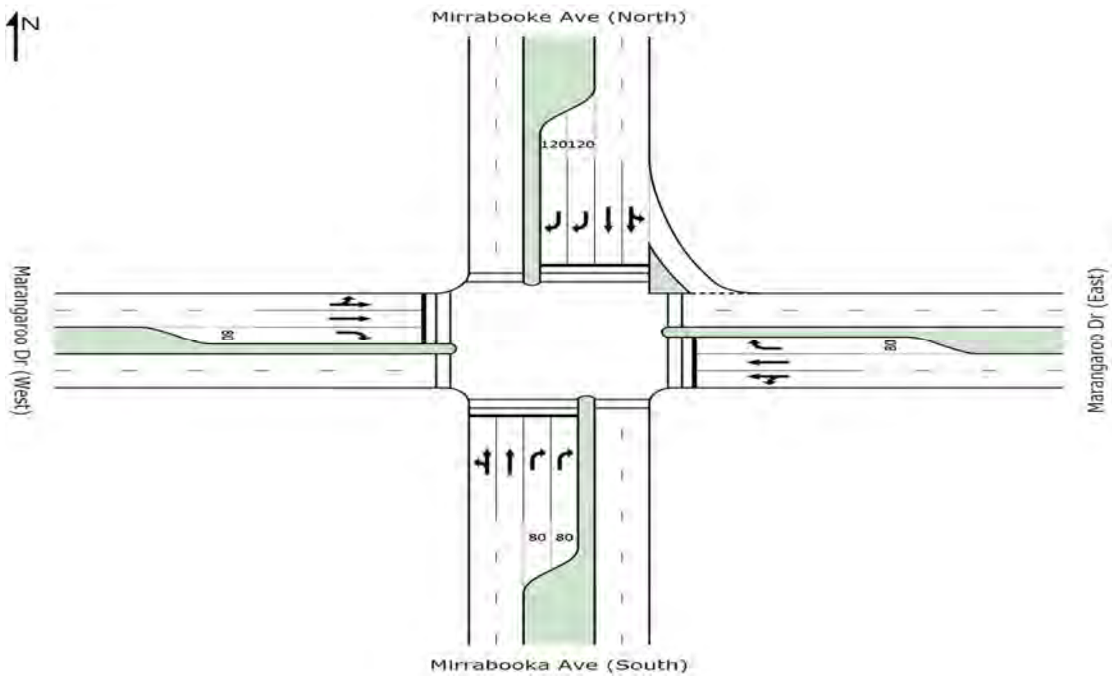
The analysis with LHS indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include double turn lanes on Marangaroo Drive and additional left turn lanes on each approach. Degree of saturation is 0.902 to 0.903, LoS is D, queue length on Mirrabooka Ave south is 307m and the stop rate is 0.88. It is noted that the reserve on Marangaroo Drive and Mirabooka Ave north would not appear to be wide enough to accommodate the proposed modifications and significant land acquisition would likely be required. Figure 6-7 refers.

Figure 6-7 Mirabooka Ave/Marrangaroo Dr – Ultimate Design




A compromise is therefore considered as follows, the performance is poor in comparison but the site is constrained. The intersection LoS is E/F. The degree of saturation is 1-1.037. The average stop rate is 0.95/1.05. Queues of up to 650m are forecast on Mirabooka Ave South. It is clear that this design does not provide a good solution and ultimately land acquisition may be required to accommodate further modification. Figure 6-8 refers.

Figure 6-8 Mirabooka Ave/Marrangaroo Dr – Compromise Design



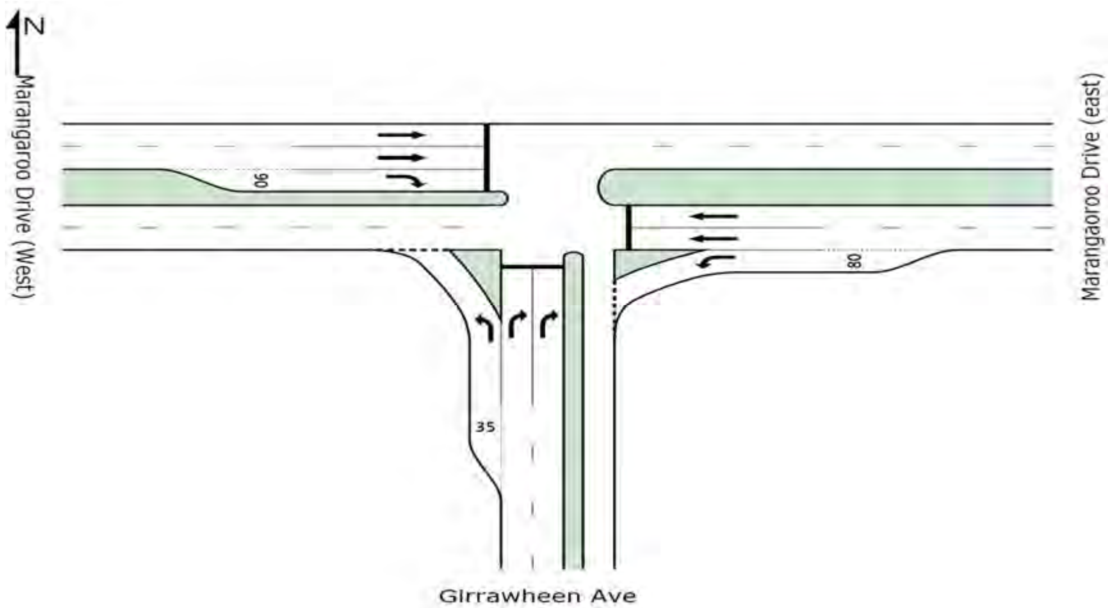

**Recommendation**

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded as indicated in Figure 6-7. However if land resumption is not possible the layout in Figure 6-8 could be considered.

#### 6.3.5 Marangaroo Drive/Girawheen Avenue intersection 2031

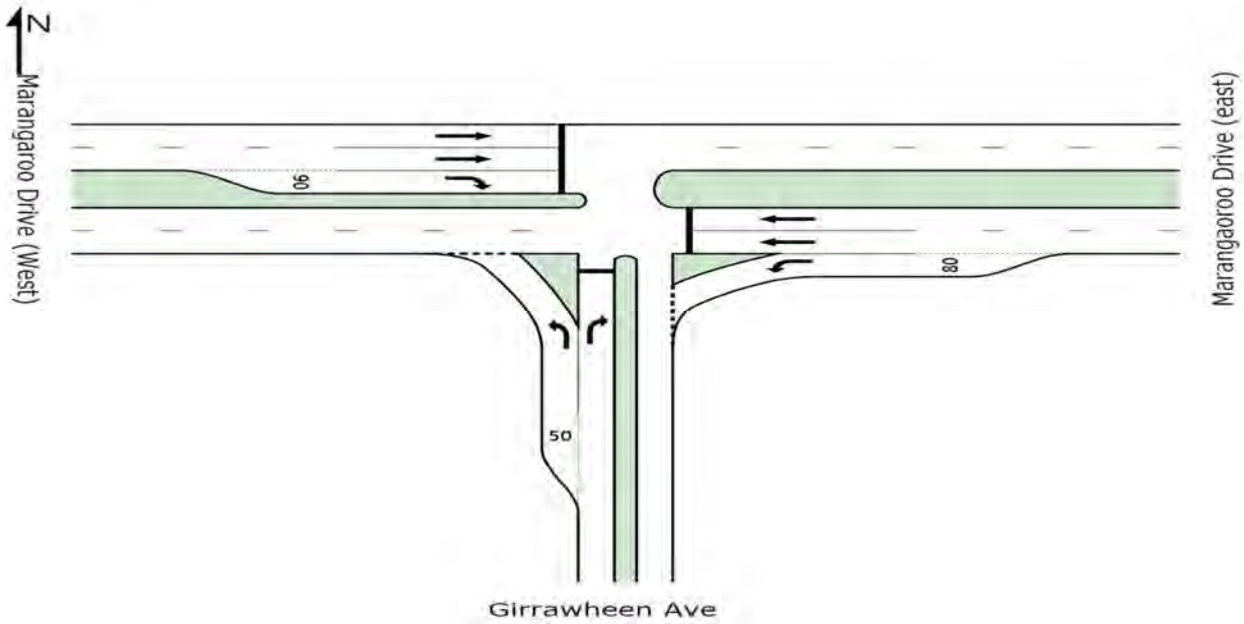
The analysis with LHS indicates that the modified signalised intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include signalising the intersection and providing double right turn lanes on Girrawheen Avenue. Degree of saturation is 0.87 to 0.906, LoS is C, queue length on Marrangaroo Dr east is 185m and the stop rate is 0.71-0.76. It is noted that the reserve on Girawheen Ave would not appear to be wide enough to accommodate the proposed double right turn and significant land acquisition would be likely. Figure 6-9 refers.

Figure 6-9 Marrangaroo Drive/Girrawheen Ave – Ultimate Design



The following geometry is therefore considered. The intersection LoS is C. The degree of saturation is 0.766-0.915. The average stop rate is 0.69/0.76. Figure 6-10 refers.

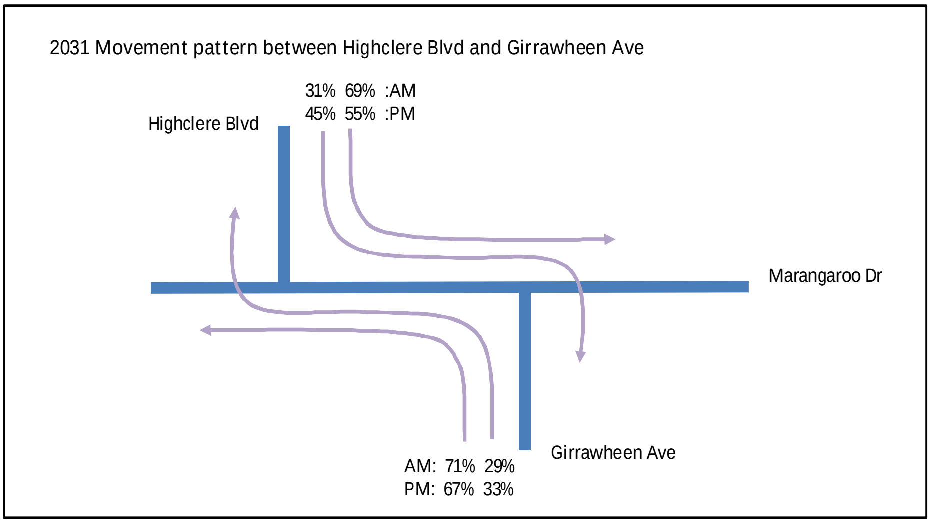
Figure 6-10 Marangaroo Drive/Girrawheen Ave – Compromise Design




Main Roads have raised the following issue with this proposal.

> **" If Girrawheen Ave is signalised at Marangaroo Dr, how does this proposal impact Highclere Bvd (currently signalised)? What is the relationship between these intersections in terms of movement patterns? The separation between these intersections is only approximately 280m."**
>
> Main Roads Western Australia

Paramics modelling has tested the operation of the two intersections and the movement pattern between these two roads is indicated on the figure below. Observation of the modelled 2031 upgraded configurations shows queuing is not expected to extend from one junction to the upstream junction. Nor were any weaving issues identified.



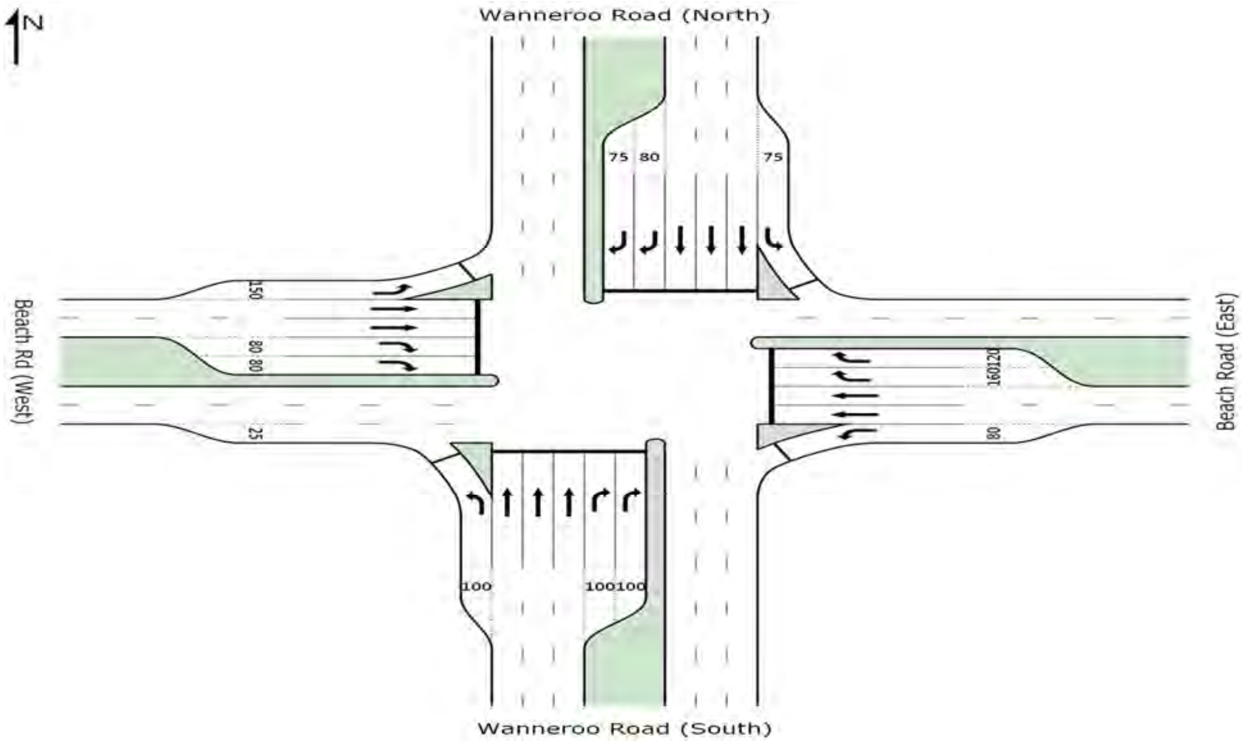
### Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing unsignalised intersection is upgraded to include a signalised intersection as indicated in Figure 6-9.

#### 6.3.6 Beach Road/Wanneroo Road intersection 2031

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS to a reasonable LoS. Most traffic will clear the intersection in a single cycle. Upgrade will include additional through lanes on Wanneroo Road and the provision of double right turns on the north, south, east and west approaches. No land acquisition would appear to be required. (To be confirmed as part of a concept design). The intersection LoS is D. The degree of saturation is 0.892-0.917. The average stop rate is 0.88/0.93 Queues on Wanneroo South are forecast to be 380m during the am peak hour. Figure 6-11 refers.

Figure 6-11 Beach Road/Wanneroo Road – Ultimate Design




### Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded as indicated above. It is noted that PTA are currently progressing a study to provide bus propriety measures at this intersection which may constrain future plans to provide double right turns.

Main Roads comment is acknowledged

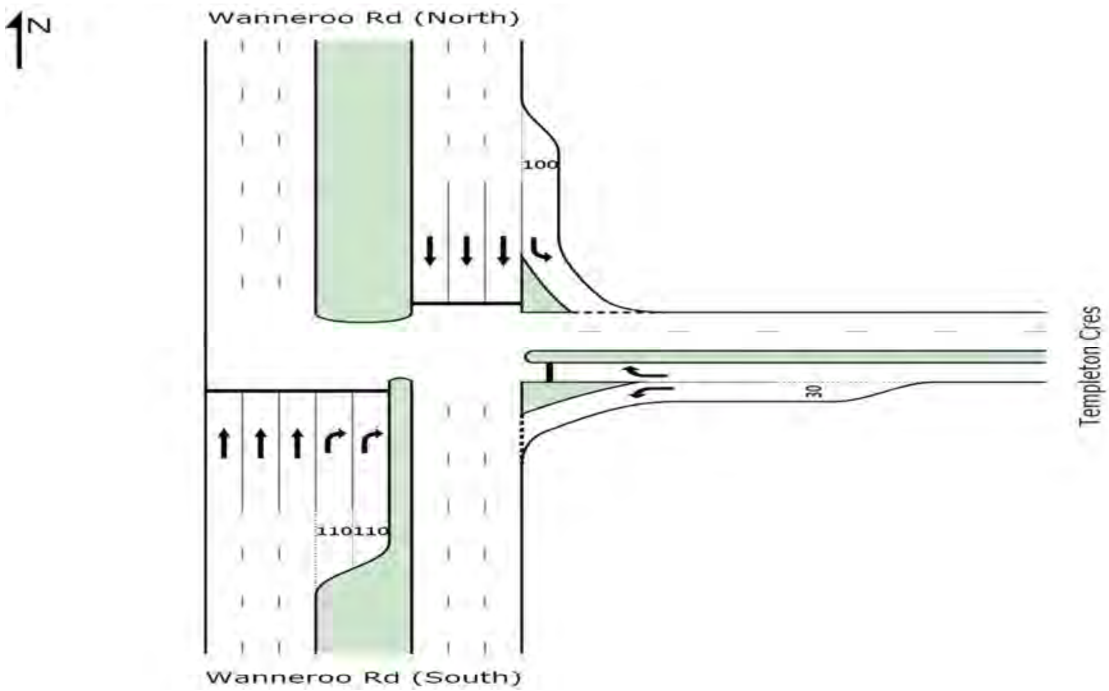
**"Reference to ARRB's North West Corridor Structure Plan Review – Strategic Assessment of Regional Transport Requirements – October 2009 concluded /recommended that four lanes for Wanneroo Rd through the Girrawheen area will be required by 2031 but accepting it will be operating at a level of service F during peak periods"**

Main Roads Western Australia

#### 6.3.7 Wanneroo Road/Templeton Road Intersection 2031

The analysis with LHS indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include signalisation, additional through lanes on Wanneroo Road and the provision of a double right turns on the south approach and a left turn lane in Wanneroo Road north. Degree of saturation is 0.629 to 1, LoS is B, queue length on Wanneroo Road north is 250m and the stop rate is 0.54 - 0.61. No land acquisition would appear to be required. Figure 6-12 refers.

Figure 6-12 Wanneroo Road/Templeton Cresc – Ultimate Design




### Recommendation

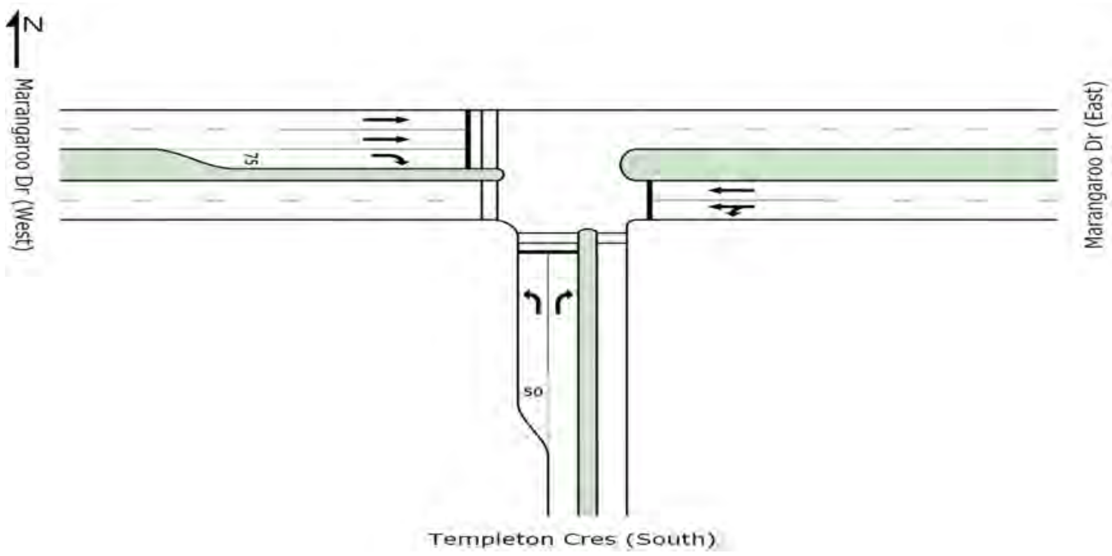
In order to accommodate increased traffic volumes due to the LHS an option is to signalise the existing unsignalised intersection as indicated above. However Main Roads does not support this proposal and suggest converting Templeton Crescent to left in/out only and promote the use of Blackmore Ave and Templeton Crescent connection to the existing east west regional roads to access Girrawheen. The aim of this is to retain the integrity of Wanneroo Road as a Primary regional road.

It is recommended therefore that the Main Roads proposal is considered as a future strategy.

#### 6.3.8 Marangaroo Dr/Templeton Crescent Intersection 2031

The analysis with LHS indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include a 50m widening along the Templeton Crescent approach to accommodate two lanes of traffic. Degree of saturation is 0.575 to 0.781, LoS is B/C, queue length on Templeton Crescent south is 168m and the stop rate is 0.62 - 0.83. No land acquisition would appear to be required. Figure 6-13 refers.

Figure 6-13 Marrangaroo Drive/Templeton Crescent – Ultimate Design



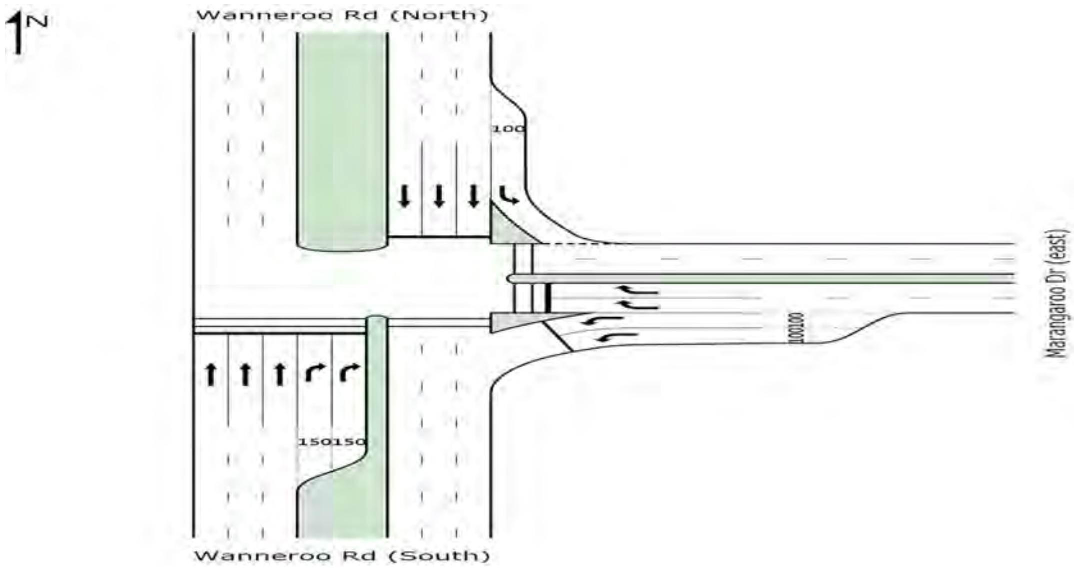

### Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded as indicated above.

## 6.3.9 Wanneroo Road/Marangaroo Drive Intersection 2031

The analysis with LHS indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include an additional lane in Wanneroo Road and a signalised double left turn lane in Marrangaroo Drive. Intersection C/D is achieved and Stop rates generally below 1. The degree of saturation is 0.904 for the am peak hour. No land acquisition would appear to be required. Figure 6-14 refers.

Figure 6-14 Wanneroo Road/Marrangaroo Dr – Ultimate Design




### Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded as indicated above.

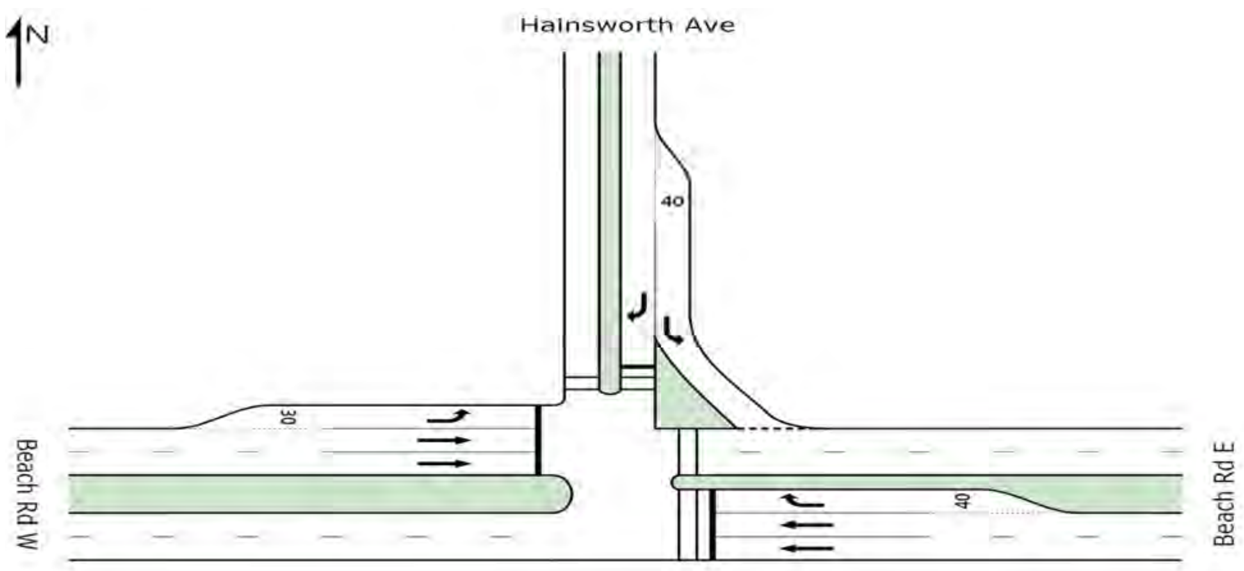
Main Roads comment is acknowledged

> **"Reference to ARRB's North West Corridor Structure Plan Review – Strategic Assessment of Regional Transport Requirements – October 2009 concluded /recommended that four lanes for Wanneroo Rd through the Girrawheen area will be required by 2031 but accepting it will be operating at a level of service F during peak periods"**
>
> Main Roads Western Australia

### 6.3.10 Beach Road/Hainsworth Ave Intersection 2031

The analysis with LHS indicates that the modified signalised intersection is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include installation of traffic signals. Intersection LoS C is achieved and Stop rates generally below 1. However the degree of saturation is 1 for the am and pm peak hour and queues in excess of 200m are forecast on Beach Road. No land acquisition would appear to be required. Figure 6-14 refers.

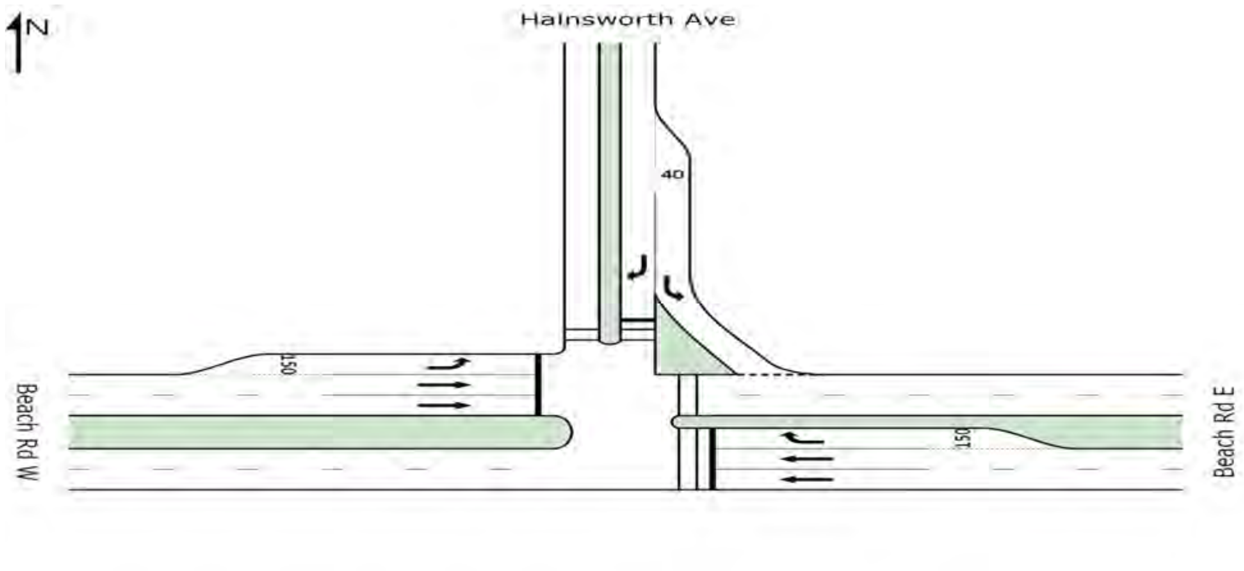
Figure 6-15 Beach Road/Hainsworth Ave – Existing Design




Further analysis has been undertaken with the turn lanes on Beach Road extended to 150m.

The analysis with LHS indicates that the modified signalised intersection improves performance and is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include installation of traffic signals and extended turn lanes (to 150m) on Beach Road. Intersection LoS C is achieved and Stop rates are below 1. The degree of saturation is 0.581-0.747 for the am and pm peak hour. Queues in below 200m are forecast on Beach Road. No land acquisition would appear to be required. Figure 6-14 refers.

Figure 6-16 Beach Road/Hainsworth Ave – Ultimate Design




### Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing unsignalised intersection is upgraded to include signals and extended turn lanes in Beach Road.

#### 6.3.11 Internal Roads

The above analysis considers road requirements to the key road network, i.e Local Distributor classification and above, there are however a number of Access Streets within the internal road network and commentary on these roads is provided as follows.

The WAPC document ‘Liveable Neighbourhoods’ indicates the anticipated traffic volumes for residential streets:

- Access Street Type C (single carriageway 7.2m to 7.5m wide): 3,000vpd
- Access Street Type D (single carriageway, 5.5m to 6m wide): 1,000vpd

The physical capacity of a single carriageway road is 8,000-12,000vpd at a good level of service C, based on the assessment of the precinct it is clear considerable capacity is available within the lower order roads in the study area and the planned increased residential density is unlikely to adversely impact these roads requiring the need to upgrade.

The following intersection thresholds are indicated by Austroads, below which capacity analysis is unnecessary.

| Major Road Flow | Minor Road Flow |
|---|---|
| 400vph | 250vph |
| 500vph | 200vph |
| 650vph | 100vph |

Based on the above thresholds, minor road intersections within the precinct are not expected to exceed these volumes on full development and therefore not anticipated to require significant upgrade for capacity reasons.

## 6.4 Stakeholder liaison

Following completion of the technical analysis the outcomes were forwarded to the City of Wanneroo who has also consulted with Main Roads. Their coordinated response is shown in Appendix F together with GHD response. Amendments have been incorporated into this report.

# 7. Cost estimates

## 7.1 Apportionment of cost estimates

The following calculation has been used to estimate the proportion of each of the cost estimates which are directly attributable to the increase in traffic in the Girrawheen-Koondoola Housing Precinct.

The following points (b and C) are the forecast total traffic volumes consisting of the current volumes plus additional volumes.

a. Forecast traffic generation from the Girrawheen-Koondoola Housing Precinct to 2031 based on current planning: 46,605vpd.

b. Forecast traffic generation from the Girrawheen-Koondoola Housing Precinct to 2031 based on increased R Codes: 120,155pd.

c. Forecast traffic generation from the Girrawheen-Koondoola Housing Precinct and Area of Influence to 2031 based on increased R Codes: 756,060pd.

Therefore the apportionment of cost is calculated by (b-a)/b and represents 61.20**%** of road upgrade cost.

Area of influence: 1km surrounding precinct.

## 7.2 Cost estimates for road network improvements

Cost estimates have been prepared for the recommended measures based on the City of Wanneroo construction rates.

Table 7-1 Cost Estimate for Road Network Improvements

| Location | Measure | Estimated Cost | Apportionment % | Apportioned Cost |
|---|---|---|---|---|
| Girrawheen Ave (Beach Road to Marrangaroo Drive). | Additional lane in each direction | $840,000 | 61.2% | $514,080 |
| Amberton Ave approach to Girrawheen Ave | Additional approach lane (60m) | $55,000 | 61.2% | $33,660 |
| Beach Road/Girrawheen Ave | Double right turn from Princess Street to Beach Road (i.e.south-to-east), left turn lane from Beach Road to Princess Street (east-to-south), right turn lane from Girrawheen Avenue to Beach Road | $495,000 | 61.2% | $302,940 |
| Mirrabooka Ave/Koondoola Ave | Left in/out for Koondoola and Montrose. | $255,000 | 61.2% | $156,060 |

| Location | Measure | Estimated Cost | Apportionment % | Apportioned Cost |
|---|---|---|---|---|
| Marrabooka Ave/Marrangaroo Drive | Flared northbound/southbound (Mirrabooka Avenue) approaches and departures to 3-lanes, double right turns east-to-north and west-to-south, left turn lanes east-to-south and west-to-north | $681,000 | 61.2% | $416,772 |
| Marrangaroo Drive/Girrawheen Ave | Upgrade will include signalising the intersection and providing double right turn lanes on Girrawheen Avenue. | $97,000 | 61.2% | $59,364 |

GHD has prepared the preliminary cost estimate set out in Table 7-1 using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD (eg indicative geometric on requirements from conceptual drawings, no survey base was provided).

The Cost Estimate has been prepared for the purpose of indicative budgets and must not be used for any other purpose.

The Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the works can or will be undertaken at a cost which is the same or less than the Cost Estimate.

No allowance is made for services protection/relocation.

No allowance is made for design costs or escalating land costs.

### 7.2.1 Services

'One Call' information is embedded into the dwg files and it should be noted that there would appear to be significant underground services at all locations. No allowance is made within the cost estimates for any relocation or protection of services. Further study should be undertaken as part of the design process to conform actual impacts and likely costs for services.

## 7.3 Staging of Works

Based on observations of the models in operation as well as the performance results presented in Table 5-10 and Table 5-11, the following table outlines the anticipated staging requirements of intersection treatments.

Table 7-2 Intersection treatment and roadworks staging

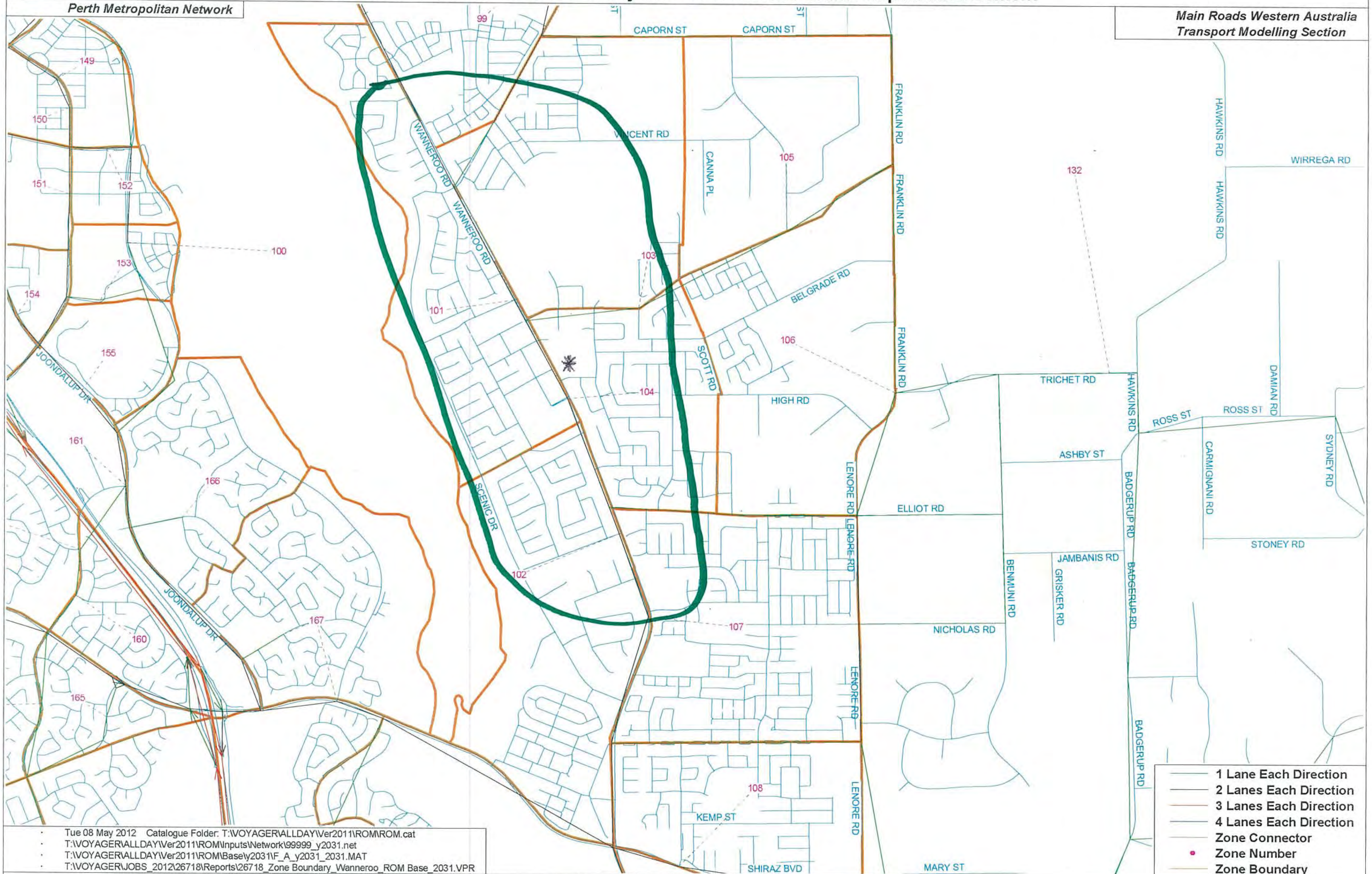
| | Without LHS | | | With LHS | | |
|---|---|---|---|---|---|---|
| | 0-5 years | 5-10 years | 10-20 years | 0-5 years | 5-10 years | 10-20 years |
| Wanneroo Rd / Beach Rd | x | | | x | | |
| Wanneroo Rd / Warwick Rd | | | x | | | x |
| Beach Rd / Princess | | | x | | x | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Rd / Girrawheen Ave | | | | | | |
| Beach Rd / Mirrabooka Ave | | | | | x | |
| Marangaroo Dr / Mirrabooka Ave | | | | | x | |
| Girrawheen Ave / Amberton Ave | | | | | | x |
| Mirrabooka Ave / Koondoola Ave | | | | | | x |
| Girrawheen Ave / Marangaroo Dr | | | | | | x |
| Beach Rd / Hainsworth Ave | | | | | | x |
| Wanneroo Rd / Templeton Cres (Signals not supported by Main Roads, left in/out preferred) | | | | | x | |
| Girrawheen Avenue | | | | | x | |
| Amberton Avenue | | | | | | x |

# Appendices

# Appendix A - Landuse input

# 2031 Base Model - Zone Boundary Plot for Wanneroo Traffic Impact Assessment




Tue 08 May 2012 Catalogue Folder: T:\VOYAGER\ALLDAY\Ver2011\ROM\ROM.cat
T:\VOYAGER\ALLDAY\Ver2011\ROM\Inputs\Network\99999_y2031.net
T:\VOYAGER\ALLDAY\Ver2011\ROM\Base\y2031\F_A_y2031_2031.MAT
T:\VOYAGER\JOBS_2012\26718\Reports\26718_Zone Boundary_Wanneroo_ROM Base_2031.VPR

*MRWA Updated Base Network - Version 2011*

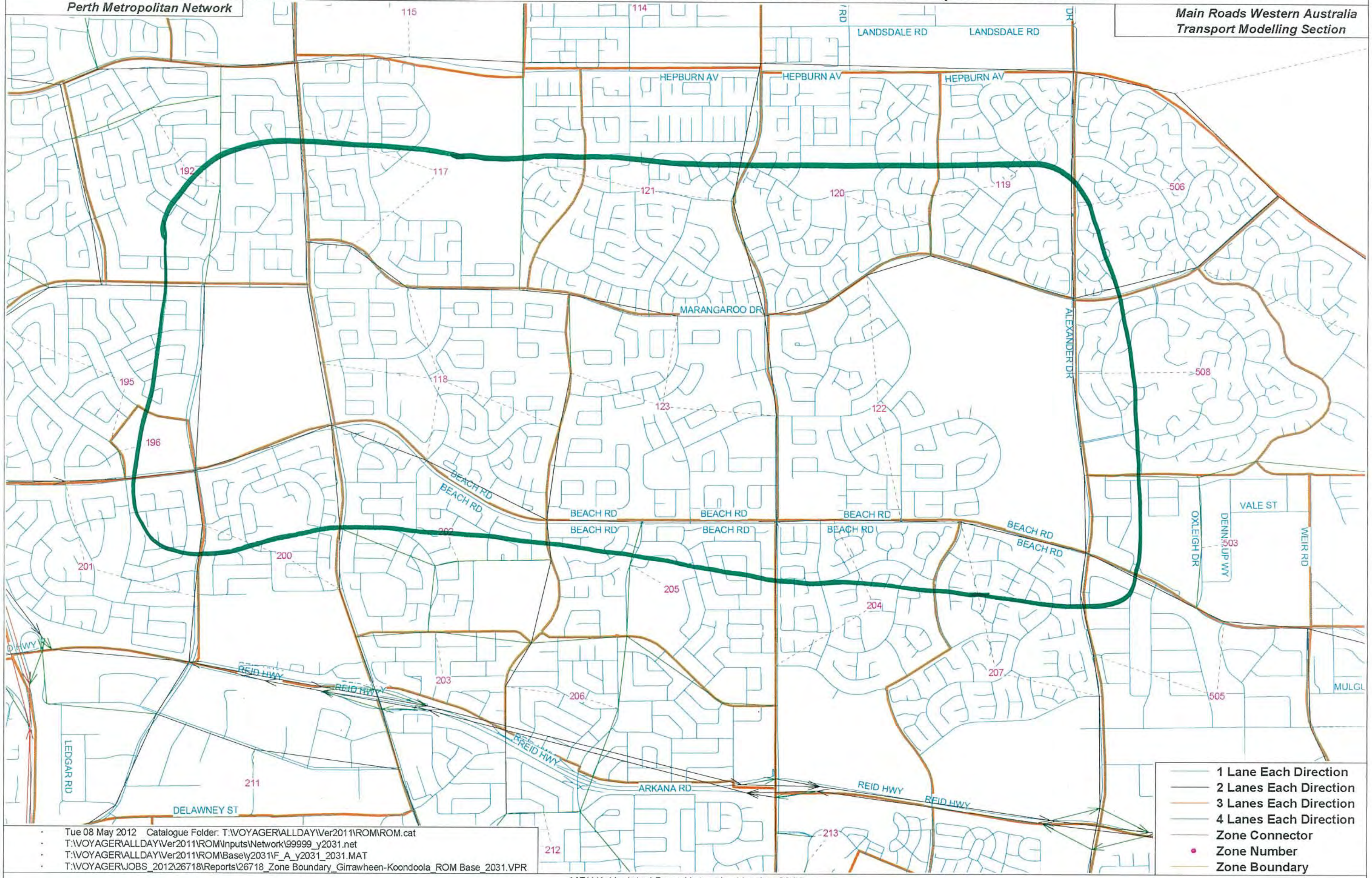
*MRWA Transport Modelling Data as supplied to approved clients is confidential and is not to be made available to unauthorised persons or organisations*

cube

# 2031 Base Model - Zone Boundary Plot for Girrawheen-Koondoola Traffic Impact Assessment

Perth Metropolitan Network

Main Roads Western Australia
Transport Modelling Section




- Tue 08 May 2012 Catalogue Folder: T:\VOYAGER\ALLDAY\Ver2011\ROM\ROM.cat
- T:\VOYAGER\ALLDAY\Ver2011\ROM\Inputs\Network\99999_y2031.net
- T:\VOYAGER\ALLDAY\Ver2011\ROM\Base\y2031\F_A_y2031_2031.MAT
- T:\VOYAGER\JOBS_2012\26718\Reports\26718_Zone Boundary_Girrawheen-Koondoola_ROM Base_2031.VPR

*MRWA Updated Base Network - Version 2011*

*MRWA Transport Modelling Data as supplied to approved clients is confidential and is not to be made available to unauthorised persons or organisations*

cube

# Appendix B - Paramics base model validation report

# City of Wanneroo

## Girrawheen-Koondoola Microsimulation Traffic Model

## Base Model Validation Report

29 January 2013

# Table of contents



# Table index

# Figure index



# Appendices

# 1. Introduction

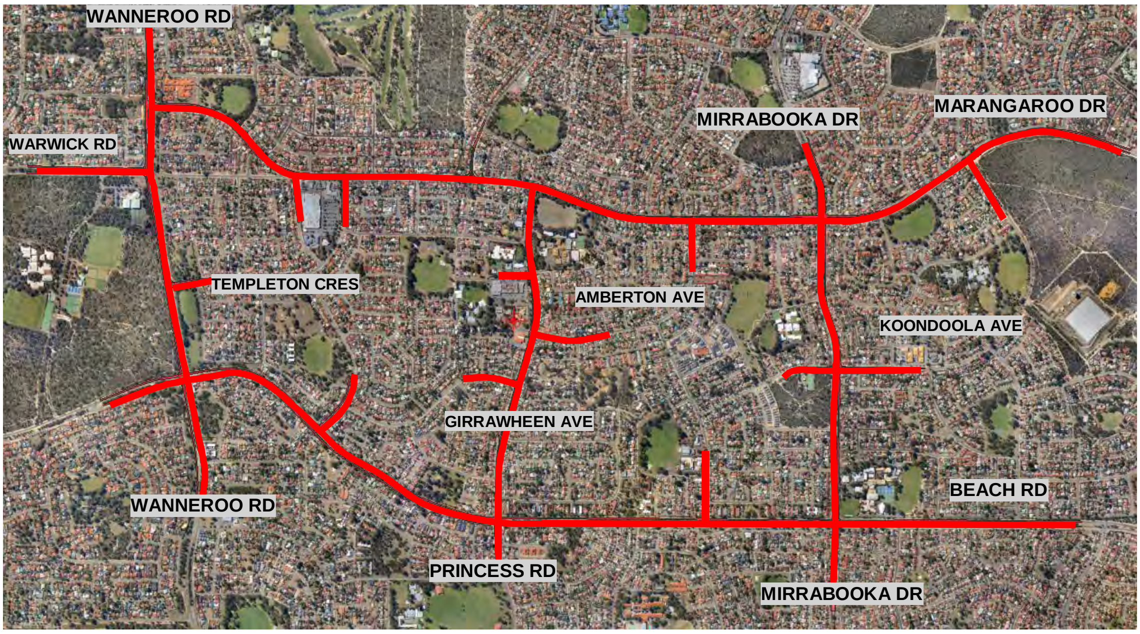
City of Wanneroo has engaged GHD to undertake a Traffic Impact Assessment (TIA) to evaluate the potential effect of the proposed increases to R Coding within the Girrawheen and Koondoola housing precincts. As part of this study, GHD is undertaking local area microsimulation traffic modelling to assist in the traffic assessment. This report discusses the development of the initial 'Base' models which provide a representation of the current on-site conditions on the Girrawheen and Koondoola road networks, and outlines the calibration and validation methodologies that have been employed.

The purpose of this report is to demonstrate and provide confidence that the Girrawheen Base models are a robust representation of the on-street conditions and as such provide a suitable foundation for the subsequent testing of future year scenario. The report therefore provides information relating to the following topics:

- Data sources used for the modelling;
- Model network development;
- Trip matrix development;
- Model calibration; and
- Model validation.

Figure 1 outlines the adopted study area for the traffic modelling assessment.

Figure 1 Extents of Model Study Area



# 2. Data Collection

## 2.1 Introduction

Microsimulation models typically require large volumes of data in order to accurately represent traffic networks at a microscopic level and to ensure the model is a good representation of current on-site conditions. This section of the report details each dataset that has been collected for the study. It provides information relating to the type of data, the source of the data and the date and time periods that the data was collected for.

## 2.2 Traffic Volume Data

Traffic volume count data was obtained from a number of sources including the following:

- SCATS loop counts;
- Manual turning movement surveys; and
- Historical tube count data.

### 2.2.1 SCATS Loop Counts

Signalised intersection detector counts were requested from Main Roads for the sites within the Girrawheen-Koondoola study area. These signalised intersections consisted of the following:

- Wanneroo Road / Marangaroo Drive (TCS 592);
- Wanneroo Road / Warwick Road (TCS 268);
- Marangaroo Drive / Templeton Crescent (TCS 683);
- Marangaroo Drive / Mirrabooka Avenue (TCS 618);
- Marangaroo Drive / Highclere Boulevard (TCS 767);
- Beach Road / Girrawheen Avenue (TCS 290);
- Beach Road / Mirrabooka Avenue (TCS 382); and
- Beach Road / Wanneroo Road (TCS 271).

Detector counts were provided in hourly intervals for each intersection loop for the week beginning 19 March 2012.

These types of traffic counts have a number of limitations which need to be considered when assessing the suitability of such data to use an input traffic models. These constraints include:

- Some intersection movements are not captured due to some lanes not being covered by an in-pavement detector, e.g. often left turn slip lanes are not detected:
- Some lanes have multiple designations e.g. a shared left turn and through movement lane. In these instances it is unclear from the detector count what proportion of vehicles conduct each movement;

- Detectors are not always reliable e.g. detectors can be faulty and hence not record all vehicles accurately; and
- Detector counts do not differentiate between vehicle classifications.

#### 2.2.2 Manual Turning Movement Count Surveys

To supplement the SCATS detector count data (and to overcome some of the shortcomings of that data set) a number of manual turning movement surveys were collected. These were undertaken by Excel Traffic Data at the following sites:

- Amberton Avenue / Girrawheen Avenue;
- Beach Road / Girrawheen Avenue / Princess Road;
- Beach Road / Hansworth Avenue;
- Girrawheen Avenue / Marangaroo Drive;
- Koondoola Avenue / Marangaroo Drive;
- Marangaroo Drive / Mirrabooka Avenue; and
- Tempelton Crescent / Wanneroo Road.

Surveys were undertaken for the following time periods:

- AM Peak: 7.30 – 9.30; and
- PM Peak: 15.30 – 17.30.

Traffic count data was provided in the form of turning counts in 15 minute intervals and was disaggregated into car and truck vehicle types. These traffic surveys provided a high level of data resolution for input into the model.

#### 2.2.3 Historical Tube Count Data

City of Wanneroo provided a number of tube count surveys which had previously been undertaken throughout the study area. These surveys were used by GHD to inform the project of indicative volumes on lower order roads and to assess the validity of recently collected data. These data sets typically provided only mid-block two-way traffic volumes, and as such they were not used to determine directional or turning movement data inputs. The provided tube counts ranged in currency from 2009 and 2012.

### 2.3 Signal Data

In additional to the SCATS detector counts (discussed in Section 2.2.1), traffic signal operation data was sourced from Main Roads for each signalised intersection in the study area to ensure signal operations could be represented accurately. The signalised sites included:

- Wanneroo Road / Marangaroo Drive (TCS 592);
- Wanneroo Road / Warwick Road (TCS 268);
- Marangaroo Drive / Templeton Crescent (TCS 683);

- Marangaroo Drive / Mirrabooka Avenue (TCS 618);
- Marangaroo Drive / Highclere Boulevard (TCS 767);
- Beach Road / Girrawheen Avenue (TCS 290);
- Beach Road / Mirrabooka Avenue (TCS 382); and
- Beach Road / Wanneroo Road (TCS 271)

The specific signal data which was requested and subsequently provided by Main Roads consisted of the following:

- SCATS TCS graphics;
- IDM (intersection diagnostic monitor) data files (for two consecutive days, June 2012); and
- Intersection timing charts.

## 2.4 Travel Time Data

Vehicular journey times through the study area were recorded on-site for the key movements. This information would provide the key source of model validation data (discussed in detail in Section 5). GHD collected travel time survey data, as well as in-car video footage for the AM and PM peak periods on Wednesday 6 June 2012. GHD staff undertook these travel time surveys which allowed observations of queuing and congestion levels on-site to be considered during the calibration and validation stages of the modelling process.

The key routes through the Girrawheen road network were identified as Wanneroo Road, Marangaroo Drive, Beach Road, Girrawheen Avenue and Mirrabooka Avenue. These routes were surveyed in both directions and journey times disaggregated into the intervals identified in Figure 2 and Table 1.

Figure 2 Surveyed Travel Time Routes

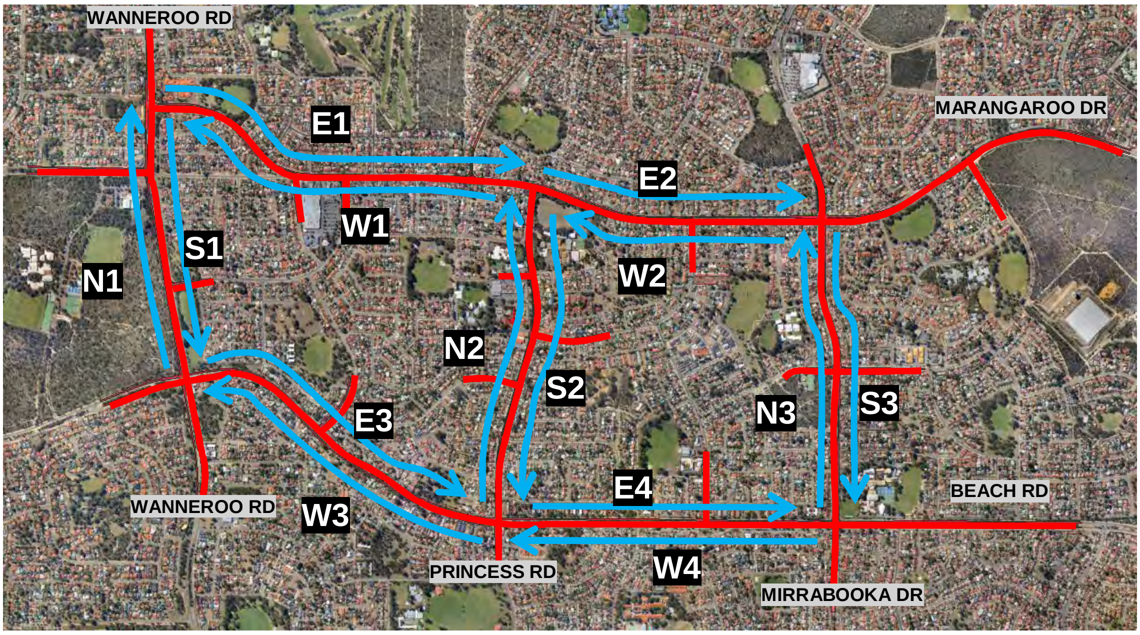


Table 1 Travel Time Section Descriptions

| Movement | Description |
|---|---|
| **Northbound movements** | |
| N1 | Wanneroo Rd: Beach Rd to Marangaroo Dr |
| N2 | Girrawheen Ave: Beach Rd to Marangaroo Dr |
| N3 | Mirrabooka Ave: Beach Rd to Marangaroo Dr |
| **Southbound movements** | |
| S1 | Wanneroo Rd: Marangaroo Dr to Beach Rd |
| S2 | Girrawheen Ave: Marangaroo Dr to Beach Rd |
| S3 | Mirrabooka Ave: Marangaroo Dr to Beach Rd |
| **Eastbound movements** | |
| E1 | Marangaroo Dr: Wanneroo Rd to Girrawheen Ave |
| E2 | Marangaroo Dr: Girrawheen Ave to Mirrabooka Ave |
| E3 | Beach Rd: Wanneroo Rd to Girrawheen Ave |
| E4 | Beach Rd: Girrawheen Ave to Mirrabooka Ave |
| **Westbound movements** | |
| W1 | Marangaroo Dr: Girrawheen Ave to Wanneroo Rd |
| W2 | Marangaroo Dr: Mirrabooka Ave to Girrawheen Ave |
| W3 | Beach Rd: Girrawheen Ave to Wanneroo Rd |
| W4 | Beach Rd: Mirrabooka Ave to Girrawheen Ave |

## 2.5 ROM Strategic Model Outputs

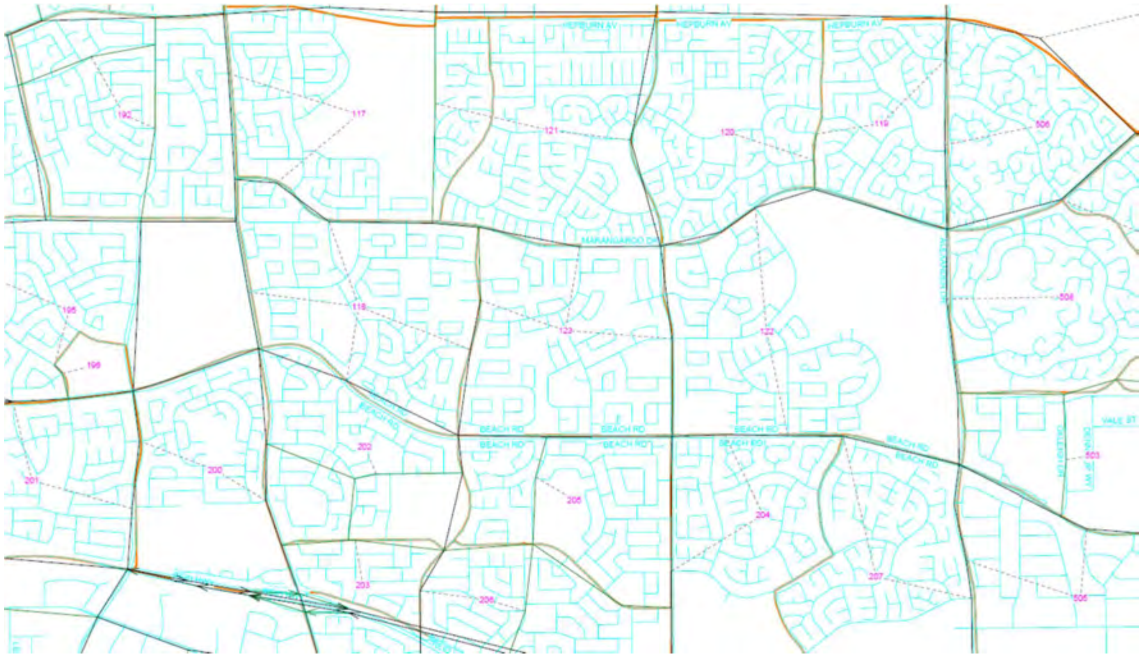
Main Roads provided outputs from the Regional Operations Model (ROM) to assist with the study. The outputs requested by GHD and provided by Main Roads consisted of the following:

- ROM network layout and zoning structure around the Girrawheen study area; and
- Sub-area cordon trip matrices from ROM for the 2011 Base scenario (as well as the 2031 scenario matrices) for the Girrawheen microsimulation model study area.

The ROM network and the requested sub-area network is shown in Figure 3.

## Figure 3    ROM Network and Sub-area

**_ROM Network_**



**_Girrawheen-Koondoola sub-area_**

# 3. Model Development

## 3.1 Introduction

The microsimulation modelling for this study has been developed using Quadstone Paramics software (version 6). Paramics is a traffic simulation software package that can be used to analyse a connected network of road links and signal controlled intersections, roundabouts, priority junctions in a single model network and to a high level of detail. The simulated driver behaviour is based on lane changing and vehicle following models and can provide an accurate reflection of on-site driver and vehicle behaviour.

## 3.2 Model Definition

The model runs for two discreet one-hour time periods as per the following:

- AM Peak Model: 8.00-9.00 with preceding warm-up period between 7.00 and 8.00; and
- PM Peak Model: 16.00-17.00 with preceding warm-up period between 15.00 and 16.00.

The time periods above were found to be the critical peak periods with regards to the highest traffic volumes following a review of the available traffic data for the study area. The warm-up periods are in place to ensure vehicles are upon the network at the commencement of the evaluation period.

The Base model is simulated using five variable 'seed values' with the resultant outputs analysed for discrepancies and ultimately averaged for output purposes. The seed value affects the generation of the random numbers that influence the model operation and variability. Therefore each time the model is run with a different seed value a slightly different set of outputs is generated. It would generally be expected that these outputs would be very similar (but not identical), and can loosely be thought of as day-to-day on-site fluctuations. The use of multiple seed values therefore provides confidence that the model results are not based upon a single outlying model run, but the result of a larger sample of model runs.

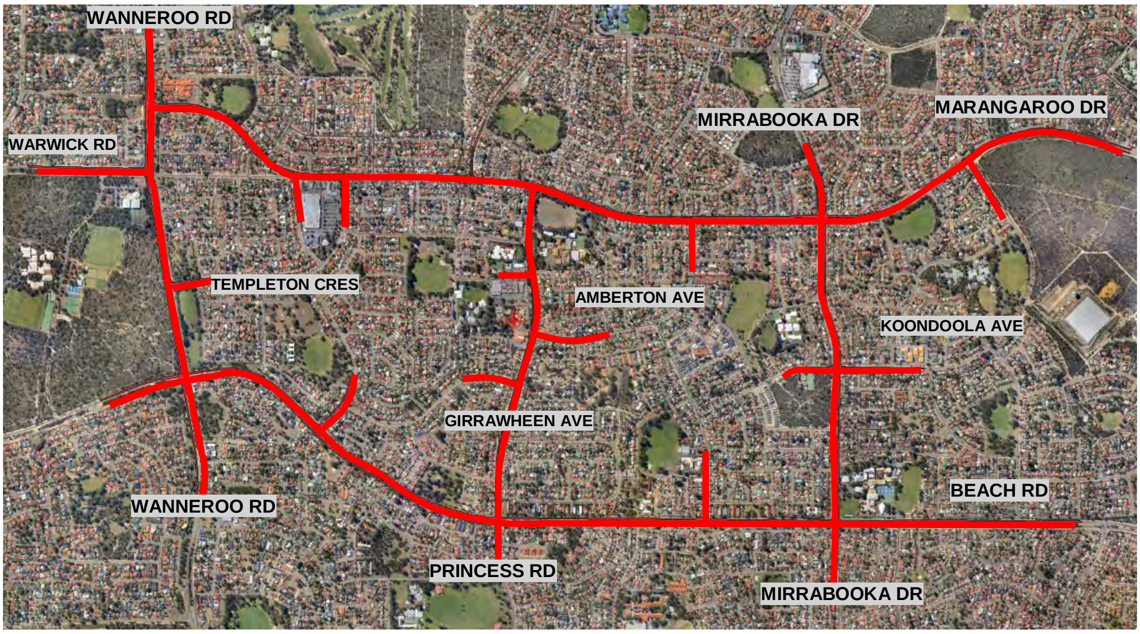
## 3.3 Model Network

The core model network was coded through the assistance of aerial photography and on-site observations to ensure the following attributes were included into the network:

- Intersection configurations;
- Number of lanes and lane allocations;
- Roadway widths, kerb locations and stopline positions;
- Road speed limits;
- Unsignalised intersection priority controls; and
- Turning lane storage lengths.

The model network is shown in Figure 4.

Figure 4    Girrawheen-Koondoola Model Network




***Shared Model Space: Wanneroo and Girrawheen-Koondoola***

It should be noted that this Girrawheen model network has been developed at the same time as a Wanneroo study area model has been developed also for City of Wanneroo. Given the close proximity of these two area, the two models have been developed within the same Paramics model space. The models can be run together (although the two networks do not interact with each other) or separately (by specifying demands for an individual network).

## 3.4 Signalised Intersections

Signalised junctions have been coded into the model to function under fixed time operation consisted with the phasing structure and times recorded in the IDM files. A review of the signal information provided by Main Roads revealed that phase and cycle times remained broadly consistent between consecutive days, as such these timing were coded into the model for the AM and PM peak periods.

## 3.5 Trip Matrices

Microsimulation models require accurate trip matrices in order to produce an indicative simulation of existing traffic movements. To develop a detailed set of trip matrices the following data sources were used:

- Turning movement volumes from recent surveys (outlined in Section 2.2); and
- An understanding of routing patterns and trip distributions through the study area network (outlined in Section 2.5).

The information above was combined to generate the trip matrices from the traffic assessment as per the following methodology:

A sub-area cordon was cut in ROM by Main Roads to represent only traffic movements within the study area. This produced a daily trips matrix for the study area network, albeit at a coarse zone and network level. A number of the ROM zones were split in order to match the more detailed definition of the zones within the microsimulation network. Following this, the proportional distribution matrix was determined from the ROM daily trip volume matrix. This distribution pattern was then utilised as the initial estimate of trip distributions for the peak period models.

An iterative process of furnessing was undertaken to factor the row and column totals of the microsimulation demand matrices to match the turning count data for entry and exit points to the Paramics model. This factored the overall matrix size to the observed traffic levels whilst retaining the broad original-destination pattern of the original matrices. This process was undertaken separately from both the AM and PM periods. The resulting matrices then underwent a manual matrix-estimation refinement process based on comparisons against known turning movement volumes. These refined trip sets were then applied as the input demand matrices for the Base models.

## 3.6 Vehicle Release Profiling

Demand release profiles were developed for each of the key model entry locations (where the necessary data was available). These profiles are used to specify the staged release of vehicles into the models across the hourly periods i.e. vehicles do not necessarily arrive at a constant rate across a one hour peak period. Profiles were developed for 15-minute intervals from observed turning movement counts. Individual profiles were applied to external zones which connect directly to an intersection where a turning movement survey was undertaken (and hence 15-minute data was available). For entry zones where data was not available in 15-minute intervals, the ‘average’ profile was applied to these releases.

## 3.7 Model Assignment

The modelled network has a number of different route choices between origins and destinations which drivers could potentially elect to use. However, for the vast majority of trips through the network the most logical, or attractive, path is clearly identifiable. The Paramics assignment method that has been employed in this instance is ‘all-or-nothing plus perturbation (AON+P)’. This assignment method produces a spread of paths for trips which have comparable alternate route choices. As such, not all vehicles will necessarily choose the same path for a specific trip through the network.

## 3.8 Vehicle Classification

Traffic survey data was interrogated to determine the average recorded proportion of light and heavy vehicles on the network during the AM and PM peak periods. The resulting truck proportions are shown in Table 2 and have been incorporated in the respective model periods.

Table 2 Heavy Vehicle Proportions

| Peak Period | Heavy Vehicle Proportion |
|---|---|
| AM Peak | 4.2 % |
| PM Peak | 2.3 % |

## 3.9 Model Plugins

Azalient Ceejazz model plugins have been utilised within the model. These third party plugins operate in conjunction with the core Paramics software and enhance its functionality. The specific plugin modules which have been used on the Girrawheen model network consist of the following:

- Validator: Used to extract results relating to modelled traffic volumes and travel times;
- Lane Choice: Used to ensure sensible and accurate lane discipline of vehicles on approach to junctions; and
- Route Choice: Used only to ensure sensible vehicle movements through roundabouts (i.e. to prevent vehicle undertaking multiple circulations of a roundabout due to perturbation of route costs).

# 4. Model Calibration

## 4.1 Introduction

Model calibration is the process whereby data that has been used in the model building process is checked against the model output to ensure that the model has been accurately coded and is representing the measured on-site conditions.  Turning movement traffic volumes have been used as the calibration measure in this instance.  As such, the calibration process involved ensuring traffic volumes output by the model were sufficiently accurate when compared against traffic volumes observed on site.

## 4.2 Turning Count Calibration

A turning count calibration was undertaken for each of the major intersections within the model study area.  The purpose of this calibration was to check that traffic volumes collected from the model were representative of traffic volumes measured on site for each traffic movement at each intersection. The GEH statistic was used to compare observed and modelled traffic volumes.

The GEH statistic is a self scaling indicator developed to sensibly compare observed and modelled flows. Rather than directly comparing flows by measure of either absolute or relative differences, the GEH statistic considers both of these measures within thresholds that are appropriate for traffic flow. For instance, the GEH statistic reflects that while an absolute difference of 100 vehicles/hr can be important in the context of a flow of 200 vehicles/hr, it is much less relevant in a flow of several thousand vehicles/hr.

GEH compares the differences between hourly observed flows and hourly modelled flows by using the following formula:

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

Where:

$V_O$ = Observed traffic flow (vehicles/hour)

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

The following criteria were used during the turning count calibration process:

- 85% of GEH statistics for individual junction turning-movement total volumes should be less than 5;
- $R^2$ statistic between 0.9 and 1.0 and slope factors between 0.9 and 1.1, of modelled vs. observed flow plots.

Table 3 provides a summary of the turning movement GEH criteria results.  It can be seen that a total of 92 individual movements were assessed within each time period.  The turning movements included as part of the calibration assessment include only movements which were directly known from recent survey information i.e. manual counts and selected SCATS detector recordings.

Table 3 demonstrates that during both peak periods, the model provides a close match of modelled and observed traffic flows.

Table 3 Summary of GEH Criteria Results

| Time Period | Number of Observations | Observations with GEH < 5 | Average GEH | $R^2$ and Slope | Exceeds Criteria? |
|---|---|---|---|---|---|
| AM Peak | 92 | 92 (*100%*) | 1.56 | 0.99, 1.009 | Yes |
| PM Peak | 92 | 92 (*100%*) | 1.66 | 0.99, 0.978 | Yes |

Figure 5 and Figure 6 show plots of modelled traffic volumes compared with observed traffic volumes for each turning movement. It can be seen from theses charts that there is close fit between observed and modelled traffic volumes across each of the time periods surveyed.

It should be noted that the raw surveyed traffic volumes have been adopted directly for this assessment. That is, there has not been any manual smoothing or manipulation of the surveyed data, as such there exist some minor discrepancies between adjacent sites due to inherent survey errors. Consequently, under this approach it is not possible to match each and every count precisely.

Appendix A provides fully tabulated results of the turning count calibration assessment for each individual turning movement.

Figure 5 AM Peak Traffic Volume Comparison

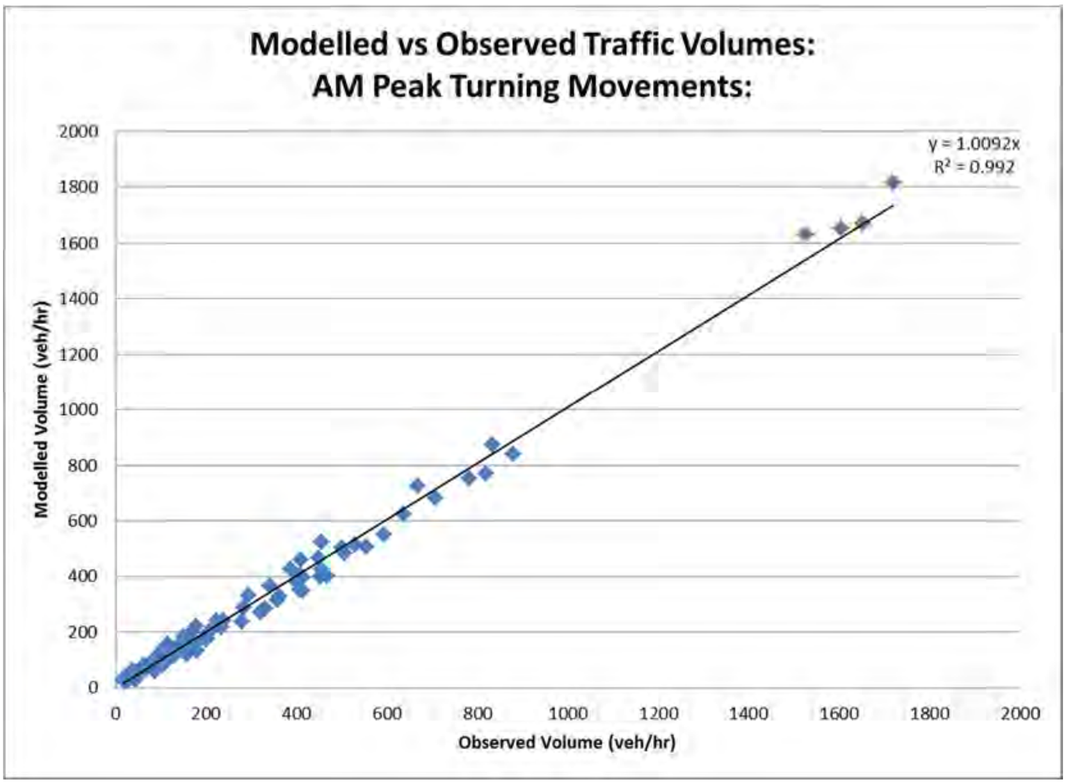
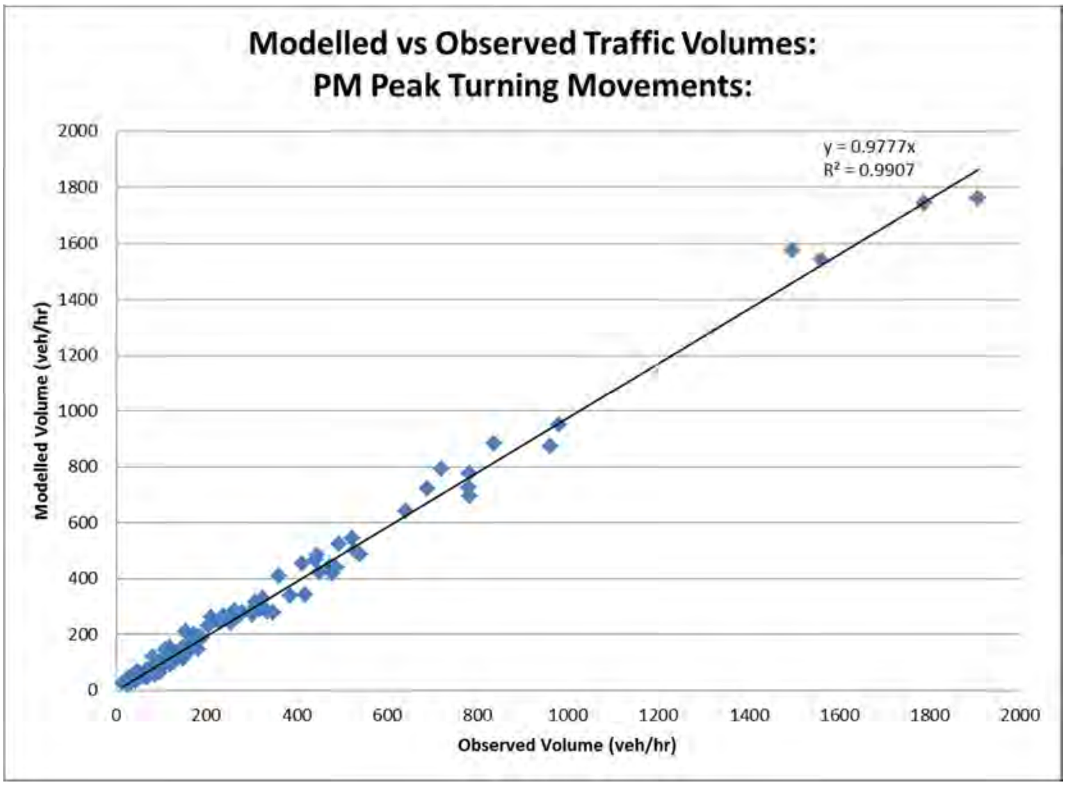


Figure 6 PM Peak Traffic Volume Comparison



# 5. Model Validation

## 5.1 Introduction

This section details the results from the validation of the base model. The purpose of model validation is to ensure that statistical results in the model accurately reflect data collected during the survey period, but have not been explicitly used as model inputs during the development stages. The validation measure used in this instance was travel time data.

In addition to the travel time validation, an assessment of model stability has also been presented which shows model output variations across multiple seed value runs.

## 5.2 Travel Time Validation

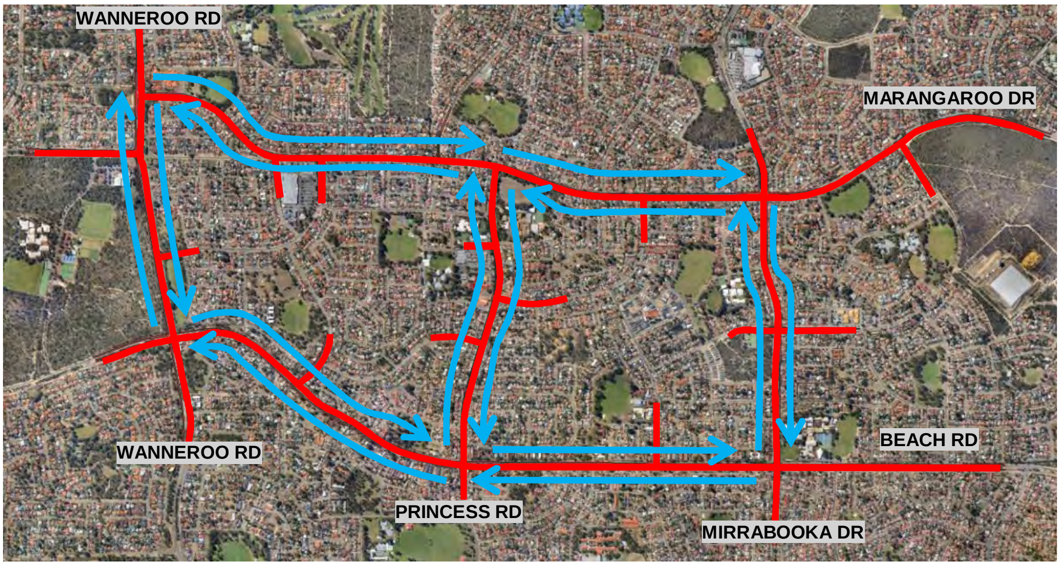
As part of the validation process GHD undertook an analysis of journey times for vehicles in the model along Wanneroo Road, Marangaroo Drive, Beach Road, Girrawheen Avenue and Mirrabooka Avenue and compared these against journey time observations recorded on site. Average journey times across five seed runs were collected from the model outputs and analysed. The following criteria was used to assess whether the modelled journey times were representative of conditions on site:

- Percentage difference between total observed and total modelled journey times for each route should be less than 15% or 1-minute (whichever is greater).

Figure 7 displays the travel time routes surveyed and compared with modelled outputs.

Table 4 and Table 5 shows a summary of the travel time validation results for the various sections of the network for the AM and PM periods respectively. It is clear that the model closely replicates the recorded travel times along the critical corridors for both the AM and PM periods.

Figure 7 Surveyed Travel Time Sections



### Table 4 AM Peak Travel Time Comparison

| Location | Observed (seconds) | Modelled (seconds) | Difference (seconds) | Meets Criteria? |
|---|---|---|---|---|
| **Northbound movements** | | | | |
| Wanneroo Rd: Beach Rd to Marangaroo Dr | 226 | 231 | 5 | *Yes* |
| Girrawheen Ave: Beach Rd to Marangaroo Dr | 180 | 161 | -19 | *Yes* |
| Mirrabooka Ave: Beach Rd to Marangaroo Dr | 126 | 128 | 2 | *Yes* |
| **Southbound movements** | | | | |
| Wanneroo Rd: Marangaroo Dr to Beach Rd | 217 | 195 | -22 | *Yes* |
| Girrawheen Ave: Marangaroo Dr to Beach Rd | 205 | 189 | -16 | *Yes* |
| Mirrabooka Ave: Marangaroo Dr to Beach Rd | 147 | 138 | -9 | *Yes* |
| **Eastbound movements** | | | | |
| Marangaroo Dr: Wanneroo Rd to Girrawheen Ave | 164 | 137 | -27 | *Yes* |
| Marangaroo Dr: Girrawheen Ave to Mirrabooka Ave | 112 | 109 | -3 | *Yes* |
| Beach Rd: Wanneroo Rd to Girrawheen Ave | 138 | 117 | -21 | *Yes* |
| Beach Rd: Girrawheen Ave to Mirrabooka Ave | 109 | 111 | 2 | *Yes* |
| **Westbound movements** | | | | |
| Marangaroo Dr: Girrawheen Ave to Wanneroo Rd | 184 | 195 | 11 | *Yes* |
| Marangaroo Dr: Mirrabooka Ave to Girrawheen Ave | 76 | 68 | -8 | *Yes* |
| Beach Rd: Girrawheen Ave to Wanneroo Rd | 153 | 151 | -1 | *Yes* |
| Beach Rd: Mirrabooka Ave to Girrawheen Ave | 138 | 112 | -26 | *Yes* |

Table 5 PM Peak Travel Time Comparison

| Location | Observed (seconds) | Modelled (seconds) | Difference (seconds) | Meets Criteria? |
|---|---|---|---|---|
| **Northbound movements** | | | | |
| Wanneroo Rd: Beach Rd to Marangaroo Dr | 202 | 177 | -24 | Yes |
| Girrawheen Ave: Beach Rd to Marangaroo Dr | 143 | 151 | 8 | Yes |
| Mirrabooka Ave: Beach Rd to Marangaroo Dr | 152 | 137 | -15 | Yes |
| **Southbound movements** | | | | |
| Wanneroo Rd: Marangaroo Dr to Beach Rd | 82 | 87 | 5 | Yes |
| Girrawheen Ave: Marangaroo Dr to Beach Rd | 143 | 174 | 31 | Yes |
| Mirrabooka Ave: Marangaroo Dr to Beach Rd | 143 | 129 | -14 | Yes |
| **Eastbound movements** | | | | |
| Marangaroo Dr: Wanneroo Rd to Girrawheen Ave | 148 | 126 | -22 | Yes |
| Marangaroo Dr: Girrawheen Ave to Mirrabooka Ave | 112 | 111 | -1 | Yes |
| Beach Rd: Wanneroo Rd to Girrawheen Ave | 117 | 115 | -2 | Yes |
| Beach Rd: Girrawheen Ave to Mirrabooka Ave | 117 | 107 | -10 | Yes |
| **Westbound movements** | | | | |
| Marangaroo Dr: Girrawheen Ave to Wanneroo Rd | 118 | 119 | 1 | Yes |
| Marangaroo Dr: Mirrabooka Ave to Girrawheen Ave | 73 | 68 | -5 | Yes |
| Beach Rd: Girrawheen Ave to Wanneroo Rd | 194 | 184 | -9 | Yes |
| Beach Rd: Mirrabooka Ave to Girrawheen Ave | 123 | 113 | -9 | Yes |

It can be seen from Table 4 and Table 5 that the difference between the observed and modelled journey times is significantly less than the 1-minute threshold for all comparisons.

## 5.3 Model Stability

The base model has been run with five 'seed' values (as discussed in Section 3.2 of this report) and the results of these model runs have been averaged for the calibration and validation outputs. However, it is important to ensure that the model runs are providing a stable and consistent model platform to take forward to the option testing stage. This requires the assessment of output statistics from each seed run to ensure that the variability of the outputs appears to be within reasonable limits.

In order to assess model stability for this study, two network wide statistics have been extracted and presented comparing each of the five individual seed value runs. The two assessment statistics are as follows:

- Average vehicle speed (veh/hr) of all vehicles currently in the model network; and
- Current number of vehicles being serviced by the network.

Figure 8 and Figure 9 show the stability test outputs for the AM and PM models respectively. These figures display variations between seed vales (as expected), but do not highlight any substantial outlying or rogue results.

### Figure 8 AM Peak Model Stability Test Results

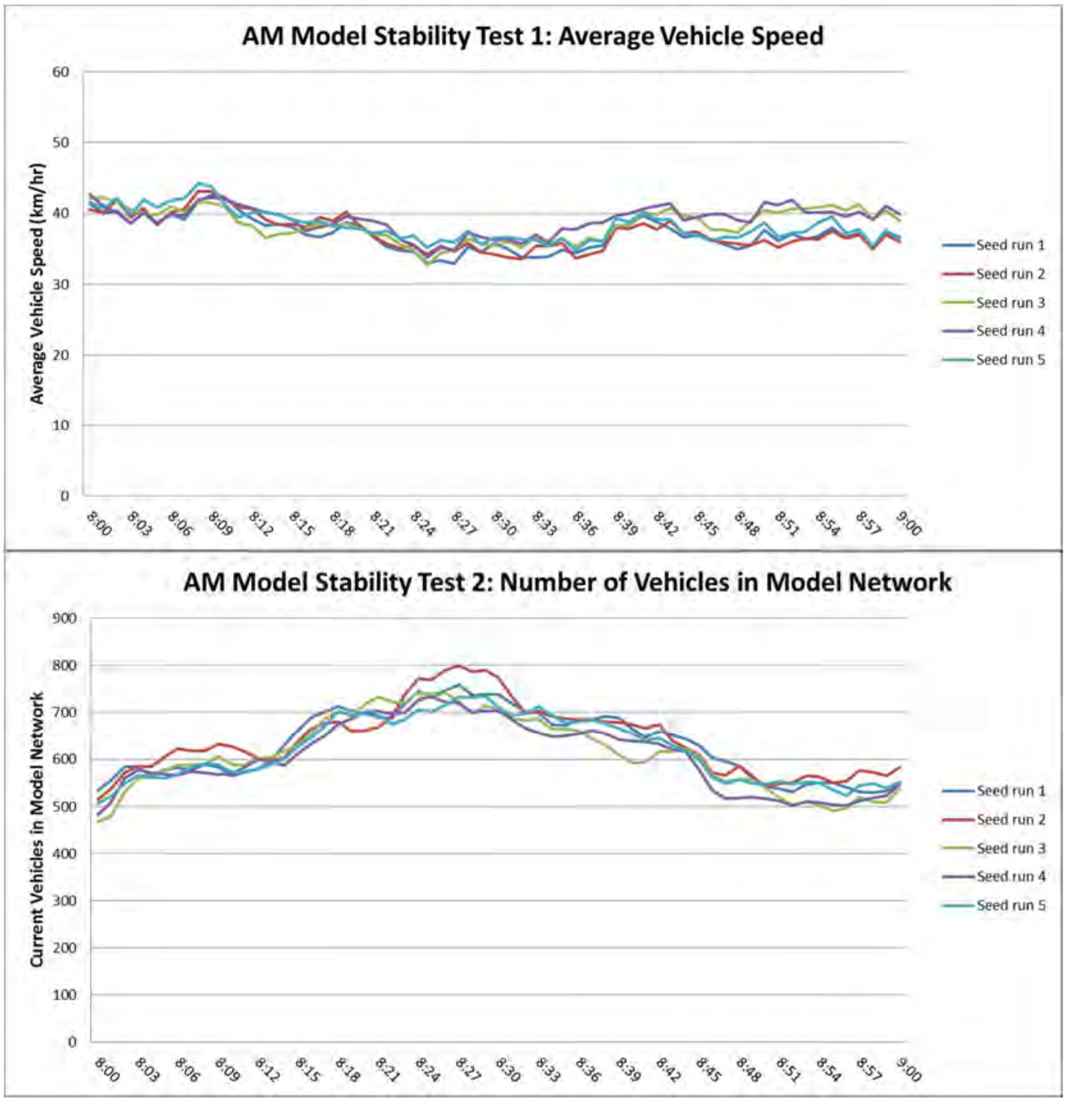
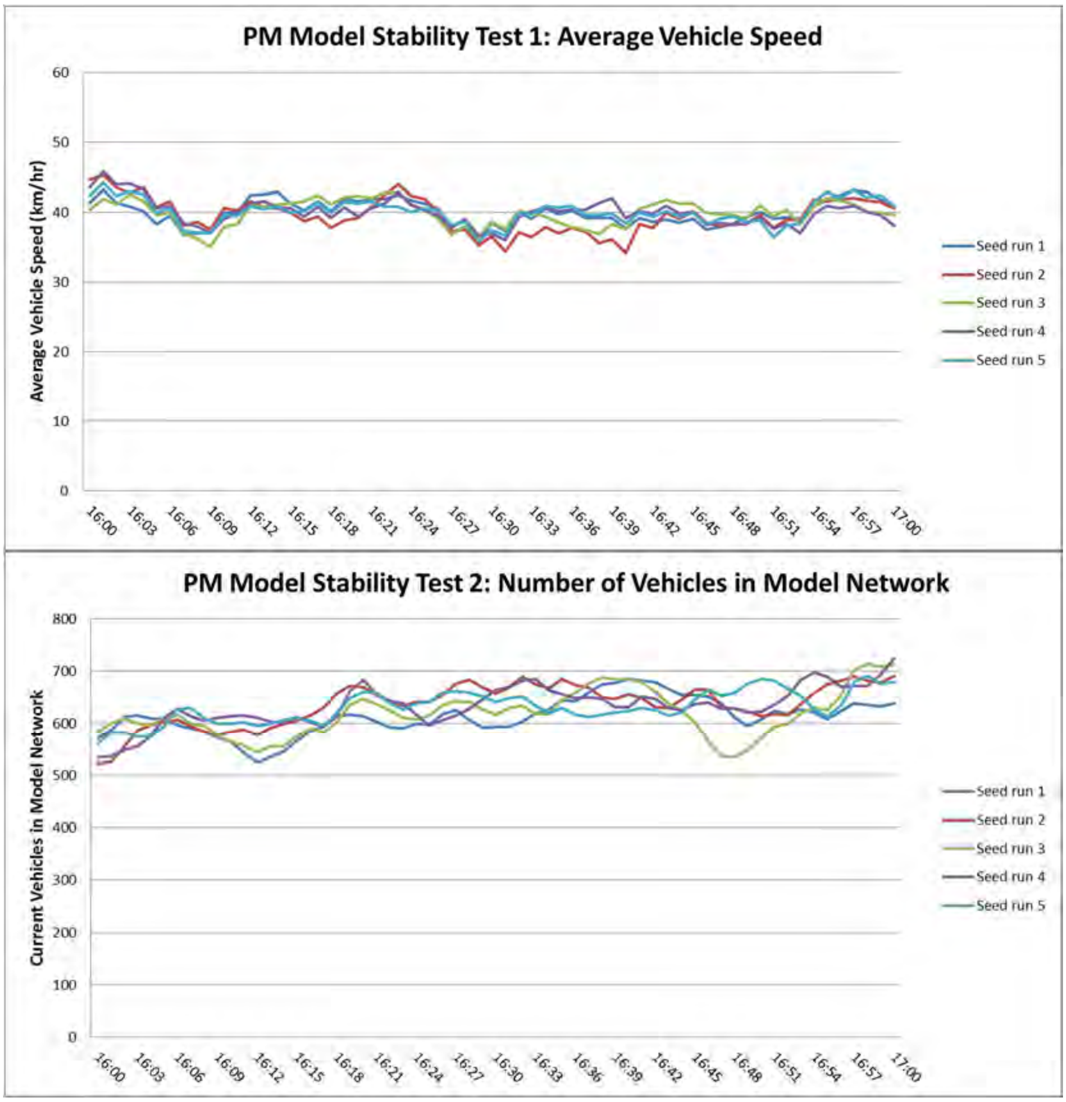


Figure 9    PM Peak Model Stability Test Results



# 6. Conclusion

## 6.1 Summary

This document has outlined the development of the microsimulation Base model for the central area of Girrawheen-Koondoola. Paramics (version 6) in conjunction with Azalient plugins has been used to simulate the movement vehicles for the critical AM and PM peak periods of an average weekday.

The report has detailed the calibration process used to ensure that the model is representative of observed on-site turning movement traffic volumes. These have been shown to meet and significantly exceed industry standard guidelines.

In addition, the validation process for travel times has been outlined. All modelled travel time data has been shown to meet the target criteria. Furthermore, both the AM and PM models have been found to exhibit stable results across different seed value runs.

Given the results of the calibration and validation process, the model is now considered a robust representation of the study area during the AM and PM peak time periods. As such, these models are considered suitable to be used as the foundation for future year scenario testing.

## 6.2 Next Steps

The next step with regards to the traffic modelling assessment consists of using the AM and PM models as detailed in this report to assess the Girrawheen-Koondoola network performance with increased traffic volumes aligning with the following scenarios:

- 2031 horizon with no change to R-coding; and
- 2031 horizon with increased R-coding designations.

The volumes and trip distributions corresponding to the above scenarios will be determined through analysis of the provided ROM trip matrices for the two scenarios. The relative change in volumes between the two scenarios, and the base volumes, will be considered when interpreting these forecast volumes.

# Appendices

# Appendix A Turning Count Calibration Statistics

### AM Peak Turning Movement Comparison

| Intersection | Movement | Observed | Modelled | GEH |
|---|---|---|---|---|
| Wanneroo Road / Marangaroo Drive | N to S | 1604 | 1655 | 1.26 |
| Wanneroo Road / Marangaroo Drive | N to E | 200 | 175 | 1.86 |
| Wanneroo Road / Marangaroo Drive | E to N | 167 | 199 | 2.38 |
| Wanneroo Road / Marangaroo Drive | E to S | 410 | 461 | 2.43 |
| Wanneroo Road / Marangaroo Drive | S to E | 239 | 243 | 0.26 |
| Wanneroo Road / Marangaroo Drive | S to N | 880 | 841 | 1.34 |
| Wanneroo Road / Warwick Road | N to W | 506 | 482 | 1.09 |
| Wanneroo Road / Warwick Road | N to S | 1527 | 1629 | 2.57 |
| Wanneroo Road / Warwick Road | S to N | 669 | 724 | 2.10 |
| Wanneroo Road / Warwick Road | W to S | 224 | 240 | 1.05 |
| Wanneroo Road / Templeton Cres | N to S | 1720 | 1814 | 2.23 |
| Wanneroo Road / Templeton Cres | N to E | 46 | 53 | 0.97 |
| Wanneroo Road / Templeton Cres | E to N | 29 | 28 | 0.15 |
| Wanneroo Road / Templeton Cres | E to S | 169 | 151 | 1.44 |
| Wanneroo Road / Templeton Cres | S to E | 87 | 61 | 3.02 |
| Wanneroo Road / Templeton Cres | S to N | 834 | 873 | 1.33 |
| Wanneroo Road / Beach Road | N to W | 158 | 140 | 1.47 |
| Wanneroo Road / Beach Road | N to S | 1652 | 1672 | 0.48 |
| Wanneroo Road / Beach Road | N to E | 147 | 135 | 0.99 |
| Wanneroo Road / Beach Road | E to N | 154 | 177 | 1.77 |
| Wanneroo Road / Beach Road | E to W | 358 | 316 | 2.31 |
| Wanneroo Road / Beach Road | E to S | 106 | 83 | 2.37 |
| Wanneroo Road / Beach Road | S to E | 32 | 38 | 1.01 |
| Wanneroo Road / Beach Road | S to N | 638 | 624 | 0.57 |
| Wanneroo Road / Beach Road | S to W | 109 | 111 | 0.19 |
| Wanneroo Road / Beach Road | W to S | 209 | 206 | 0.24 |
| Wanneroo Road / Beach Road | W to E | 449 | 465 | 0.77 |
| Wanneroo Road / Beach Road | W to N | 106 | 136 | 2.76 |
| Beach Road / Girrawheen Avenue | N to W | 38 | 63 | 3.49 |
| Beach Road / Girrawheen Avenue | N to S | 363 | 328 | 1.91 |
| Beach Road / Girrawheen Avenue | N to E | 160 | 148 | 0.98 |
| Beach Road / Girrawheen Avenue | E to N | 121 | 140 | 1.70 |
| Beach Road / Girrawheen Avenue | E to W | 407 | 354 | 2.72 |
| Beach Road / Girrawheen Avenue | E to S | 152 | 184 | 2.44 |
| Beach Road / Girrawheen Avenue | S to E | 112 | 101 | 1.11 |
| Beach Road / Girrawheen Avenue | S to N | 170 | 176 | 0.44 |
| Beach Road / Girrawheen Avenue | S to W | 104 | 98 | 0.64 |

**AM Peak Turning Movement Comparison (*Continued*)**

| Intersection | Movement | Observed | Modelled | GEH |
|---|---|---|---|---|
| Beach Road / Girrawheen Avenue | W to S | 92 | 91 | 0.10 |
| Beach Road / Girrawheen Avenue | W to E | 555 | 508 | 2.04 |
| Beach Road / Girrawheen Avenue | W to N | 18 | 33 | 2.90 |
| Beach Road / Hainsworth Avenue | N to W | 158 | 120 | 3.24 |
| Beach Road / Hainsworth Avenue | N to E | 162 | 141 | 1.67 |
| Beach Road / Hainsworth Avenue | E to N | 117 | 157 | 3.42 |
| Beach Road / Hainsworth Avenue | E to W | 594 | 552 | 1.75 |
| Beach Road / Hainsworth Avenue | W to E | 708 | 683 | 0.96 |
| Beach Road / Hainsworth Avenue | W to N | 90 | 73 | 1.84 |
| Beach Road / Mirrabooka Avenue | N to W | 153 | 176 | 1.76 |
| Beach Road / Mirrabooka Avenue | N to S | 782 | 754 | 1.01 |
| Beach Road / Mirrabooka Avenue | E to N | 234 | 217 | 1.16 |
| Beach Road / Mirrabooka Avenue | E to W | 453 | 399 | 2.60 |
| Beach Road / Mirrabooka Avenue | S to E | 141 | 145 | 0.30 |
| Beach Road / Mirrabooka Avenue | S to N | 342 | 364 | 1.18 |
| Beach Road / Mirrabooka Avenue | W to S | 206 | 197 | 0.61 |
| Beach Road / Mirrabooka Avenue | W to E | 529 | 514 | 0.66 |
| Marangaroo Drive / Koondoola Avenue | E to W | 455 | 524 | 3.10 |
| Marangaroo Drive / Koondoola Avenue | E to S | 119 | 126 | 0.65 |
| Marangaroo Drive / Koondoola Avenue | S to E | 67 | 68 | 0.07 |
| Marangaroo Drive / Koondoola Avenue | S to W | 21 | 22 | 0.13 |
| Marangaroo Drive / Koondoola Avenue | W to S | 28 | 27 | 0.19 |
| Marangaroo Drive / Koondoola Avenue | W to E | 388 | 427 | 1.92 |
| Marangaroo Drive / Mirrabooka Avenue | N to W | 128 | 130 | 0.19 |
| Marangaroo Drive / Mirrabooka Avenue | N to S | 820 | 770 | 1.77 |
| Marangaroo Drive / Mirrabooka Avenue | N to E | 103 | 113 | 0.94 |
| Marangaroo Drive / Mirrabooka Avenue | E to N | 103 | 96 | 0.66 |
| Marangaroo Drive / Mirrabooka Avenue | E to W | 321 | 271 | 2.88 |
| Marangaroo Drive / Mirrabooka Avenue | E to S | 201 | 176 | 1.82 |
| Marangaroo Drive / Mirrabooka Avenue | S to E | 50 | 53 | 0.47 |
| Marangaroo Drive / Mirrabooka Avenue | S to N | 400 | 382 | 0.92 |
| Marangaroo Drive / Mirrabooka Avenue | S to W | 105 | 140 | 3.20 |
| Marangaroo Drive / Mirrabooka Avenue | W to S | 165 | 135 | 2.45 |
| Marangaroo Drive / Mirrabooka Avenue | W to E | 284 | 289 | 0.30 |
| Marangaroo Drive / Mirrabooka Avenue | W to N | 54 | 62 | 1.08 |
| Marangaroo Drive / Girrawheen Avenue | E to W | 456 | 426 | 1.44 |
| Marangaroo Drive / Girrawheen Avenue | E to S | 177 | 155 | 1.68 |

### AM Peak Turning Movement Comparison (*Continued*)

| Intersection | Movement | Observed | Modelled | GEH |
|---|---|---|---|---|
| Marangaroo Drive / Girrawheen Avenue | S to E | 63 | 80 | 2.01 |
| Marangaroo Drive / Girrawheen Avenue | S to W | 178 | 222 | 3.10 |
| Marangaroo Drive / Girrawheen Avenue | W to S | 293 | 332 | 2.22 |
| Marangaroo Drive / Girrawheen Avenue | W to E | 414 | 395 | 0.93 |
| Girrawheen Avenue / Amberton Avenue | N to S | 407 | 405 | 0.12 |
| Girrawheen Avenue / Amberton Avenue | N to E | 129 | 114 | 1.34 |
| Girrawheen Avenue / Amberton Avenue | E to N | 180 | 135 | 3.60 |
| Girrawheen Avenue / Amberton Avenue | E to S | 87 | 103 | 1.62 |
| Girrawheen Avenue / Amberton Avenue | S to E | 66 | 79 | 1.50 |
| Girrawheen Avenue / Amberton Avenue | S to N | 331 | 285 | 2.61 |
| Marangaroo Drive / Highclere Boulevard | N to W | 279 | 238 | 2.58 |
| Marangaroo Drive / Highclere Boulevard | E to N | 134 | 144 | 0.83 |
| Marangaroo Drive / Highclere Boulevard | E to W | 501 | 503 | 0.11 |
| Marangaroo Drive / Highclere Boulevard | W to E | 467 | 401 | 3.15 |
| Marangaroo Drive / Templeton Cres | S to E | 118 | 106 | 1.11 |
| Marangaroo Drive / Templeton Cres | S to W | 46 | 33 | 2.07 |
| Marangaroo Drive / Templeton Cres | W to S | 44 | 31 | 2.09 |
| Marangaroo Drive / Templeton Cres | W to E | 413 | 350 | 3.24 |

### PM Peak Turning Movement Comparison

| Intersection | Movement | Observed | Modelled | GEH |
|---|---|---|---|---|
| Wanneroo Road / Marangaroo Drive | N to S | 961 | 872 | 2.93 |
| Wanneroo Road / Marangaroo Drive | N to E | 177 | 191 | 1.05 |
| Wanneroo Road / Marangaroo Drive | E to N | 237 | 263 | 1.67 |
| Wanneroo Road / Marangaroo Drive | E to S | 263 | 286 | 1.38 |
| Wanneroo Road / Marangaroo Drive | S to E | 359 | 409 | 2.54 |
| Wanneroo Road / Marangaroo Drive | S to N | 1907 | 1762 | 3.39 |
| Wanneroo Road / Warwick Road | N to W | 335 | 283 | 2.98 |
| Wanneroo Road / Warwick Road | N to S | 836 | 882 | 1.57 |
| Wanneroo Road / Warwick Road | S to N | 1494 | 1576 | 2.08 |
| Wanneroo Road / Warwick Road | W to S | 135 | 125 | 0.88 |
| Wanneroo Road / Templeton Cres | N to S | 979 | 952 | 0.87 |
| Wanneroo Road / Templeton Cres | N to E | 85 | 55 | 3.59 |
| Wanneroo Road / Templeton Cres | E to N | 37 | 39 | 0.29 |
| Wanneroo Road / Templeton Cres | E to S | 119 | 93 | 2.53 |
| Wanneroo Road / Templeton Cres | S to E | 309 | 295 | 0.83 |
| Wanneroo Road / Templeton Cres | S to N | 1787 | 1743 | 1.05 |
| Wanneroo Road / Beach Road | N to W | 185 | 194 | 0.67 |
| Wanneroo Road / Beach Road | N to S | 780 | 725 | 2.02 |
| Wanneroo Road / Beach Road | N to E | 115 | 123 | 0.72 |
| Wanneroo Road / Beach Road | E to N | 210 | 263 | 3.43 |
| Wanneroo Road / Beach Road | E to W | 446 | 485 | 1.81 |
| Wanneroo Road / Beach Road | E to S | 61 | 50 | 1.53 |
| Wanneroo Road / Beach Road | S to E | 52 | 51 | 0.11 |
| Wanneroo Road / Beach Road | S to N | 1558 | 1544 | 0.37 |
| Wanneroo Road / Beach Road | S to W | 162 | 158 | 0.28 |
| Wanneroo Road / Beach Road | W to S | 149 | 152 | 0.28 |
| Wanneroo Road / Beach Road | W to E | 307 | 315 | 0.48 |
| Wanneroo Road / Beach Road | W to N | 204 | 232 | 1.87 |
| Beach Road / Girrawheen Avenue | N to W | 29 | 47 | 2.92 |
| Beach Road / Girrawheen Avenue | N to S | 230 | 244 | 0.91 |
| Beach Road / Girrawheen Avenue | N to E | 97 | 87 | 1.09 |
| Beach Road / Girrawheen Avenue | E to N | 148 | 113 | 3.10 |
| Beach Road / Girrawheen Avenue | E to W | 641 | 641 | 0.00 |
| Beach Road / Girrawheen Avenue | E to S | 127 | 99 | 2.61 |
| Beach Road / Girrawheen Avenue | S to E | 154 | 212 | 4.30 |
| Beach Road / Girrawheen Avenue | S to N | 418 | 342 | 3.91 |
| Beach Road / Girrawheen Avenue | S to W | 118 | 155 | 3.20 |

**PM Peak Turning Movement Comparison (*Continued*)**

| Intersection | Movement | Observed | Modelled | GEH |
|---|---|---|---|---|
| Beach Road / Girrawheen Avenue | W to S | 95 | 63 | 3.60 |
| Beach Road / Girrawheen Avenue | W to E | 324 | 328 | 0.22 |
| Beach Road / Girrawheen Avenue | W to N | 38 | 54 | 2.39 |
| Beach Road / Hainsworth Avenue | N to W | 68 | 45 | 3.03 |
| Beach Road / Hainsworth Avenue | N to E | 65 | 66 | 0.15 |
| Beach Road / Hainsworth Avenue | E to N | 166 | 154 | 0.98 |
| Beach Road / Hainsworth Avenue | E to W | 720 | 792 | 2.63 |
| Beach Road / Hainsworth Avenue | W to E | 492 | 525 | 1.46 |
| Beach Road / Hainsworth Avenue | W to N | 119 | 106 | 1.25 |
| Beach Road / Mirrabooka Avenue | N to W | 69 | 75 | 0.68 |
| Beach Road / Mirrabooka Avenue | N to S | 450 | 422 | 1.35 |
| Beach Road / Mirrabooka Avenue | E to N | 275 | 271 | 0.27 |
| Beach Road / Mirrabooka Avenue | E to W | 688 | 722 | 1.27 |
| Beach Road / Mirrabooka Avenue | S to E | 137 | 132 | 0.45 |
| Beach Road / Mirrabooka Avenue | S to N | 781 | 694 | 3.21 |
| Beach Road / Mirrabooka Avenue | W to S | 100 | 96 | 0.38 |
| Beach Road / Mirrabooka Avenue | W to E | 347 | 277 | 3.94 |
| Marangaroo Drive / Koondoola Avenue | E to W | 411 | 455 | 2.10 |
| Marangaroo Drive / Koondoola Avenue | E to S | 30 | 24 | 1.15 |
| Marangaroo Drive / Koondoola Avenue | S to E | 65 | 63 | 0.22 |
| Marangaroo Drive / Koondoola Avenue | S to W | 26 | 19 | 1.39 |
| Marangaroo Drive / Koondoola Avenue | W to S | 15 | 25 | 2.16 |
| Marangaroo Drive / Koondoola Avenue | W to E | 440 | 466 | 1.20 |
| Marangaroo Drive / Mirrabooka Avenue | N to W | 124 | 120 | 0.40 |
| Marangaroo Drive / Mirrabooka Avenue | N to S | 487 | 439 | 2.24 |
| Marangaroo Drive / Mirrabooka Avenue | N to E | 83 | 71 | 1.41 |
| Marangaroo Drive / Mirrabooka Avenue | E to N | 133 | 121 | 1.06 |
| Marangaroo Drive / Mirrabooka Avenue | E to W | 318 | 290 | 1.59 |
| Marangaroo Drive / Mirrabooka Avenue | E to S | 51 | 62 | 1.46 |
| Marangaroo Drive / Mirrabooka Avenue | S to E | 109 | 144 | 3.14 |
| Marangaroo Drive / Mirrabooka Avenue | S to N | 782 | 775 | 0.24 |
| Marangaroo Drive / Mirrabooka Avenue | S to W | 161 | 137 | 1.97 |
| Marangaroo Drive / Mirrabooka Avenue | W to S | 113 | 102 | 1.04 |
| Marangaroo Drive / Mirrabooka Avenue | W to E | 278 | 278 | 0.00 |
| Marangaroo Drive / Mirrabooka Avenue | W to N | 189 | 187 | 0.13 |
| Marangaroo Drive / Girrawheen Avenue | E to W | 475 | 445 | 1.39 |
| Marangaroo Drive / Girrawheen Avenue | E to S | 87 | 95 | 0.88 |

### PM Peak Turning Movement Comparison (*Continued*)

| Intersection | Movement | Observed | Modelled | GEH |
|---|---|---|---|---|
| Marangaroo Drive / Girrawheen Avenue | S to E | 148 | 128 | 1.70 |
| Marangaroo Drive / Girrawheen Avenue | S to W | 254 | 241 | 0.83 |
| Marangaroo Drive / Girrawheen Avenue | W to S | 156 | 206 | 3.70 |
| Marangaroo Drive / Girrawheen Avenue | W to E | 529 | 502 | 1.20 |
| Girrawheen Avenue / Amberton Avenue | N to S | 301 | 273 | 1.64 |
| Girrawheen Avenue / Amberton Avenue | N to E | 111 | 99 | 1.15 |
| Girrawheen Avenue / Amberton Avenue | E to N | 102 | 87 | 1.54 |
| Girrawheen Avenue / Amberton Avenue | E to S | 46 | 68 | 2.89 |
| Girrawheen Avenue / Amberton Avenue | S to E | 82 | 120 | 3.82 |
| Girrawheen Avenue / Amberton Avenue | S to N | 384 | 339 | 2.38 |
| Marangaroo Drive / Highclere Boulevard | N to W | 181 | 149 | 2.52 |
| Marangaroo Drive / Highclere Boulevard | E to N | 173 | 201 | 2.08 |
| Marangaroo Drive / Highclere Boulevard | E to W | 538 | 485 | 2.33 |
| Marangaroo Drive / Highclere Boulevard | W to E | 523 | 545 | 0.93 |
| Marangaroo Drive / Templeton Cres | S to E | 324 | 295 | 1.67 |
| Marangaroo Drive / Templeton Cres | S to W | 66 | 70 | 0.44 |
| Marangaroo Drive / Templeton Cres | W to S | 45 | 34 | 1.72 |
| Marangaroo Drive / Templeton Cres | W to E | 479 | 419 | 2.82 |

GHD

180 Lonsdale Street
Melbourne, Victoria 3000
T: (03) 8687 8000 F: (03) 8687 8111 E: melmail@ghd.com.au



G:\31\29005\WP\213867.docx

Document Status

| Rev No. | Author | Reviewer | | Approved for Issue | | |
|---|---|---|---|---|---|---|
| | | Name | Signature | Name | Signature | Date |
| 0 | S. Bennett | S. Smedley | | S. Smedley | | |
| | | | | | | |
| | | | | | | |

www.ghd.com

# Appendix C - 2031 forecast traffic volumes

Turning movement volumes - veh/hr

| Intersection | Movement | 2031 AM without LHS | 2031 AM with LHS | 2031 PM without LHS | 2031 PM with LHS |
|---|---|---|---|---|---|
| Wanneroo Road / Marangaroo Drive | N to S | 2224 | 2337 | 1144 | 1206 |
| Wanneroo Road / Marangaroo Drive | N to E | 182 | 351 | 193 | 316 |
| Wanneroo Road / Marangaroo Drive | E to N | 278 | 380 | 318 | 443 |
| Wanneroo Road / Marangaroo Drive | E to S | 550 | 722 | 356 | 531 |
| Wanneroo Road / Marangaroo Drive | S to E | 254 | 407 | 463 | 694 |
| Wanneroo Road / Marangaroo Drive | S to N | 1156 | 1158 | 2452 | 2460 |
| Wanneroo Road / Warwick Road | N to W | 637 | 665 | 339 | 368 |
| Wanneroo Road / Warwick Road | N to S | 2145 | 2392 | 1156 | 1364 |
| Wanneroo Road / Warwick Road | S to N | 947 | 1076 | 2174 | 2375 |
| Wanneroo Road / Warwick Road | S to W | 192 | 200 | 256 | 233 |
| Wanneroo Road / Warwick Road | W to S | 302 | 319 | 139 | 159 |
| Wanneroo Road / Warwick Road | W to N | 468 | 497 | 752 | 799 |
| Wanneroo Road / Templeton Cres | N to S | 2404 | 2607 | 1242 | 1395 |
| Wanneroo Road / Templeton Cres | N to E | 44 | 107 | 52 | 129 |
| Wanneroo Road / Templeton Cres | E to N | 26 | 56 | 31 | 88 |
| Wanneroo Road / Templeton Cres | E to S | 139 | 368 | 87 | 190 |
| Wanneroo Road / Templeton Cres | S to E | 53 | 153 | 249 | 622 |
| Wanneroo Road / Templeton Cres | S to N | 1112 | 1223 | 2401 | 2520 |
| Wanneroo Road / Beach Road | N to W | 156 | 197 | 220 | 271 |
| Wanneroo Road / Beach Road | N to S | 2218 | 2490 | 911 | 1066 |
| Wanneroo Road / Beach Road | N to E | 155 | 283 | 196 | 244 |
| Wanneroo Road / Beach Road | E to N | 201 | 291 | 356 | 508 |
| Wanneroo Road / Beach Road | E to W | 384 | 408 | 578 | 572 |
| Wanneroo Road / Beach Road | E to S | 88 | 216 | 47 | 98 |
| Wanneroo Road / Beach Road | S to E | 26 | 71 | 48 | 111 |
| Wanneroo Road / Beach Road | S to N | 794 | 874 | 1980 | 2244 |
| Wanneroo Road / Beach Road | S to W | 125 | 108 | 232 | 166 |
| Wanneroo Road / Beach Road | W to S | 306 | 283 | 226 | 175 |
| Wanneroo Road / Beach Road | W to E | 570 | 574 | 370 | 374 |
| Wanneroo Road / Beach Road | W to N | 172 | 210 | 298 | 362 |
| Beach Road / Girrawheen Avenue | N to W | 47 | 153 | 28 | 107 |
| Beach Road / Girrawheen Avenue | N to S | 541 | 695 | 347 | 539 |
| Beach Road / Girrawheen Avenue | N to E | 98 | 285 | 56 | 197 |
| Beach Road / Girrawheen Avenue | E to N | 91 | 244 | 68 | 220 |
| Beach Road / Girrawheen Avenue | E to W | 359 | 474 | 665 | 799 |
| Beach Road / Girrawheen Avenue | E to S | 422 | 416 | 256 | 206 |
| Beach Road / Girrawheen Avenue | S to E | 210 | 188 | 483 | 451 |
| Beach Road / Girrawheen Avenue | S to N | 296 | 396 | 568 | 736 |
| Beach Road / Girrawheen Avenue | S to W | 199 | 170 | 312 | 317 |
| Beach Road / Girrawheen Avenue | W to S | 197 | 189 | 176 | 127 |
| Beach Road / Girrawheen Avenue | W to E | 528 | 672 | 358 | 410 |
| Beach Road / Girrawheen Avenue | W to N | 30 | 82 | 41 | 106 |
| Beach Road / Hainsworth Avenue | N to W | 128 | 339 | 48 | 142 |
| Beach Road / Hainsworth Avenue | N to E | 100 | 288 | 52 | 132 |
| Beach Road / Hainsworth Avenue | E to N | 127 | 343 | 126 | 336 |
| Beach Road / Hainsworth Avenue | E to W | 751 | 798 | 947 | 1098 |
| Beach Road / Hainsworth Avenue | W to E | 780 | 941 | 775 | 778 |
| Beach Road / Hainsworth Avenue | W to N | 56 | 205 | 119 | 280 |
| Beach Road / Mirrabooka Avenue | N to W | 325 | 410 | 121 | 243 |
| Beach Road / Mirrabooka Avenue | N to S | 1014 | 1116 | 555 | 644 |
| Beach Road / Mirrabooka Avenue | N to E | 369 | 464 | 270 | 388 |
| Beach Road / Mirrabooka Avenue | E to N | 241 | 322 | 324 | 384 |
| Beach Road / Mirrabooka Avenue | E to W | 450 | 506 | 809 | 899 |
| Beach Road / Mirrabooka Avenue | E to S | 133 | 114 | 126 | 118 |
| Beach Road / Mirrabooka Avenue | S to E | 117 | 122 | 114 | 116 |
| Beach Road / Mirrabooka Avenue | S to N | 550 | 593 | 925 | 1061 |
| Beach Road / Mirrabooka Avenue | S to W | 111 | 227 | 144 | 293 |
| Beach Road / Mirrabooka Avenue | W to S | 146 | 338 | 76 | 154 |
| Beach Road / Mirrabooka Avenue | W to E | 584 | 606 | 312 | 279 |
| Beach Road / Mirrabooka Avenue | W to N | 167 | 286 | 439 | 482 |

| Intersection | Movement | 2031 AM without LHS | 2031 AM with LHS | 2031 PM without LHS | 2031 PM with LHS |
|---|---|---|---|---|---|
| Marangaroo Drive / Koondoola Avenue | E to W | 706 | 650 | 662 | 635 |
| Marangaroo Drive / Koondoola Avenue | E to S | 101 | 263 | 31 | 73 |
| Marangaroo Drive / Koondoola Avenue | S to E | 72 | 158 | 63 | 137 |
| Marangaroo Drive / Koondoola Avenue | S to W | 21 | 78 | 20 | 83 |
| Marangaroo Drive / Koondoola Avenue | W to S | 32 | 108 | 19 | 80 |
| Marangaroo Drive / Koondoola Avenue | W to E | 491 | 499 | 591 | 544 |
| Marangaroo Drive / Mirrabooka Avenue | N to W | 243 | 323 | 178 | 248 |
| Marangaroo Drive / Mirrabooka Avenue | N to S | 1272 | 1285 | 724 | 735 |
| Marangaroo Drive / Mirrabooka Avenue | N to E | 198 | 179 | 146 | 98 |
| Marangaroo Drive / Mirrabooka Avenue | E to N | 189 | 134 | 268 | 173 |
| Marangaroo Drive / Mirrabooka Avenue | E to W | 306 | 360 | 332 | 443 |
| Marangaroo Drive / Mirrabooka Avenue | E to S | 241 | 241 | 77 | 98 |
| Marangaroo Drive / Mirrabooka Avenue | S to E | 68 | 77 | 171 | 174 |
| Marangaroo Drive / Mirrabooka Avenue | S to N | 677 | 694 | 1300 | 1334 |
| Marangaroo Drive / Mirrabooka Avenue | S to W | 114 | 262 | 126 | 269 |
| Marangaroo Drive / Mirrabooka Avenue | W to S | 108 | 262 | 82 | 267 |
| Marangaroo Drive / Mirrabooka Avenue | W to E | 260 | 350 | 292 | 353 |
| Marangaroo Drive / Mirrabooka Avenue | W to N | 96 | 116 | 290 | 377 |
| Marangaroo Drive / Girrawheen Avenue | E to W | 554 | 686 | 549 | 731 |
| Marangaroo Drive / Girrawheen Avenue | E to S | 160 | 383 | 74 | 201 |
| Marangaroo Drive / Girrawheen Avenue | S to E | 61 | 140 | 115 | 273 |
| Marangaroo Drive / Girrawheen Avenue | S to W | 280 | 492 | 374 | 454 |
| Marangaroo Drive / Girrawheen Avenue | W to S | 449 | 600 | 217 | 430 |
| Marangaroo Drive / Girrawheen Avenue | W to E | 398 | 565 | 607 | 878 |
| Girrawheen Avenue / Amberton Avenue | N to S | 556 | 768 | 318 | 577 |
| Girrawheen Avenue / Amberton Avenue | N to E | 82 | 278 | 62 | 232 |
| Girrawheen Avenue / Amberton Avenue | E to N | 120 | 351 | 62 | 215 |
| Girrawheen Avenue / Amberton Avenue | E to S | 92 | 256 | 72 | 178 |
| Girrawheen Avenue / Amberton Avenue | S to E | 79 | 200 | 139 | 280 |
| Girrawheen Avenue / Amberton Avenue | S to N | 326 | 521 | 477 | 656 |
| Marangaroo Drive / Highclere Boulevard | N to W | 242 | 311 | 160 | 181 |
| Marangaroo Drive / Highclere Boulevard | N to E | 470 | 409 | 242 | 222 |
| Marangaroo Drive / Highclere Boulevard | E to N | 218 | 212 | 358 | 280 |
| Marangaroo Drive / Highclere Boulevard | E to W | 610 | 964 | 566 | 912 |
| Marangaroo Drive / Highclere Boulevard | W to E | 371 | 760 | 589 | 1089 |
| Marangaroo Drive / Highclere Boulevard | W to N | 69 | 78 | 157 | 250 |
| Marangaroo Drive / Templeton Cres | E to W | 776 | 1085 | 648 | 934 |
| Marangaroo Drive / Templeton Cres | E to S | 74 | 189 | 78 | 156 |
| Marangaroo Drive / Templeton Cres | S to E | 83 | 221 | 265 | 670 |
| Marangaroo Drive / Templeton Cres | S to W | 35 | 78 | 74 | 181 |
| Marangaroo Drive / Templeton Cres | W to S | 34 | 60 | 32 | 89 |
| Marangaroo Drive / Templeton Cres | W to E | 358 | 618 | 482 | 664 |
| Mirrabooka Ave / Koondoola Ave | N to E | 56 | 130 | 47 | 141 |
| Mirrabooka Ave / Koondoola Ave | N to S | 1563 | 1536 | 799 | 773 |
| Mirrabooka Ave / Koondoola Ave | N to W | 52 | 104 | 44 | 132 |
| Mirrabooka Ave / Koondoola Ave | E to S | 140 | 283 | 94 | 227 |
| Mirrabooka Ave / Koondoola Ave | E to W | 74 | 301 | 17 | 78 |
| Mirrabooka Ave / Koondoola Ave | E to N | 75 | 155 | 95 | 232 |
| Mirrabooka Ave / Koondoola Ave | S to W | 68 | 153 | 116 | 272 |
| Mirrabooka Ave / Koondoola Ave | S to N | 764 | 798 | 1448 | 1305 |
| Mirrabooka Ave / Koondoola Ave | S to E | 109 | 253 | 99 | 249 |
| Mirrabooka Ave / Koondoola Ave | W to N | 40 | 100 | 65 | 197 |
| Mirrabooka Ave / Koondoola Ave | W to E | 32 | 143 | 29 | 80 |
| Mirrabooka Ave / Koondoola Ave | W to S | 75 | 156 | 83 | 224 |

# Appendix D - Modelled intersection configurations – Paramics

| Beach Road – Wanneroo Raod | | |
|---|---|---|
| Existing layout | ‘without LHS’ | ‘with LHS’ *(no change from ‘without LHS’)* |
|  |  |  |
| Beach Road – Girrawheen Avenue | | |
| Existing layout | ‘without LHS’ | ‘with LHS’ |
|  |  |  |
| Beach Road – Mirrabooka Avenue | | |
| Existing layout | ‘without LHS’ *(no change from existing)* | ‘with LHS’ |
|  |  |  |

| Mirrabooka Avenue - Koondoola Avenue | | |
|---|---|---|
| Existing layout | 'without LHS' *(no change from existing)* | 'with LHS' |
|  |  |  |

| Marangaroo Drive – Mirrabooka Avenue | | |
|---|---|---|
| Existing layout | 'without LHS' *(no change from existing)* | 'with LHS' |
|  |  |  |

| Wanneroo Road – Warwick Road | | |
|---|---|---|
| Existing layout | 'without LHS' | 'with LHS' *(no change from 'without LHS')* |
|  |  |  |

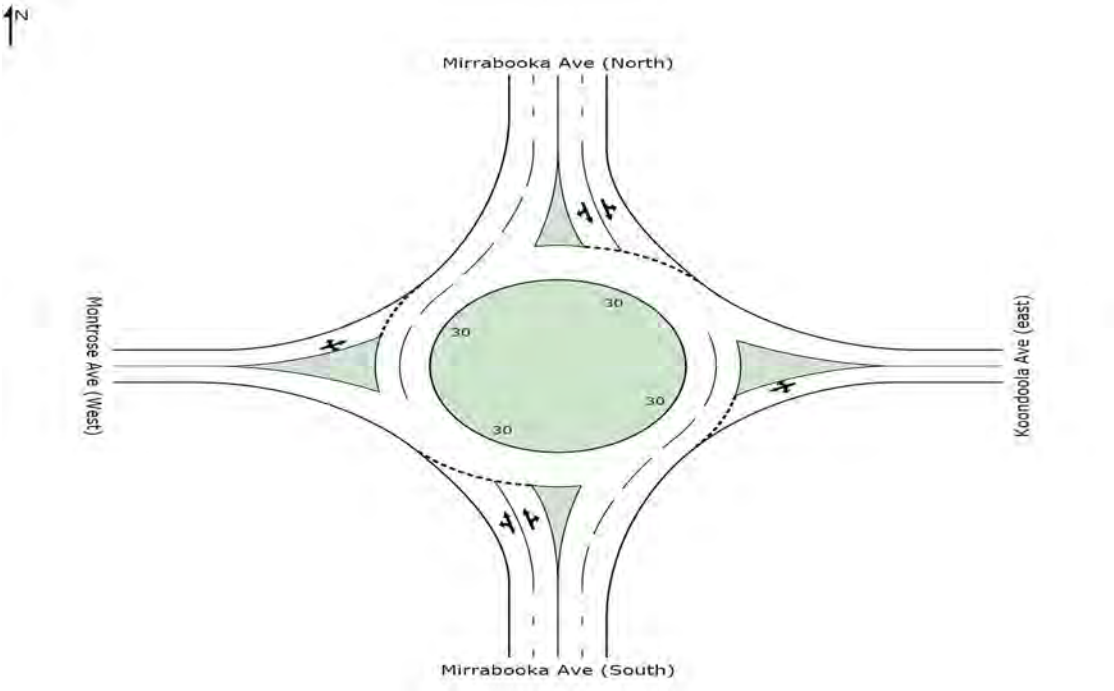
<table>
<tr><td colspan="3">Marangaroo Drive – Girrawheen Avenue</td></tr>
<tr><td>Existing layout</td><td>‘without LHS’ (no change from existing)</td><td>‘with LHS’</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">Wanneroo Road – Templeton Crescent</td></tr>
<tr><td>Existing layout</td><td>‘without LHS’</td><td>‘with  LHS’</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

# Appendix E - Summary of Sidra analysis - 2031 no LHS, existing geometry

# Sidra Analysis with NO LHS 2031

This technical note provides the Sidra analysis and output for the Existing Intersection Geometry for full development (2031) with No LHS.

## Mirrabooka/Koondoola Intersection 2031




Mirabooka Koondoola 2031 No LHS am Existing Geometry
Roundabout

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Ave (South) | | | | | | | | | | | |
| 1 | L | 68 | 4.0 | 0.334 | 6.5 | LOS A | 2.4 | 17.5 | 0.44 | 0.56 | 49.5 |
| 2 | T | 764 | 4.0 | 0.334 | 5.3 | LOS A | 2.4 | 17.5 | 0.45 | 0.48 | 49.8 |
| 3 | R | 109 | 4.0 | 0.334 | 12.4 | LOS B | 2.3 | 16.7 | 0.47 | 0.78 | 46.3 |
| Approach | | 941 | 4.0 | 0.334 | 6.2 | LOS A | 2.4 | 17.5 | 0.45 | 0.52 | 49.3 |
| East: Koondoola Ave (east) | | | | | | | | | | | |
| 4 | L | 140 | 4.0 | 0.585 | 15.2 | LOS B | 3.7 | 26.8 | 0.87 | 1.04 | 42.3 |
| 5 | T | 74 | 4.0 | 0.585 | 14.2 | LOS B | 3.7 | 26.8 | 0.87 | 1.02 | 42.5 |
| 6 | R | 75 | 4.0 | 0.585 | 21.1 | LOS C | 3.7 | 26.8 | 0.87 | 1.09 | 39.9 |
| Approach | | 289 | 4.0 | 0.585 | 16.5 | LOS B | 3.7 | 26.8 | 0.87 | 1.05 | 41.7 |
| North: Mirrabooka Ave (North) | | | | | | | | | | | |
| 7 | L | 56 | 4.0 | 0.587 | 6.9 | LOS A | 5.2 | 37.5 | 0.55 | 0.60 | 49.0 |
| 8 | T | 1563 | 4.0 | 0.587 | 5.8 | LOS A | 5.2 | 37.5 | 0.57 | 0.52 | 49.1 |
| 9 | R | 52 | 4.0 | 0.587 | 12.9 | LOS B | 5.0 | 36.5 | 0.59 | 0.80 | 46.4 |
| Approach | | 1671 | 4.0 | 0.587 | 6.1 | LOS A | 5.2 | 37.5 | 0.57 | 0.54 | 49.0 |
| West: Montrose Ave (West) | | | | | | | | | | | |
| 10 | L | 40 | 4.0 | 0.194 | 8.3 | LOS A | 0.8 | 6.0 | 0.62 | 0.72 | 47.7 |
| 11 | T | 32 | 4.0 | 0.194 | 7.3 | LOS A | 0.8 | 6.0 | 0.62 | 0.65 | 47.7 |
| 12 | R | 75 | 4.0 | 0.194 | 14.2 | LOS B | 0.8 | 6.0 | 0.62 | 0.92 | 44.7 |
| Approach | | 147 | 4.0 | 0.194 | 11.1 | LOS B | 0.8 | 6.0 | 0.62 | 0.81 | 46.1 |
| All Vehicles | | 3048 | 4.0 | 0.587 | 7.4 | LOS A | 5.2 | 37.5 | 0.57 | 0.59 | 48.1 |

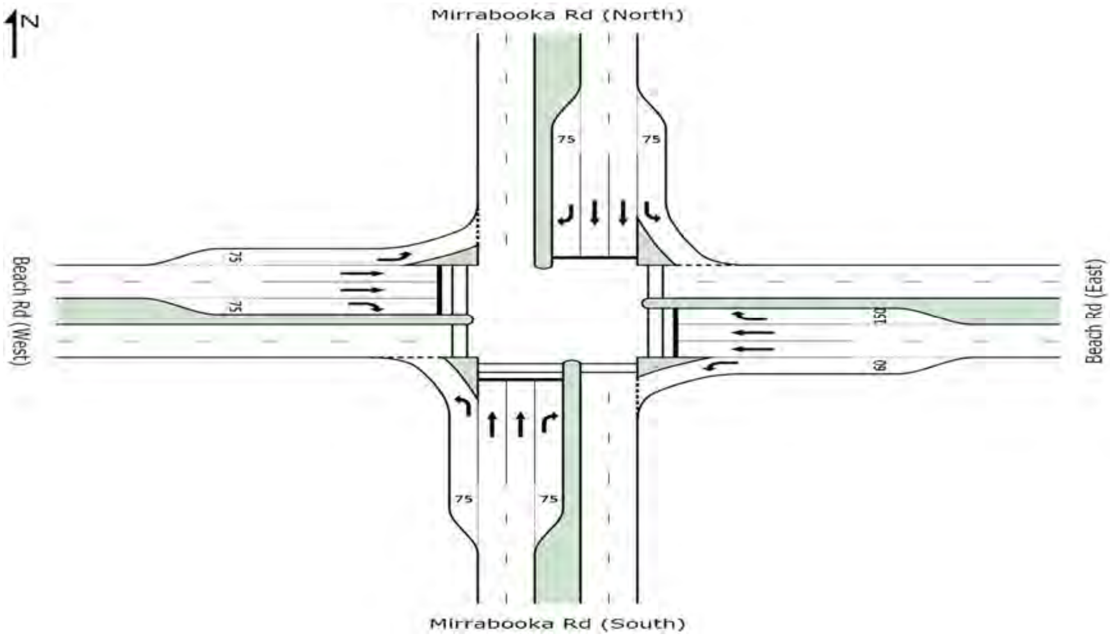
Mirabooka Koondoola 2031 No LHS pm Existing Geometry
Roundabout

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Ave (South) | | | | | | | | | | | |
| 1 | L | 116 | 4.0 | 0.560 | 6.5 | LOS A | 5.0 | 36.6 | 0.48 | 0.55 | 49.4 |
| 2 | T | 1448 | 4.0 | 0.560 | 5.4 | LOS A | 5.0 | 36.6 | 0.49 | 0.49 | 49.6 |
| 3 | R | 99 | 4.0 | 0.560 | 12.5 | LOS B | 4.9 | 35.7 | 0.52 | 0.78 | 46.5 |
| Approach | | 1663 | 4.0 | 0.560 | 5.9 | LOS A | 5.0 | 36.6 | 0.49 | 0.51 | 49.3 |
| East: Koondoola Ave (east) | | | | | | | | | | | |
| 4 | L | 94 | 4.0 | 0.268 | 8.5 | LOS A | 1.2 | 8.7 | 0.64 | 0.73 | 47.6 |
| 5 | T | 17 | 4.0 | 0.268 | 7.5 | LOS A | 1.2 | 8.7 | 0.64 | 0.67 | 47.5 |
| 6 | R | 95 | 4.0 | 0.268 | 14.3 | LOS B | 1.2 | 8.7 | 0.64 | 0.93 | 44.5 |
| Approach | | 206 | 4.0 | 0.268 | 11.1 | LOS B | 1.2 | 8.7 | 0.64 | 0.82 | 46.1 |
| North: Mirrabooka Ave (North) | | | | | | | | | | | |
| 7 | L | 47 | 4.0 | 0.315 | 6.5 | LOS A | 2.1 | 15.4 | 0.42 | 0.56 | 49.7 |
| 8 | T | 799 | 4.0 | 0.315 | 5.4 | LOS A | 2.1 | 15.4 | 0.44 | 0.48 | 50.0 |
| 9 | R | 44 | 4.0 | 0.315 | 12.4 | LOS B | 2.0 | 14.8 | 0.45 | 0.82 | 46.6 |
| Approach | | 890 | 4.0 | 0.315 | 5.8 | LOS A | 2.1 | 15.4 | 0.44 | 0.50 | 49.8 |
| West: Montrose Ave (West) | | | | | | | | | | | |
| 10 | L | 65 | 4.0 | 0.330 | 11.3 | LOS B | 1.6 | 11.8 | 0.79 | 0.90 | 45.6 |
| 11 | T | 29 | 4.0 | 0.330 | 10.3 | LOS B | 1.6 | 11.8 | 0.79 | 0.88 | 45.8 |
| 12 | R | 83 | 4.0 | 0.330 | 17.2 | LOS B | 1.6 | 11.8 | 0.79 | 0.98 | 42.4 |
| Approach | | 177 | 4.0 | 0.330 | 13.9 | LOS B | 1.6 | 11.8 | 0.79 | 0.93 | 44.0 |
| All Vehicles | | 2936 | 4.0 | 0.560 | 6.7 | LOS A | 5.0 | 36.6 | 0.50 | 0.55 | 48.9 |

The above analysis indicates that the existing roundabout will accommodate forecast traffic volumes to 2031 with no LHS.

**Beach Road/Mirrabooka Road Intersection 2031**
Existing Geometry




Beach Rd/Mirrabooka Ave 2031 No LHS Existing Geometry AM
Signals - Fixed Time    Cycle Time = 116 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Rd (South) | | | | | | | | | | | |
| 1 | L | 111 | 5.0 | 0.187 | 14.7 | LOS B | 2.1 | 15.6 | 0.42 | 0.69 | 43.0 |
| 2 | T | 550 | 5.0 | 0.512 | 37.5 | LOS D | 13.1 | 95.4 | 0.89 | 0.76 | 28.3 |
| 3 | R | 117 | 5.0 | 0.390 | 52.5 | LOS D | 5.8 | 42.5 | 0.91 | 0.78 | 24.7 |
| Approach | | 778 | 5.0 | 0.512 | 36.5 | LOS D | 13.1 | 95.4 | 0.83 | 0.75 | 29.1 |
| East: Beach Rd (East) | | | | | | | | | | | |
| 4 | L | 133 | 5.0 | 0.297 | 18.4 | LOS B | 3.2 | 23.4 | 0.51 | 0.71 | 40.0 |
| 5 | T | 450 | 5.0 | 0.658 | 48.6 | LOS D | 12.1 | 88.4 | 0.98 | 0.82 | 24.7 |
| 6 | R | 241 | 5.0 | 0.974 | 103.1 | LOS F | 19.6 | 142.7 | 1.00 | 1.23 | 15.7 |
| Approach | | 824 | 5.0 | 0.974 | 59.7 | LOS E | 19.6 | 142.7 | 0.91 | 0.92 | 22.4 |
| North: Mirrabooka Rd (North) | | | | | | | | | | | |
| 7 | L | 369 | 5.0 | 0.538 | 13.0 | LOS B | 6.7 | 49.2 | 0.42 | 0.71 | 44.4 |
| 8 | T | 1041 | 5.0 | 0.970 | 86.9 | LOS F | 43.2 | 315.2 | 1.00 | 1.34 | 17.2 |
| 9 | R | 298 | 5.0 | 1.000 [3] | 58.3 | LOS E | 16.8 | 122.4 | 1.00 | 0.85 | 23.2 |
| Approach | | 1708 | 5.0 | 1.000 | 66.0 | LOS E | 43.2 | 315.2 | 0.87 | 1.12 | 20.9 |
| West: Beach Rd (West) | | | | | | | | | | | |
| 10 | L | 167 | 5.0 | 0.283 | 14.3 | LOS B | 3.2 | 23.3 | 0.42 | 0.70 | 43.3 |
| 11 | T | 584 | 5.0 | 0.854 | 58.1 | LOS E | 18.0 | 131.5 | 1.00 | 1.00 | 22.3 |
| 12 | R | 146 | 5.0 | 0.590 | 60.1 | LOS E | 8.0 | 58.4 | 0.99 | 0.80 | 22.8 |
| Approach | | 897 | 5.0 | 0.854 | 50.3 | LOS D | 18.0 | 131.5 | 0.89 | 0.91 | 24.6 |
| All Vehicles | | 4207 | 5.0 | 1.000 | 55.9 | LOS E | 43.2 | 315.2 | 0.88 | 0.97 | 23.2 |

Beach Rd/Mirrabooka Ave 2031 No LHS Existing Geometry PM
Signals - Fixed Time  Cycle Time = 118 seconds (Optimum Cycle Time - Minimum Delay)

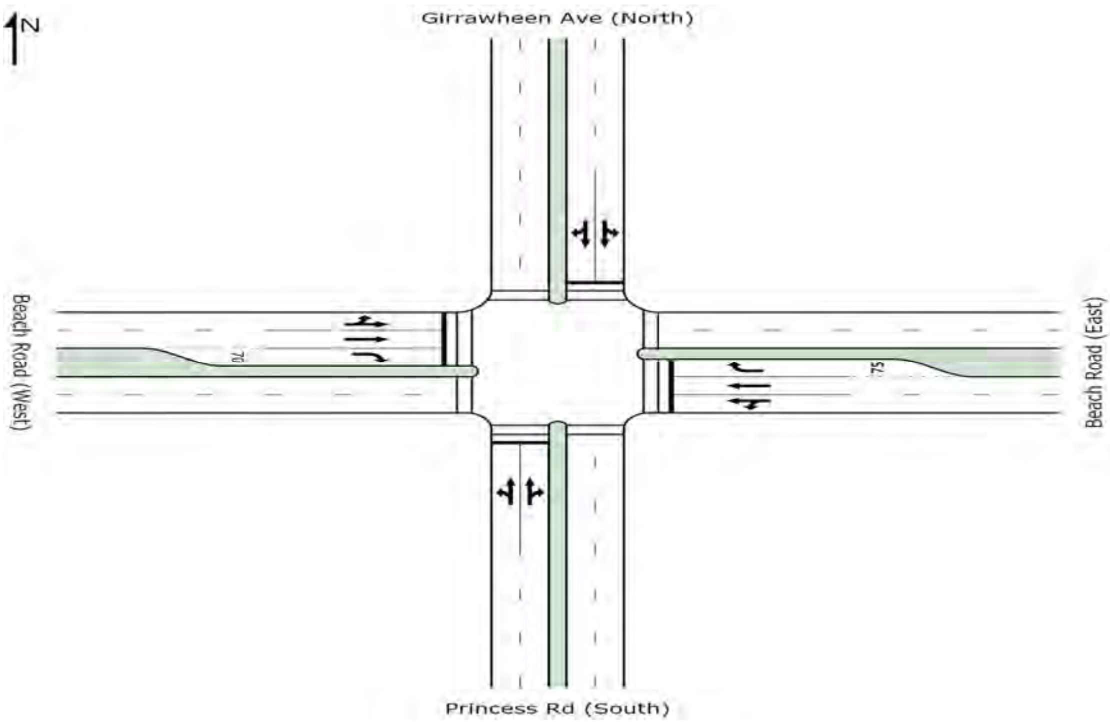
**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Rd (South) | | | | | | | | | | | |
| 1 | L | 144 | 5.0 | 0.245 | 15.1 | LOS B | 2.9 | 21.2 | 0.43 | 0.69 | 42.6 |
| 2 | T | 925 | 5.0 | 0.876 | 54.0 | LOS D | 29.2 | 213.1 | 1.00 | 1.03 | 23.2 |
| 3 | R | 114 | 5.0 | 0.834 | 74.4 | LOS E | 7.3 | 53.0 | 1.00 | 0.94 | 19.8 |
| Approach | | 1183 | 5.0 | 0.876 | 51.2 | LOS D | 29.2 | 213.1 | 0.93 | 0.98 | 24.2 |
| East: Beach Rd (East) | | | | | | | | | | | |
| 4 | L | 126 | 5.0 | 0.197 | 10.7 | LOS B | 1.6 | 11.7 | 0.29 | 0.66 | 46.5 |
| 5 | T | 809 | 5.0 | 0.871 | 56.0 | LOS E | 25.6 | 186.6 | 1.00 | 1.03 | 22.7 |
| 6 | R | 324 | 5.0 | 0.927 | 80.1 | LOS F | 23.2 | 169.7 | 1.00 | 1.07 | 18.8 |
| Approach | | 1259 | 5.0 | 0.927 | 57.7 | LOS E | 25.6 | 186.6 | 0.93 | 1.00 | 22.7 |
| North: Mirrabooka Rd (North) | | | | | | | | | | | |
| 7 | L | 270 | 5.0 | 0.338 | 10.3 | LOS B | 3.3 | 24.2 | 0.29 | 0.68 | 46.9 |
| 8 | T | 555 | 5.0 | 0.525 | 38.7 | LOS D | 13.5 | 98.8 | 0.90 | 0.76 | 27.9 |
| 9 | R | 121 | 5.0 | 0.885 | 78.4 | LOS E | 8.0 | 58.4 | 1.00 | 1.02 | 19.1 |
| Approach | | 946 | 5.0 | 0.885 | 35.7 | LOS D | 13.5 | 98.8 | 0.74 | 0.77 | 29.6 |
| West: Beach Rd (West) | | | | | | | | | | | |
| 10 | L | 438 | 5.0 | 1.000 [3] | 27.3 | LOS C | 16.8 | 122.8 | 0.77 | 0.81 | 34.5 |
| 11 | T | 313 | 5.0 | 0.337 | 39.5 | LOS D | 7.4 | 54.3 | 0.87 | 0.71 | 27.6 |
| 12 | R | 76 | 5.0 | 0.254 | 51.4 | LOS D | 3.7 | 27.1 | 0.88 | 0.76 | 25.0 |
| Approach | | 827 | 5.0 | 1.000 | 34.2 | LOS C | 16.8 | 122.8 | 0.82 | 0.77 | 30.6 |
| All Vehicles | | 4215 | 5.0 | 1.000 | 46.3 | LOS D | 29.2 | 213.1 | 0.86 | 0.90 | 25.8 |

The above analysis indicates an intersection LoS of D/E to 2031 with no LHS for the current geometry. Stop rates for some movements are greater than 1 and the degree of saturation is 1. The analysis indicates that upgrade is required to improve the performance.

## Girrawheen/Beach Road Intersection 2031

### Existing Geometry




Girrawheen Avenue / Beach Road / Princess Rd AM 2031 Existing Geometry No LHS
Signals - Fixed Time    Cycle Time = 117 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Princess Rd (South) | | | | | | | | | | | |
| 1 | L | 199 | 5.0 | 0.900 | 71.8 | LOS E | 23.6 | 172.1 | 1.00 | 1.06 | 20.5 |
| 2 | T | 296 | 5.0 | 0.900 | 63.4 | LOS E | 23.6 | 172.1 | 1.00 | 1.06 | 20.6 |
| 3 | R | 210 | 5.0 | 0.900 | 71.5 | LOS E | 23.5 | 171.8 | 1.00 | 1.06 | 20.6 |
| Approach | | 705 | 5.0 | 0.900 | 68.2 | LOS E | 23.6 | 172.1 | 1.00 | 1.06 | 20.6 |
| East: Beach Road (East) | | | | | | | | | | | |
| 4 | L | 422 | 5.0 | 0.918 | 73.6 | LOS E | 29.4 | 214.8 | 1.00 | 1.02 | 19.8 |
| 5 | T | 359 | 5.0 | 0.741 | 44.5 | LOS D | 19.3 | 141.2 | 0.98 | 0.87 | 25.9 |
| 6 | R | 91 | 5.0 | 0.424 | 61.4 | LOS E | 5.0 | 36.3 | 0.97 | 0.78 | 22.4 |
| Approach | | 872 | 5.0 | 0.918 | 60.3 | LOS E | 29.4 | 214.8 | 0.99 | 0.93 | 22.2 |
| North: Girrawheen Ave (North) | | | | | | | | | | | |
| 7 | L | 98 | 5.0 | 0.895 | 71.1 | LOS E | 22.6 | 164.7 | 1.00 | 1.08 | 20.9 |
| 8 | T | 541 | 5.0 | 0.895 | 62.7 | LOS E | 22.7 | 165.8 | 1.00 | 1.08 | 21.1 |
| 9 | R | 47 | 5.0 | 0.895 | 70.8 | LOS E | 22.7 | 165.8 | 1.00 | 1.08 | 21.1 |
| Approach | | 686 | 5.0 | 0.895 | 64.5 | LOS E | 22.7 | 165.8 | 1.00 | 1.08 | 21.0 |
| West: Beach Road (West) | | | | | | | | | | | |
| 10 | L | 30 | 5.0 | 0.578 | 49.5 | LOS D | 14.0 | 101.9 | 0.93 | 0.86 | 26.5 |
| 11 | T | 528 | 5.0 | 0.578 | 41.1 | LOS D | 14.0 | 102.4 | 0.93 | 0.79 | 26.9 |
| 12 | R | 197 | 5.0 | 0.918 | 81.1 | LOS F | 13.6 | 99.2 | 1.00 | 1.06 | 18.6 |
| Approach | | 755 | 5.0 | 0.918 | 51.9 | LOS D | 14.0 | 102.4 | 0.95 | 0.86 | 24.1 |
| All Vehicles | | 3018 | 5.0 | 0.918 | 61.0 | LOS E | 29.4 | 214.8 | 0.98 | 0.98 | 22.0 |

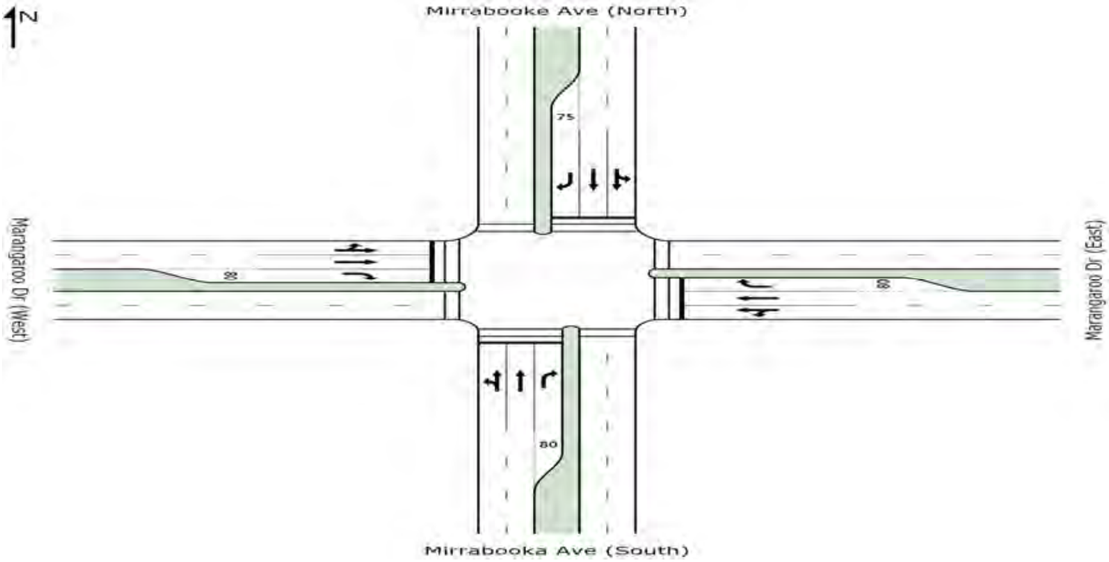
Girrawheen Avenue / Beach Road / Princess Rd PM 2031 Existing Geometry No LHS
Signals - Fixed Time Cycle Time = 160 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Princess Rd (South) | | | | | | | | | | | |
| 1 | L | 312 | 5.0 | 0.992 | 125.2 | LOS F | 79.2 | 578.2 | 1.00 | 1.22 | 13.7 |
| 2 | T | 568 | 5.0 | 0.992 | 117.0 | LOS F | 79.2 | 578.2 | 1.00 | 1.20 | 13.7 |
| 3 | R | 483 | 5.0 | 0.992 | 125.4 | LOS F | 78.3 | 571.9 | 1.00 | 1.18 | 13.6 |
| Approach | | 1363 | 5.0 | 0.992 | 121.9 | LOS F | 79.2 | 578.2 | 1.00 | 1.20 | 13.7 |
| East: Beach Road (East) | | | | | | | | | | | |
| 4 | L | 256 | 5.0 | 1.015 | 161.6 | LOS F | 57.0 | 415.9 | 1.00 | 1.31 | 11.1 |
| 5 | T | 665 | 5.0 | 1.015 | 152.6 | LOS F | 58.5 | 426.8 | 1.00 | 1.42 | 11.3 |
| 6 | R | 68 | 5.0 | 0.379 | 82.5 | LOS F | 5.1 | 37.1 | 0.98 | 0.77 | 18.4 |
| Approach | | 989 | 5.0 | 1.015 | 150.1 | LOS F | 58.5 | 426.8 | 1.00 | 1.35 | 11.6 |
| North: Girrawheen Ave (North) | | | | | | | | | | | |
| 7 | L | 56 | 5.0 | 0.878 | 93.6 | LOS F | 18.4 | 134.2 | 1.00 | 1.01 | 17.2 |
| 8 | T | 347 | 5.0 | 0.878 | 85.1 | LOS F | 18.5 | 135.1 | 1.00 | 1.01 | 17.3 |
| 9 | R | 28 | 5.0 | 0.878 | 93.2 | LOS F | 18.5 | 135.1 | 1.00 | 1.01 | 17.4 |
| Approach | | 431 | 5.0 | 0.878 | 86.8 | LOS F | 18.5 | 135.1 | 1.00 | 1.01 | 17.3 |
| West: Beach Road (West) | | | | | | | | | | | |
| 10 | L | 41 | 5.0 | 0.436 | 63.2 | LOS E | 13.0 | 95.2 | 0.90 | 0.85 | 22.6 |
| 11 | T | 358 | 5.0 | 0.436 | 54.8 | LOS D | 13.2 | 96.2 | 0.90 | 0.75 | 23.0 |
| 12 | R | 176 | 5.0 | 0.982 | 103.1 | LOS F | 15.6 | 114.2 | 1.00 | 0.92 | 15.7 |
| Approach | | 575 | 5.0 | 0.982 | 70.2 | LOS E | 15.6 | 114.2 | 0.93 | 0.81 | 20.1 |
| All Vehicles | | 3358 | 5.0 | 1.015 | 116.8 | LOS F | 79.2 | 578.2 | 0.99 | 1.15 | 14.1 |

The above analysis indicates an intersection LoS of E/F to 2031 with no LHS for the current geometry. Stop rates for most movements are greater than 1 and the degree of saturation is greater than 1 in the pm peak hour 1. The analysis indicates that upgrade is required to improve the performance.

**Mirabooka/Marangaroo Ave Intersection 2031**
Exiting Geometry




Marangaroo Dr / Mirrabooka Ave 2031 Existing Geometry AM
Signals - Fixed Time Cycle Time = 135 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Ave (South) | | | | | | | | | | | |
| 1 | L | 114 | 4.0 | 0.505 | 39.4 | LOS D | 18.9 | 136.9 | 0.79 | 0.89 | 29.7 |
| 2 | T | 677 | 4.0 | 0.505 | 31.1 | LOS C | 19.2 | 139.0 | 0.79 | 0.70 | 30.9 |
| 3 | R | 68 | 4.0 | 0.268 | 64.7 | LOS E | 4.1 | 29.4 | 0.93 | 0.76 | 21.7 |
| Approach | | 859 | 4.0 | 0.505 | 34.9 | LOS C | 19.2 | 139.0 | 0.80 | 0.73 | 29.7 |
| East: Marangaroo Dr (East) | | | | | | | | | | | |
| 4 | L | 241 | 4.0 | 0.947 | 97.5 | LOS F | 22.4 | 162.4 | 1.00 | 1.09 | 16.3 |
| 5 | T | 306 | 4.0 | 0.947 | 88.5 | LOS F | 23.4 | 169.1 | 1.00 | 1.18 | 17.0 |
| 6 | R | 189 | 4.0 | 0.942 | 97.4 | LOS F | 15.5 | 112.2 | 1.00 | 1.09 | 16.4 |
| Approach | | 736 | 4.0 | 0.947 | 93.7 | LOS F | 23.4 | 169.1 | 1.00 | 1.13 | 16.6 |
| North: Mirrabooke Ave (North) | | | | | | | | | | | |
| 7 | L | 198 | 4.0 | 0.939 | 74.2 | LOS E | 59.2 | 428.9 | 1.00 | 1.09 | 20.3 |
| 8 | T | 1272 | 4.0 | 0.939 | 65.6 | LOS E | 59.9 | 433.6 | 1.00 | 1.11 | 20.6 |
| 9 | R | 243 | 4.0 | 0.956 | 75.6 | LOS E | 16.9 | 122.4 | 1.00 | 0.87 | 19.6 |
| Approach | | 1713 | 4.0 | 0.956 | 68.0 | LOS E | 59.9 | 433.6 | 1.00 | 1.07 | 20.4 |
| West: Marangaroo Dr (West) | | | | | | | | | | | |
| 10 | L | 96 | 4.0 | 0.611 | 66.6 | LOS E | 11.0 | 79.5 | 0.98 | 0.82 | 21.6 |
| 11 | T | 260 | 4.0 | 0.611 | 58.3 | LOS E | 11.3 | 81.7 | 0.98 | 0.81 | 22.1 |
| 12 | R | 108 | 4.0 | 0.538 | 71.0 | LOS E | 6.9 | 50.2 | 0.99 | 0.79 | 20.4 |
| Approach | | 464 | 4.0 | 0.611 | 63.0 | LOS E | 11.3 | 81.7 | 0.99 | 0.81 | 21.6 |
| All Vehicles | | 3772 | 4.0 | 0.956 | 64.9 | LOS E | 59.9 | 433.6 | 0.95 | 0.97 | 21.1 |

Marangaroo Dr / Mirrabooka Ave 2031 Existing Geometry PM
Signals - Fixed Time    Cycle Time = 136 seconds (Optimum Cycle Time - Minimum Delay)

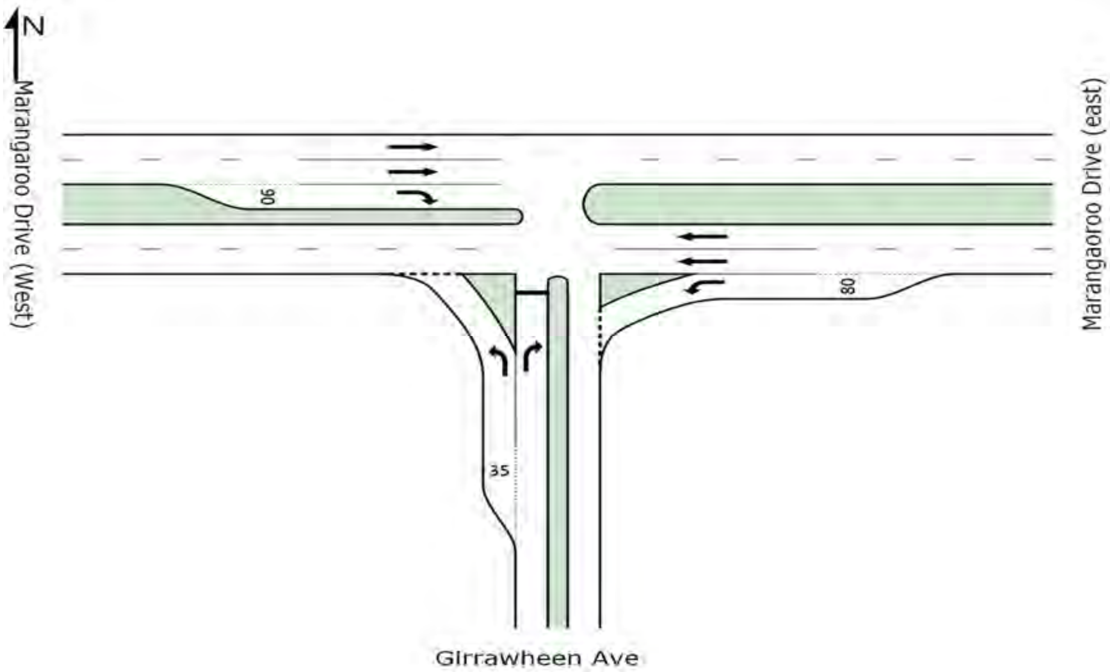
**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Ave (South) | | | | | | | | | | | |
| 1 | L | 126 | 4.0 | 0.949 | 81.2 | LOS F | 60.5 | 437.9 | 1.00 | 1.14 | 19.1 |
| 2 | T | 1300 | 4.0 | 0.949 | 72.7 | LOS E | 60.9 | 441.0 | 1.00 | 1.15 | 19.3 |
| 3 | R | 171 | 4.0 | 0.920 | 91.8 | LOS F | 13.5 | 97.4 | 1.00 | 1.05 | 17.1 |
| Approach | | 1597 | 4.0 | 0.949 | 75.4 | LOS E | 60.9 | 441.0 | 1.00 | 1.14 | 19.0 |
| East: Marangaroo Dr (East) | | | | | | | | | | | |
| 4 | L | 77 | 4.0 | 0.643 | 65.9 | LOS E | 12.7 | 92.1 | 0.99 | 0.83 | 21.9 |
| 5 | T | 332 | 4.0 | 0.643 | 57.5 | LOS E | 13.0 | 93.8 | 0.99 | 0.82 | 22.3 |
| 6 | R | 268 | 4.0 | 0.961 | 71.0 | LOS E | 18.1 | 130.9 | 1.00 | 0.84 | 20.4 |
| Approach | | 677 | 4.0 | 0.961 | 63.8 | LOS E | 18.1 | 130.9 | 0.99 | 0.83 | 21.4 |
| North: Mirrabooke Ave (North) | | | | | | | | | | | |
| 7 | L | 146 | 4.0 | 0.582 | 42.6 | LOS D | 22.2 | 160.7 | 0.84 | 0.88 | 28.5 |
| 8 | T | 724 | 4.0 | 0.582 | 34.2 | LOS C | 22.6 | 163.5 | 0.84 | 0.74 | 29.4 |
| 9 | R | 178 | 4.0 | 0.958 | 104.6 | LOS F | 15.2 | 110.4 | 1.00 | 1.13 | 15.5 |
| Approach | | 1048 | 4.0 | 0.958 | 47.3 | LOS D | 22.6 | 163.5 | 0.87 | 0.83 | 25.4 |
| West: Marangaroo Dr (West) | | | | | | | | | | | |
| 10 | L | 290 | 4.0 | 0.950 | 98.9 | LOS F | 24.8 | 179.7 | 1.00 | 1.07 | 16.1 |
| 11 | T | 292 | 4.0 | 0.908 | 76.1 | LOS E | 22.5 | 162.9 | 1.00 | 1.09 | 18.8 |
| 12 | R | 82 | 4.0 | 0.294 | 63.6 | LOS E | 4.9 | 35.4 | 0.93 | 0.77 | 21.9 |
| Approach | | 664 | 4.0 | 0.950 | 84.5 | LOS F | 24.8 | 179.7 | 0.99 | 1.04 | 17.8 |
| All Vehicles | | 3986 | 4.0 | 0.961 | 67.6 | LOS E | 60.9 | 441.0 | 0.96 | 0.99 | 20.6 |

The above analysis indicates an intersection LoS of E to 2031 with no LHS, for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 0.9. The analysis indicates that upgrade is required to improve the performance. Queues in excess of 400m are forecast in Mirrabooka Drive.

## Marangaroo Drive/Girawheen Ave Intersection 2031

Existing Geometry




Marangaroo Drive / Girrawheen Avenue Existing Geometry 2031 AM
Stop (Two-Way)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Girrawheen Ave | | | | | | | | | | | |
| 1 | L | 280 | 4.0 | 0.470 | 14.5 | LOS B | 2.6 | 19.1 | 0.66 | 0.97 | 43.2 |
| 3 | R | 61 | 4.0 | 1.017 | 291.1 | LOS F | 8.3 | 60.0 | 1.00 | 1.63 | 6.7 |
| Approach | | 341 | 4.0 | 1.017 | 63.9 | LOS F | 8.3 | 60.0 | 0.72 | 1.09 | 22.0 |
| East: Marangaoroo Drive (east) | | | | | | | | | | | |
| 4 | L | 160 | 4.0 | 0.182 | 10.2 | LOS B | 0.7 | 5.3 | 0.51 | 0.74 | 47.1 |
| 5 | T | 554 | 4.0 | 0.146 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| Approach | | 714 | 4.0 | 0.182 | 2.3 | NA | 0.7 | 5.3 | 0.11 | 0.17 | 56.5 |
| West: Marangaroo Drive (West) | | | | | | | | | | | |
| 11 | T | 398 | 4.0 | 0.105 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| 12 | R | 449 | 4.0 | 0.556 | 14.0 | LOS B | 4.2 | 30.4 | 0.68 | 1.04 | 43.4 |
| Approach | | 847 | 4.0 | 0.556 | 7.4 | NA | 4.2 | 30.4 | 0.36 | 0.55 | 49.9 |
| All Vehicles | | 1902 | 4.0 | 1.017 | 15.6 | NA | 8.3 | 60.0 | 0.33 | 0.50 | 42.1 |

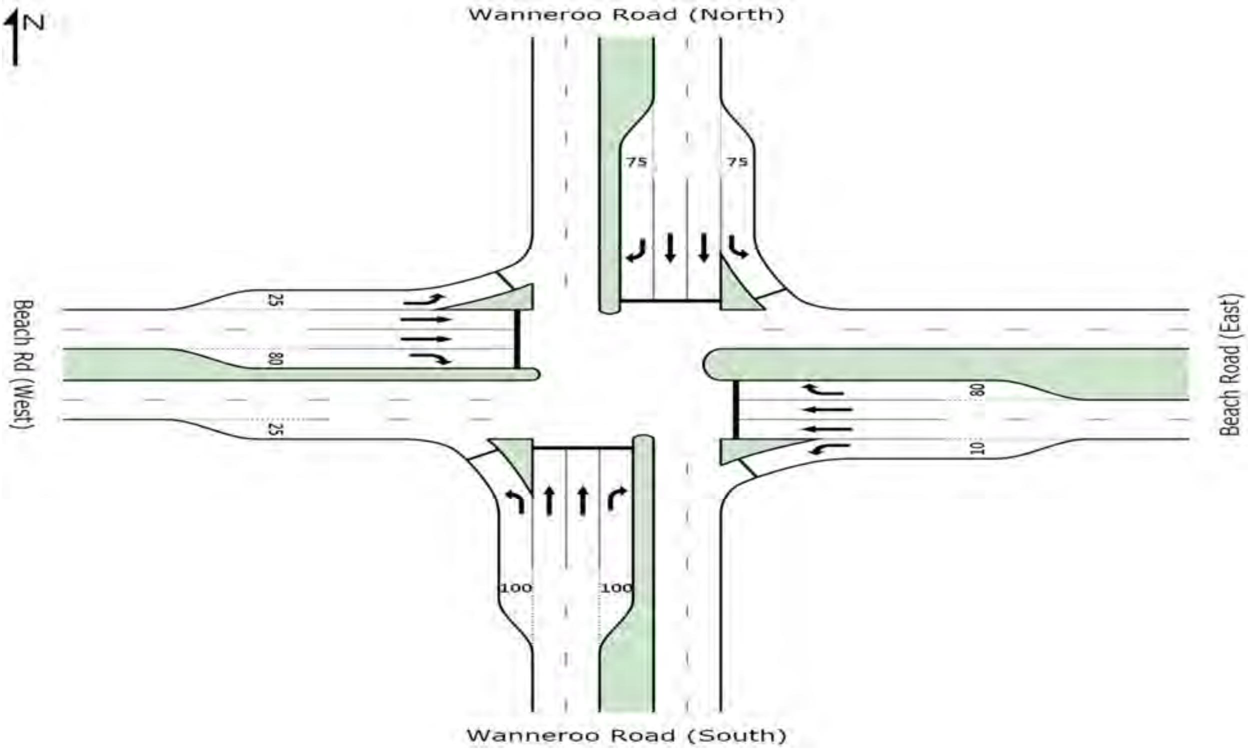
Marangaroo Drive / Girrawheen Avenue Existing Geometry 2031 PM
Stop (Two-Way)

| Movement Performance - Vehicles | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Girrawheen Ave | | | | | | | | | | | |
| 1 | L | 374 | 4.0 | 0.592 | 15.4 | LOS C | 4.2 | 30.4 | 0.70 | 1.05 | 42.4 |
| 3 | R | 115 | 4.0 | 1.743 | 1448.2 | LOS F | 67.2 | 486.6 | 1.00 | 4.28 | 1.5 |
| Approach | | 489 | 4.0 | 1.743 | 352.4 | LOS F | 67.2 | 486.6 | 0.77 | 1.81 | 5.7 |
| East: Marangaoroo Drive (east) | | | | | | | | | | | |
| 4 | L | 74 | 4.0 | 0.064 | 8.6 | LOS A | 0.3 | 1.8 | 0.32 | 0.60 | 48.1 |
| 5 | T | 549 | 4.0 | 0.144 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| Approach | | 623 | 4.0 | 0.144 | 1.0 | NA | 0.3 | 1.8 | 0.04 | 0.07 | 58.3 |
| West: Marangaroo Drive (West) | | | | | | | | | | | |
| 11 | T | 607 | 4.0 | 0.160 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| 12 | R | 217 | 4.0 | 0.267 | 11.5 | LOS B | 1.2 | 8.5 | 0.57 | 0.83 | 45.8 |
| Approach | | 824 | 4.0 | 0.267 | 3.0 | NA | 1.2 | 8.5 | 0.15 | 0.22 | 55.5 |
| All Vehicles | | 1936 | 4.0 | 1.743 | 90.6 | NA | 67.2 | 486.6 | 0.27 | 0.57 | 17.3 |

The above analysis indicates an intersection LoS of F for the right turn from Girrawheen Ave to 2031 with no LHS, for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 1. Queues in excess of 400m are forecast in Girrawheen Ave. The analysis indicates that upgrade is required to improve the performance.

# Beach Road/Wanneroo Road Intersection 2031

## Existing Geometry




Wanneroo Beach 2031 No LHS Existing Geometry AM
Signals - Fixed Time    Cycle Time = 154 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Road (South) | | | | | | | | | | | |
| 1 | L | 125 | 5.0 | 0.266 | 27.8 | LOS C | 4.7 | 34.5 | 0.55 | 0.72 | 34.3 |
| 2 | T | 794 | 5.0 | 0.405 | 23.7 | LOS C | 17.8 | 129.6 | 0.65 | 0.58 | 35.0 |
| 3 | R | 26 | 5.0 | 0.248 | 85.8 | LOS F | 1.9 | 14.2 | 0.99 | 0.72 | 18.0 |
| Approach | | 945 | 5.0 | 0.405 | 25.9 | LOS C | 17.8 | 129.6 | 0.65 | 0.60 | 34.0 |
| East: Beach Road (East) | | | | | | | | | | | |
| 4 | L | 36 | 5.0 | 1.000 [3] | 69.7 | LOS E | 2.2 | 16.3 | 0.97 | 0.72 | 20.8 |
| 5 | T | 502 | 5.0 | 0.691 | 62.5 | LOS E | 17.7 | 129.2 | 0.99 | 0.83 | 21.1 |
| 6 | R | 134 | 5.0 | 1.049 | 207.1 | LOS F | 17.9 | 130.4 | 1.00 | 1.40 | 9.0 |
| Approach | | 673 | 5.0 | 1.049 | 91.7 | LOS F | 17.9 | 130.4 | 0.99 | 0.94 | 16.6 |
| North: Wanneroo Road (North) | | | | | | | | | | | |
| 7 | L | 155 | 5.0 | 0.412 | 28.1 | LOS C | 6.0 | 43.6 | 0.56 | 0.72 | 34.1 |
| 8 | T | 2261 | 5.0 | 1.154 | 351.2 | LOS F | 232.4 | 1696.3 | 1.00 | 2.32 | 5.6 |
| 9 | R | 113 | 5.0 | 1.076 | 249.5 | LOS F | 16.8 | 122.3 | 1.00 | 1.45 | 7.7 |
| Approach | | 2529 | 5.0 | 1.154 | 326.8 | LOS F | 232.4 | 1696.3 | 0.97 | 2.18 | 6.0 |
| West: Beach Rd (West) | | | | | | | | | | | |
| 10 | L | 88 | 5.0 | 1.000 [3] | 69.7 | LOS E | 5.6 | 40.8 | 0.98 | 0.77 | 20.8 |
| 11 | T | 826 | 5.0 | 1.141 | 348.4 | LOS F | 79.9 | 583.0 | 1.00 | 2.12 | 5.6 |
| 12 | R | 134 | 5.0 | 1.048 | 206.2 | LOS F | 17.8 | 130.0 | 1.00 | 1.41 | 9.1 |
| Approach | | 1048 | 5.0 | 1.141 | 306.8 | LOS F | 79.9 | 583.0 | 1.00 | 1.92 | 6.3 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| All Vehicles | 5195 | 5.0 | 1.154 | 237.6 | LOS F | 232.4 | 1696.3 | 0.92 | 1.68 | 7.9 |

Wanneroo Beach 2031 No LHS Existing Geometry PM
Signals - Fixed Time   Cycle Time = 155 seconds (Optimum Cycle Time - Minimum Delay)

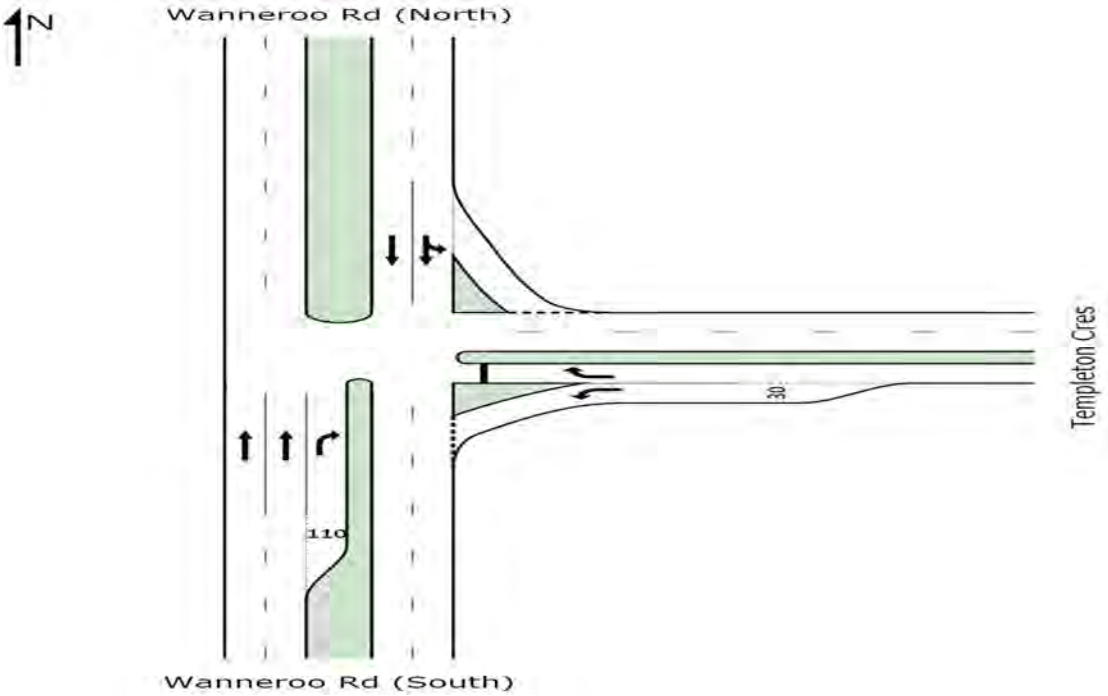
**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Road (South) | | | | | | | | | | | |
| 1 | L | 232 | 5.0 | 0.526 | 32.7 | LOS C | 10.2 | 74.3 | 0.63 | 0.76 | 31.9 |
| 2 | T | 1980 | 5.0 | 1.083 | 234.2 | LOS F | 162.6 | 1187.3 | 1.00 | 1.85 | 8.0 |
| 3 | R | 48 | 5.0 | 0.377 | 84.9 | LOS F | 3.6 | 26.3 | 0.99 | 0.75 | 18.1 |
| Approach | | 2260 | 5.0 | 1.083 | 210.3 | LOS F | 162.6 | 1187.3 | 0.96 | 1.71 | 8.8 |
| East: Beach Road (East) | | | | | | | | | | | |
| 4 | L | 35 | 5.0 | 1.000 [3] | 71.2 | LOS E | 2.2 | 16.3 | 0.97 | 0.71 | 20.5 |
| 5 | T | 749 | 5.0 | 1.111 | 298.0 | LOS F | 66.1 | 482.9 | 1.00 | 1.93 | 6.4 |
| 6 | R | 197 | 5.0 | 1.000 [3] | 108.9 | LOS F | 17.9 | 130.6 | 1.00 | 0.98 | 15.1 |
| Approach | | 981 | 5.0 | 1.111 | 251.9 | LOS F | 66.1 | 482.9 | 1.00 | 1.70 | 7.5 |
| North: Wanneroo Road (North) | | | | | | | | | | | |
| 7 | L | 196 | 5.0 | 0.555 | 32.1 | LOS C | 8.4 | 61.3 | 0.62 | 0.74 | 32.1 |
| 8 | T | 999 | 5.0 | 0.549 | 29.7 | LOS C | 26.2 | 191.0 | 0.76 | 0.68 | 31.6 |
| 9 | R | 132 | 5.0 | 1.037 | 190.9 | LOS F | 16.8 | 122.3 | 1.00 | 1.36 | 9.7 |
| Approach | | 1327 | 5.0 | 1.037 | 46.1 | LOS D | 26.2 | 191.0 | 0.76 | 0.75 | 25.8 |
| West: Beach Rd (West) | | | | | | | | | | | |
| 10 | L | 86 | 5.0 | 1.000 [3] | 71.2 | LOS E | 5.6 | 40.8 | 0.97 | 0.77 | 20.5 |
| 11 | T | 612 | 5.0 | 0.915 | 85.7 | LOS F | 27.2 | 198.5 | 1.00 | 1.07 | 17.2 |
| 12 | R | 197 | 5.0 | 1.000 [3] | 108.8 | LOS F | 17.9 | 130.6 | 1.00 | 0.99 | 15.2 |
| Approach | | 894 | 5.0 | 1.000 | 89.4 | LOS F | 27.2 | 198.5 | 1.00 | 1.02 | 16.9 |
| All Vehicles | | 5462 | 5.0 | 1.111 | 158.1 | LOS F | 162.6 | 1187.3 | 0.93 | 1.36 | 11.1 |

The above analysis indicates an intersection LoS of F to 2031 with no LHS, for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 1. Queues in excess of 1km are forecast in Wanneroo Road. The analysis indicates that upgrade is required to improve the performance.

## Wanneroo Road/Templeton Road Intersection 2031

Existing Geometry




Wanneroo Rd/ Templeton Cres 2031 No LHS Existing Geometry AM
Stop (Two-Way)

| Movement Performance - Vehicles | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 2 | T | 1112 | 4.0 | 0.293 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| 3 | R | 53 | 4.0 | 1.000 [3] | 260.6 | LOS F | 5.4 | 38.9 | 1.00 | 1.44 | 7.4 |
| Approach | | 1165 | 4.0 | 1.000 | 11.9 | NA | 5.4 | 38.9 | 0.05 | 0.07 | 45.3 |
| East: Templeton Cres | | | | | | | | | | | |
| 4 | L | 65 | 4.0 | 1.089 | 311.8 | LOS F | 10.3 | 74.6 | 1.00 | 1.90 | 6.4 |
| 6 | R | 100 | 4.0 | 1.661 | 1284.1 | LOS F | 57.3 | 414.8 | 1.00 | 2.57 | 1.7 |
| Approach | | 165 | 4.0 | 1.661 | 899.0 | LOS F | 57.3 | 414.8 | 1.00 | 2.31 | 2.4 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 44 | 4.0 | 0.648 | 8.6 | LOS A | 8.3 | 59.9 | 0.33 | 1.27 | 50.6 |
| 8 | T | 2404 | 4.0 | 0.648 | 0.3 | LOS A | 8.3 | 59.9 | 0.16 | 0.00 | 56.9 |
| Approach | | 2448 | 4.0 | 0.648 | 0.4 | NA | 8.3 | 59.9 | 0.16 | 0.02 | 56.8 |
| All Vehicles | | 3778 | 4.0 | 1.661 | 43.2 | NA | 57.3 | 414.8 | 0.16 | 0.14 | 27.1 |

Wanneroo Rd/ Templeton Cres 2031 No LHS Existing Geometry PM
Stop (Two-Way)

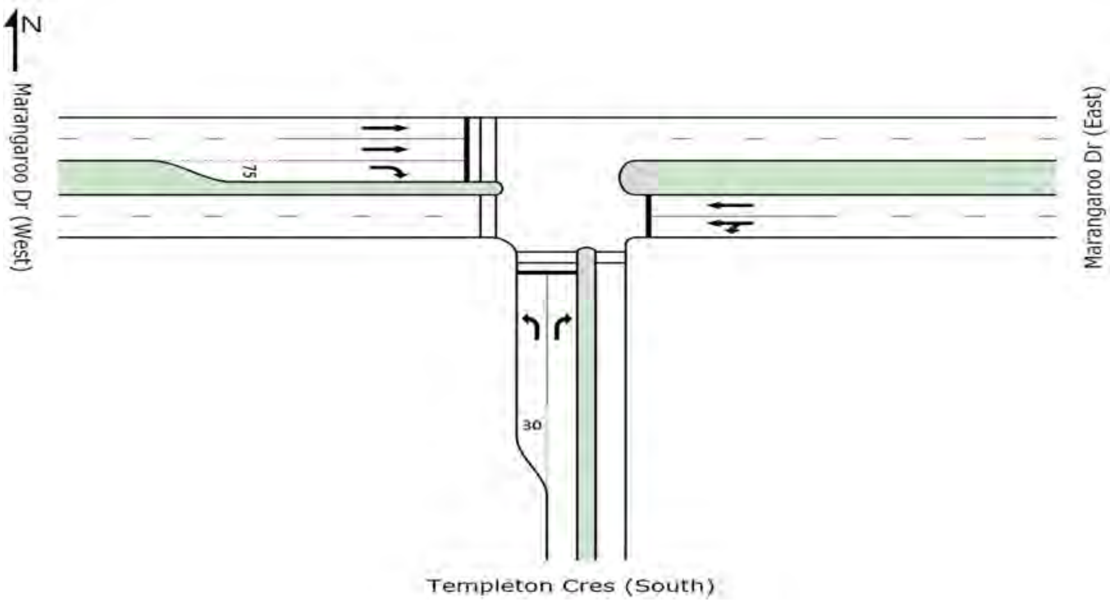
**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 2 | T | 2401 | 4.0 | 0.632 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| 3 | R | 249 | 4.0 | 0.836 | 42.4 | LOS E | 6.1 | 44.5 | 0.96 | 1.44 | 27.8 |
| Approach | | 2650 | 4.0 | 0.836 | 4.0 | NA | 6.1 | 44.5 | 0.09 | 0.14 | 54.1 |
| East: Templeton Cres | | | | | | | | | | | |
| 4 | L | 87 | 4.0 | 0.432 | 30.5 | LOS D | 1.6 | 11.5 | 0.90 | 1.03 | 32.9 |
| 6 | R | 31 | 4.0 | 1.000 [4] | 276.4 | LOS F | 3.4 | 24.9 | 1.00 | 1.29 | 7.0 |
| Approach | | 118 | 4.0 | 1.000 | 95.1 | LOS F | 3.4 | 24.9 | 0.92 | 1.10 | 16.8 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 52 | 4.0 | 0.350 | 9.6 | LOS A | 3.0 | 22.1 | 0.51 | 1.13 | 50.9 |
| 8 | T | 1242 | 4.0 | 0.350 | 0.8 | LOS A | 3.0 | 22.1 | 0.24 | 0.00 | 55.5 |
| Approach | | 1294 | 4.0 | 0.350 | 1.1 | NA | 3.0 | 22.1 | 0.25 | 0.05 | 55.3 |
| All Vehicles | | 4062 | 4.0 | 1.000 | 5.7 | NA | 6.1 | 44.5 | 0.16 | 0.13 | 51.1 |

The above analysis indicates a LoS of F for right turn movements to 2031 with no LHS, for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 1. Queues in excess of 400m are forecast in Templeton Crescent. The analysis indicates that upgrade is required to improve the performance.

## Marangaroo Dr/Templeton Crescent Intersection 2031

### Existing Geometry




Marangaroo Drive / Templeton Crescent NO LHS Signals am 2031 AM
Signals - Fixed Time    Cycle Time = 125 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Templeton Cres (South) | | | | | | | | | | | |
| 1 | L | 35 | 4.0 | 0.284 | 56.1 | LOS E | 1.8 | 13.2 | 0.88 | 0.72 | 23.6 |
| 3 | R | 83 | 4.0 | 0.274 | 57.8 | LOS E | 4.5 | 32.4 | 0.91 | 0.77 | 23.2 |
| Approach | | 118 | 4.0 | 0.284 | 57.3 | LOS E | 4.5 | 32.4 | 0.90 | 0.76 | 23.3 |
| East: Marangaroo Dr (East) | | | | | | | | | | | |
| 4 | L | 74 | 4.0 | 0.395 | 24.2 | LOS C | 14.1 | 102.2 | 0.60 | 0.92 | 37.4 |
| 5 | T | 776 | 4.0 | 0.395 | 15.9 | LOS B | 14.2 | 103.1 | 0.60 | 0.53 | 40.0 |
| Approach | | 850 | 4.0 | 0.395 | 16.6 | LOS B | 14.2 | 103.1 | 0.60 | 0.56 | 39.7 |
| West: Marangaroo Dr (West) | | | | | | | | | | | |
| 11 | T | 358 | 4.0 | 0.128 | 5.0 | LOS A | 3.1 | 22.4 | 0.31 | 0.26 | 51.4 |
| 12 | R | 34 | 4.0 | 0.157 | 62.4 | LOS E | 1.9 | 13.7 | 0.93 | 0.73 | 22.1 |
| Approach | | 392 | 4.0 | 0.157 | 10.0 | LOS A | 3.1 | 22.4 | 0.36 | 0.30 | 46.1 |
| All Vehicles | | 1360 | 4.0 | 0.395 | 18.2 | LOS B | 14.2 | 103.1 | 0.56 | 0.51 | 38.9 |

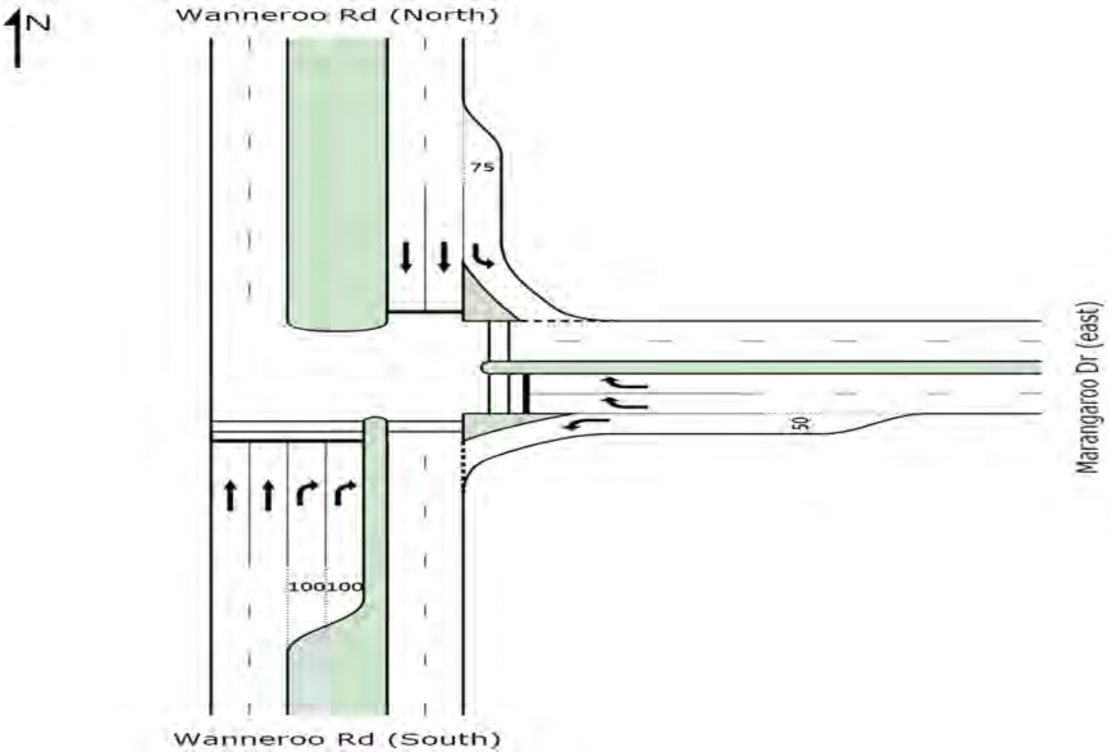
Marangaroo Drive / Templeton Crescent NO LHS Signals am 2031 PM
Signals - Fixed Time Cycle Time = 82 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Templeton Cres (South) | | | | | | | | | | | |
| 1 | L | 74 | 4.0 | 0.371 | 34.1 | LOS C | 2.3 | 16.8 | 0.81 | 0.75 | 31.0 |
| 3 | R | 265 | 4.0 | 0.573 | 37.6 | LOS D | 9.5 | 68.5 | 0.92 | 0.83 | 29.5 |
| Approach | | 339 | 4.0 | 0.573 | 36.8 | LOS D | 9.5 | 68.5 | 0.90 | 0.81 | 29.8 |
| East: Marangaroo Dr (East) | | | | | | | | | | | |
| 4 | L | 78 | 4.0 | 0.563 | 32.3 | LOS C | 11.9 | 86.2 | 0.87 | 0.87 | 33.2 |
| 5 | T | 648 | 4.0 | 0.563 | 24.0 | LOS C | 12.0 | 87.1 | 0.87 | 0.75 | 34.2 |
| Approach | | 726 | 4.0 | 0.563 | 24.8 | LOS C | 12.0 | 87.1 | 0.87 | 0.76 | 34.1 |
| West: Marangaroo Dr (West) | | | | | | | | | | | |
| 11 | T | 482 | 4.0 | 0.212 | 8.1 | LOS A | 4.4 | 31.8 | 0.49 | 0.42 | 47.2 |
| 12 | R | 32 | 4.0 | 0.097 | 38.8 | LOS D | 1.1 | 7.9 | 0.86 | 0.72 | 29.1 |
| Approach | | 514 | 4.0 | 0.212 | 10.0 | LOS B | 4.4 | 31.8 | 0.51 | 0.44 | 45.5 |
| All Vehicles | | 1579 | 4.0 | 0.573 | 22.6 | LOS C | 12.0 | 87.1 | 0.76 | 0.67 | 35.9 |

The above analysis indicates a LoS of A to D for most movements to 2031 with no LHS, for the current geometry. Stop rates for all movements are less than 1 and the degree of saturation is 0.395 and 0.573. Queues in excess of 60m are forecast in Templeton Crescent during the pm peak hour indicating this two lane approach should be extended. The analysis indicates that minor upgrade is required to improve the performance.

**Wanneroo Road/Marangaroo Dr Intersection 2031**
Existing Geometry




Marangaroo Dr / Wanneroo Rd No LHS 2031 AM
Signals - Fixed Time    Cycle Time = 150 seconds (Practical Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 2 | T | 1156 | 5.0 | 0.425 | 8.9 | LOS A | 16.6 | 121.2 | 0.44 | 0.40 | 46.6 |
| 3 | R | 254 | 5.0 | 0.966 | 116.8 | LOS F | 11.9 | 87.0 | 1.00 | 1.14 | 14.3 |
| Approach | | 1410 | 5.0 | 0.966 | 28.3 | LOS C | 16.6 | 121.2 | 0.54 | 0.53 | 33.1 |
| East: Marangaroo Dr (east) | | | | | | | | | | | |
| 4 | L | 213 | 5.0 | 1.000 [3] | 42.7 | LOS D | 11.2 | 81.8 | 0.79 | 0.78 | 27.8 |
| 6 | R | 615 | 5.0 | 0.940 | 82.6 | LOS F | 20.1 | 146.4 | 1.00 | 0.40 | 20.2 |
| Approach | | 828 | 5.0 | 1.000 | 72.4 | LOS E | 30.6 | 223.6 | 0.95 | 0.50 | 22.9 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 182 | 5.0 | 0.183 | 8.9 | LOS A | 1.6 | 11.5 | 0.17 | 0.64 | 48.4 |
| 8 | T | 2224 | 5.0 | 0.971 | 67.7 | LOS E | 105.6 | 770.8 | 1.00 | 1.14 | 20.3 |
| Approach | | 2406 | 5.0 | 0.971 | 63.3 | LOS E | 105.6 | 770.8 | 0.94 | 1.10 | 21.2 |
| All Vehicles | | 4644 | 5.0 | 1.000 | 54.3 | LOS D | 105.6 | 770.8 | 0.82 | 0.82 | 24.3 |

Marangaroo Dr / Wanneroo Rd No LHS 2031 PM
Signals - Fixed Time    Cycle Time = 127 seconds (Practical Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 2 | T | 2452 | 5.0 | 0.896 | 19.0 | LOS B | 63.4 | 462.5 | 0.86 | 0.84 | 37.4 |
| 3 | R | 463 | 5.0 | 0.631 | 58.4 | LOS E | 13.3 | 96.9 | 0.97 | 0.83 | 23.1 |
| Approach | | 2915 | 5.0 | 0.896 | 25.2 | LOS C | 63.4 | 462.5 | 0.88 | 0.84 | 34.0 |
| East: Marangaroo Dr (east) | | | | | | | | | | | |
| 4 | L | 356 | 5.0 | 0.845 | 24.2 | LOS C | 11.2 | 81.6 | 0.49 | 0.78 | 36.3 |
| 6 | R | 318 | 5.0 | 0.490 | 59.2 | LOS E | 9.0 | 65.6 | 0.95 | 0.81 | 22.9 |
| Approach | | 674 | 5.0 | 0.845 | 40.7 | LOS D | 11.2 | 81.6 | 0.70 | 0.79 | 28.5 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 193 | 5.0 | 0.231 | 9.8 | LOS A | 2.1 | 15.6 | 0.25 | 0.66 | 47.4 |
| 8 | T | 1144 | 5.0 | 0.641 | 27.0 | LOS C | 26.5 | 193.4 | 0.82 | 0.73 | 33.0 |
| Approach | | 1337 | 5.0 | 0.641 | 24.5 | LOS C | 26.5 | 193.4 | 0.73 | 0.72 | 34.5 |
| All Vehicles | | 4926 | 5.0 | 0.896 | 27.1 | LOS C | 63.4 | 462.5 | 0.81 | 0.80 | 33.3 |

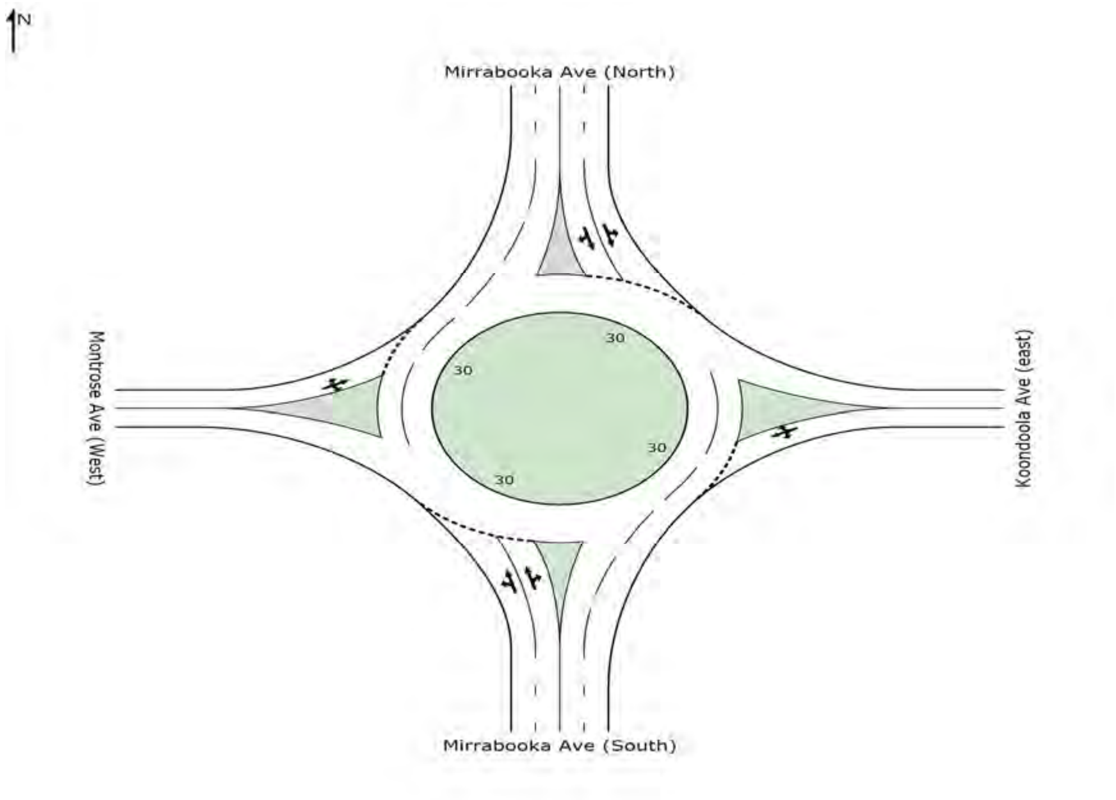
The above analysis indicates a LoS of E and F for some movements to 2031 with no LHS, for the current geometry. Stop rates for all movements during the pm peak hour are less than 1 however some are greater than 1 during the am peak hour. The degree of saturation is 1 and 0.896. Queues in excess of 700m are forecast on Wanneroo Road north during the am peak hour.  The analysis indicates upgrade is required to improve the performance.

# Appendix F - Summary of Sidra analysis - 2031 with LHS existing and proposed geometry

# Sidra Analysis with LHS 2031

This technical note provides the Sidra analysis and output for the Proposed Ultimate Intersection Geometry for full development (2031) WITH LHS and a compromise Geometry where the site is constrained to avoid land acquisition.

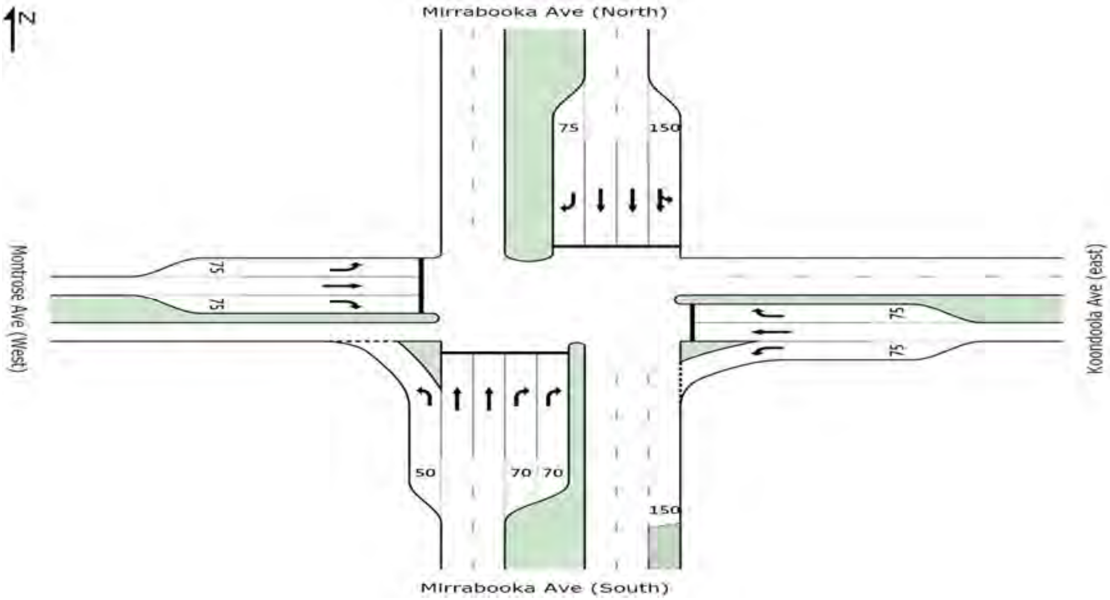
### Mirrabooka/Koondoola Intersection 2031




Analysis indicates that the existing roundabout will not accommodate forecast traffic volumes to 2031 with LHS.

The following analysis indicates the requirements to accommodate the forecast traffic volumes to 2031.

## Proposed Ultimate Geometry




Mirabooka Koondoola With LHS 2031 am
Signals - Fixed Time    Cycle Time = 92 seconds (Practical Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Ave (South) | | | | | | | | | | | |
| 1 | L | 153 | 4.0 | 0.245 | 11.3 | LOS B | 1.9 | 13.8 | 0.37 | 0.68 | 45.9 |
| 2 | T | 798 | 4.0 | 0.601 | 27.5 | LOS C | 15.0 | 108.5 | 0.89 | 0.77 | 32.6 |
| 3 | R | 253 | 4.0 | 0.777 | 57.7 | LOS E | 6.2 | 44.7 | 1.00 | 0.90 | 23.4 |
| Approach | | 1204 | 4.0 | 0.777 | 31.8 | LOS C | 15.0 | 108.5 | 0.84 | 0.79 | 31.1 |
| East: Koondoola Ave (east) | | | | | | | | | | | |
| 4 | L | 283 | 4.0 | 0.442 | 15.5 | LOS B | 5.4 | 39.4 | 0.56 | 0.74 | 42.3 |
| 5 | T | 301 | 4.0 | 0.611 | 33.4 | LOS C | 12.2 | 88.0 | 0.94 | 0.80 | 29.9 |
| 6 | R | 155 | 4.0 | 0.734 | 53.0 | LOS D | 7.0 | 50.6 | 1.00 | 0.94 | 24.6 |
| Approach | | 739 | 4.0 | 0.734 | 30.7 | LOS C | 12.2 | 88.0 | 0.81 | 0.80 | 32.0 |
| North: Mirrabooka Ave (North) | | | | | | | | | | | |
| 7 | L | 130 | 4.0 | 0.759 | 39.3 | LOS D | 20.7 | 150.1 | 0.95 | 0.91 | 30.0 |
| 8 | T | 1536 | 4.0 | 0.880 | 39.1 | LOS D | 29.6 | 214.4 | 0.99 | 1.02 | 27.5 |
| 9 | R | 104 | 4.0 | 0.639 | 55.1 | LOS E | 4.9 | 35.2 | 1.00 | 0.82 | 24.0 |
| Approach | | 1770 | 4.0 | 0.880 | 40.0 | LOS D | 29.6 | 214.4 | 0.99 | 1.00 | 27.5 |
| West: Montrose Ave (West) | | | | | | | | | | | |
| 10 | L | 100 | 4.0 | 0.254 | 38.0 | LOS D | 3.6 | 26.0 | 0.83 | 0.77 | 29.3 |
| 11 | T | 437 | 4.0 | 0.887 | 47.7 | LOS D | 22.9 | 165.4 | 1.00 | 1.08 | 24.9 |
| 12 | R | 156 | 4.0 | 0.534 | 41.5 | LOS D | 6.3 | 45.8 | 0.96 | 0.80 | 28.2 |
| Approach | | 693 | 4.0 | 0.887 | 44.9 | LOS D | 22.9 | 165.4 | 0.97 | 0.97 | 26.2 |
| All Vehicles | | 4406 | 4.0 | 0.887 | 37.0 | LOS D | 29.6 | 214.4 | 0.91 | 0.90 | 28.9 |

Mirabooka Koondoola with LHS 2031 pm
Signals - Fixed Time Cycle Time = 72 seconds (Practical Cycle Time)

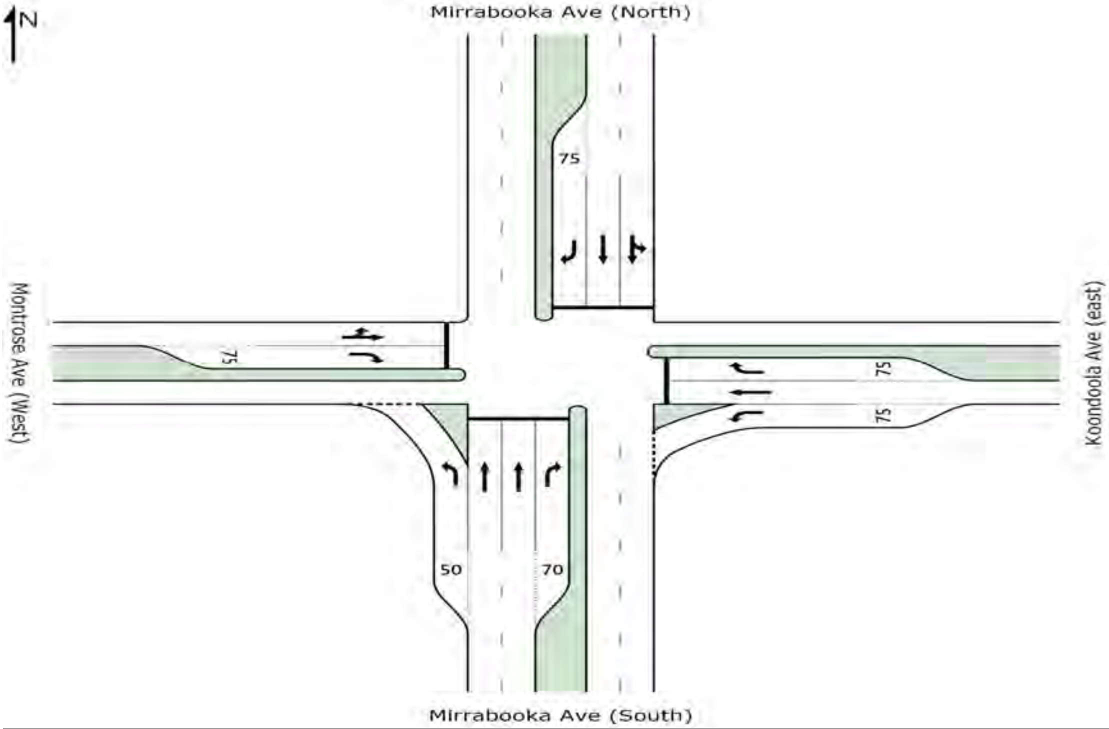
**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Ave (South) | | | | | | | | | | | |
| 1 | L | 272 | 4.0 | 0.316 | 9.5 | LOS A | 2.1 | 15.1 | 0.33 | 0.68 | 47.6 |
| 2 | T | 1305 | 4.0 | 0.883 | 33.8 | LOS C | 27.1 | 195.9 | 1.00 | 1.10 | 29.6 |
| 3 | R | 249 | 4.0 | 0.798 | 48.7 | LOS D | 4.9 | 35.6 | 1.00 | 0.93 | 25.8 |
| Approach | | 1826 | 4.0 | 0.883 | 32.2 | LOS C | 27.1 | 195.9 | 0.90 | 1.01 | 30.7 |
| East: Koondoola Ave (east) | | | | | | | | | | | |
| 4 | L | 227 | 4.0 | 0.271 | 10.4 | LOS B | 2.1 | 15.5 | 0.40 | 0.70 | 46.7 |
| 5 | T | 78 | 4.0 | 0.317 | 32.4 | LOS C | 2.6 | 19.0 | 0.95 | 0.73 | 30.2 |
| 6 | R | 232 | 4.0 | 0.873 | 48.1 | LOS D | 8.7 | 62.9 | 1.00 | 1.09 | 26.1 |
| Approach | | 537 | 4.0 | 0.873 | 29.9 | LOS C | 8.7 | 62.9 | 0.74 | 0.87 | 32.9 |
| North: Mirrabooka Ave (North) | | | | | | | | | | | |
| 7 | L | 141 | 4.0 | 0.376 | 26.1 | LOS C | 7.0 | 50.5 | 0.77 | 0.84 | 35.8 |
| 8 | T | 773 | 4.0 | 0.436 | 18.2 | LOS B | 8.5 | 61.8 | 0.79 | 0.67 | 37.8 |
| 9 | R | 132 | 4.0 | 0.846 | 50.8 | LOS D | 5.4 | 38.9 | 1.00 | 0.99 | 25.2 |
| Approach | | 1046 | 4.0 | 0.846 | 23.4 | LOS C | 8.5 | 61.8 | 0.81 | 0.73 | 35.3 |
| West: Montrose Ave (West) | | | | | | | | | | | |
| 10 | L | 197 | 4.0 | 0.842 | 48.9 | LOS D | 7.9 | 57.3 | 1.00 | 0.98 | 25.6 |
| 11 | T | 80 | 4.0 | 0.325 | 32.5 | LOS C | 2.7 | 19.5 | 0.95 | 0.73 | 30.2 |
| 12 | R | 224 | 4.0 | 0.686 | 35.9 | LOS D | 7.4 | 53.3 | 0.99 | 0.87 | 30.4 |
| Approach | | 501 | 4.0 | 0.842 | 40.5 | LOS D | 7.9 | 57.3 | 0.99 | 0.89 | 28.3 |
| All Vehicles | | 3910 | 4.0 | 0.883 | 30.6 | LOS C | 27.1 | 195.9 | 0.87 | 0.90 | 31.8 |

The above analysis indicates that a signalised intersection is likely to accommodate forecast traffic volumes to 2031 with LHS. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required.

A compromise design is indicated as follows. The performance is not as good as the optimal upgrade however the site is constrained.

## Possible Geometry (if no land resumption)




Mirabooka Koondoola 2031 with LHS am
Signals - Fixed Time Cycle Time = 150 seconds (Practical Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Ave (South) | | | | | | | | | | | |
| 1 | L | 153 | 4.0 | 0.276 | 11.0 | LOS B | 2.3 | 16.6 | 0.28 | 0.66 | 46.3 |
| 2 | T | 798 | 4.0 | 0.416 | 26.1 | LOS C | 18.4 | 133.3 | 0.69 | 0.61 | 33.6 |
| 3 | R | 253 | 4.0 | 0.881 | 78.0 | LOS E | 17.6 | 127.1 | 1.00 | 1.05 | 19.2 |
| Approach | | 1204 | 4.0 | 0.881 | 35.1 | LOS D | 18.4 | 133.3 | 0.70 | 0.71 | 29.9 |
| East: Koondoola Ave (east) | | | | | | | | | | | |
| 4 | L | 283 | 4.0 | 0.795 | 39.0 | LOS D | 14.5 | 105.0 | 0.69 | 0.83 | 29.2 |
| 5 | T | 301 | 4.0 | 0.882 | 76.3 | LOS E | 24.1 | 174.5 | 1.00 | 1.02 | 18.8 |
| 6 | R | 155 | 4.0 | 0.722 | 79.5 | LOS E | 11.2 | 81.0 | 1.00 | 0.97 | 18.9 |
| Approach | | 739 | 4.0 | 0.882 | 62.7 | LOS E | 24.1 | 174.5 | 0.88 | 0.94 | 21.8 |
| North: Mirrabooka Ave (North) | | | | | | | | | | | |
| 7 | L | 130 | 4.0 | 0.873 | 48.7 | LOS D | 56.3 | 407.3 | 0.97 | 0.95 | 26.8 |
| 8 | T | 1536 | 4.0 | 0.873 | 40.3 | LOS D | 56.6 | 409.8 | 0.97 | 0.92 | 27.1 |
| 9 | R | 104 | 4.0 | 0.227 | 31.3 | LOS C | 4.5 | 32.4 | 0.65 | 0.77 | 32.3 |
| Approach | | 1770 | 4.0 | 0.873 | 40.4 | LOS D | 56.6 | 409.8 | 0.95 | 0.91 | 27.4 |
| West: Montrose Ave (West) | | | | | | | | | | | |
| 10 | L | 100 | 4.0 | 0.727 | 73.1 | LOS E | 17.2 | 124.6 | 1.00 | 0.86 | 20.4 |
| 11 | T | 143 | 4.0 | 0.727 | 64.7 | LOS E | 17.2 | 124.6 | 1.00 | 0.86 | 20.5 |
| 12 | R | 156 | 4.0 | 0.858 | 92.1 | LOS F | 12.1 | 88.0 | 1.00 | 1.10 | 17.1 |
| Approach | | 399 | 4.0 | 0.858 | 77.5 | LOS E | 17.2 | 124.6 | 1.00 | 0.95 | 19.0 |
| All Vehicles | | 4112 | 4.0 | 0.882 | 46.5 | LOS D | 56.6 | 409.8 | 0.87 | 0.86 | 25.7 |

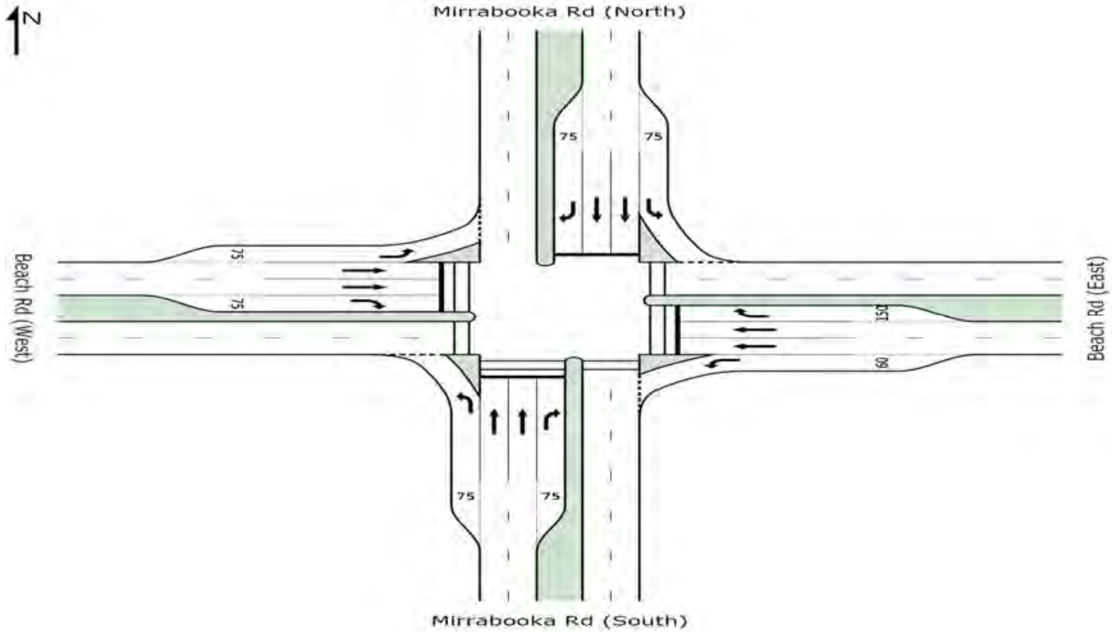
Mirabooka Koondoola 2031 with LHS pm
Signals - Fixed Time Cycle Time = 83 seconds (Practical Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Ave (South) | | | | | | | | | | | |
| 1 | L | 272 | 4.0 | 0.265 | 8.6 | LOS A | 1.4 | 10.3 | 0.23 | 0.66 | 48.5 |
| 2 | T | 1305 | 4.0 | 0.887 | 37.9 | LOS D | 30.7 | 221.9 | 1.00 | 1.09 | 28.1 |
| 3 | R | 249 | 4.0 | 0.825 | 47.5 | LOS D | 10.9 | 79.0 | 1.00 | 1.05 | 26.2 |
| Approach | | 1826 | 4.0 | 0.887 | 34.8 | LOS C | 30.7 | 221.9 | 0.88 | 1.02 | 29.7 |
| East: Koondoola Ave (east) | | | | | | | | | | | |
| 4 | L | 227 | 4.0 | 0.309 | 12.1 | LOS B | 2.9 | 21.3 | 0.47 | 0.71 | 45.3 |
| 5 | T | 78 | 4.0 | 0.235 | 33.0 | LOS C | 2.8 | 20.3 | 0.90 | 0.70 | 30.1 |
| 6 | R | 232 | 4.0 | 0.841 | 52.1 | LOS D | 9.6 | 69.8 | 1.00 | 1.07 | 24.8 |
| Approach | | 537 | 4.0 | 0.841 | 32.4 | LOS C | 9.6 | 69.8 | 0.76 | 0.87 | 31.7 |
| North: Mirrabooka Ave (North) | | | | | | | | | | | |
| 7 | L | 141 | 4.0 | 0.626 | 31.4 | LOS C | 15.1 | 109.5 | 0.87 | 0.88 | 33.5 |
| 8 | T | 773 | 4.0 | 0.626 | 23.1 | LOS C | 15.4 | 111.3 | 0.87 | 0.76 | 34.6 |
| 9 | R | 132 | 4.0 | 0.555 | 42.8 | LOS D | 5.1 | 37.1 | 0.98 | 0.82 | 27.7 |
| Approach | | 1046 | 4.0 | 0.626 | 26.7 | LOS C | 15.4 | 111.3 | 0.89 | 0.79 | 33.4 |
| West: Montrose Ave (West) | | | | | | | | | | | |
| 10 | L | 197 | 4.0 | 0.865 | 53.8 | LOS D | 12.9 | 93.3 | 1.00 | 1.03 | 24.5 |
| 11 | T | 80 | 4.0 | 0.865 | 45.4 | LOS D | 12.9 | 93.3 | 1.00 | 1.03 | 24.6 |
| 12 | R | 224 | 4.0 | 0.557 | 34.4 | LOS C | 7.8 | 56.2 | 0.94 | 0.81 | 31.0 |
| Approach | | 501 | 4.0 | 0.865 | 43.8 | LOS D | 12.9 | 93.3 | 0.97 | 0.94 | 27.1 |
| All Vehicles | | 3910 | 4.0 | 0.887 | 33.5 | LOS C | 30.7 | 221.9 | 0.88 | 0.92 | 30.5 |

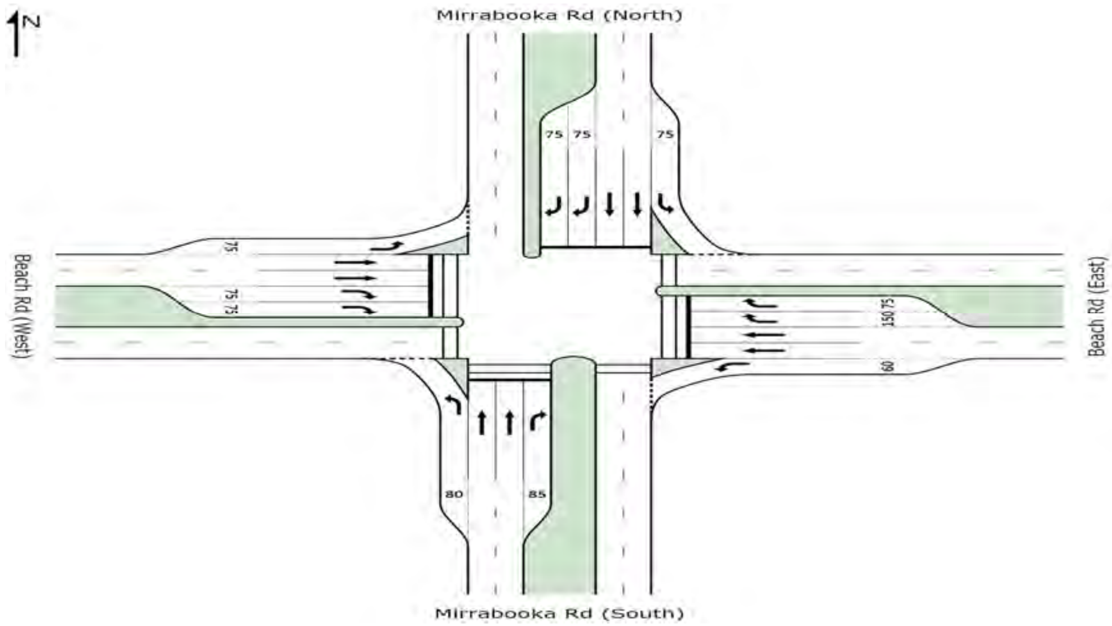
**Beach Road/Mirrabooka Road Intersection 2031**

Existing Geometry




Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry



New Site
Signals - Fixed Time    Cycle Time = 100 seconds (Practical Cycle Time) am 2031

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Rd (South) | | | | | | | | | | | |
| 1 | L | 239 | 4.0 | 0.312 | 13.2 | LOS B | 4.1 | 29.6 | 0.43 | 0.71 | 44.2 |
| 2 | T | 624 | 4.0 | 0.684 | 38.1 | LOS D | 14.2 | 102.5 | 0.97 | 0.83 | 28.0 |
| 3 | R | 128 | 4.0 | 0.889 | 68.7 | LOS E | 7.3 | 52.9 | 1.00 | 1.00 | 20.9 |
| Approach | | 992 | 4.0 | 0.889 | 36.1 | LOS D | 14.2 | 102.5 | 0.84 | 0.82 | 29.3 |
| East: Beach Rd (East) | | | | | | | | | | | |
| 4 | L | 120 | 4.0 | 0.237 | 19.7 | LOS B | 2.9 | 21.2 | 0.57 | 0.72 | 39.1 |
| 5 | T | 533 | 4.0 | 0.667 | 40.1 | LOS D | 12.3 | 88.7 | 0.97 | 0.83 | 27.3 |
| 6 | R | 339 | 4.0 | 0.782 | 59.2 | LOS E | 8.8 | 63.9 | 1.00 | 0.91 | 23.0 |
| Approach | | 992 | 4.0 | 0.782 | 44.2 | LOS D | 12.3 | 88.7 | 0.93 | 0.84 | 26.6 |
| North: Mirrabooka Rd (North) | | | | | | | | | | | |
| 7 | L | 488 | 4.0 | 0.549 | 13.5 | LOS B | 9.4 | 68.2 | 0.49 | 0.73 | 43.9 |
| 8 | T | 1175 | 4.0 | 0.883 | 43.7 | LOS D | 31.9 | 230.6 | 1.00 | 1.05 | 26.1 |
| 9 | R | 432 | 4.0 | 0.629 | 49.0 | LOS D | 9.9 | 72.0 | 0.97 | 0.82 | 25.7 |
| Approach | | 2095 | 4.0 | 0.883 | 37.7 | LOS D | 31.9 | 230.6 | 0.87 | 0.93 | 28.8 |
| West: Beach Rd (West) | | | | | | | | | | | |
| 10 | L | 301 | 4.0 | 0.387 | 13.9 | LOS B | 5.6 | 40.7 | 0.47 | 0.72 | 43.6 |
| 11 | T | 638 | 4.0 | 0.799 | 45.0 | LOS D | 16.1 | 116.3 | 1.00 | 0.94 | 25.7 |
| 12 | R | 356 | 4.0 | 0.821 | 61.1 | LOS E | 9.5 | 68.7 | 1.00 | 0.94 | 22.5 |
| Approach | | 1295 | 4.0 | 0.821 | 42.2 | LOS D | 16.1 | 116.3 | 0.88 | 0.89 | 27.3 |
| All Vehicles | | 5373 | 4.0 | 0.889 | 39.7 | LOS D | 31.9 | 230.6 | 0.88 | 0.88 | 28.1 |

New Site
Signals - Fixed Time    Cycle Time = 100 seconds (Practical Cycle Time) pm 2031

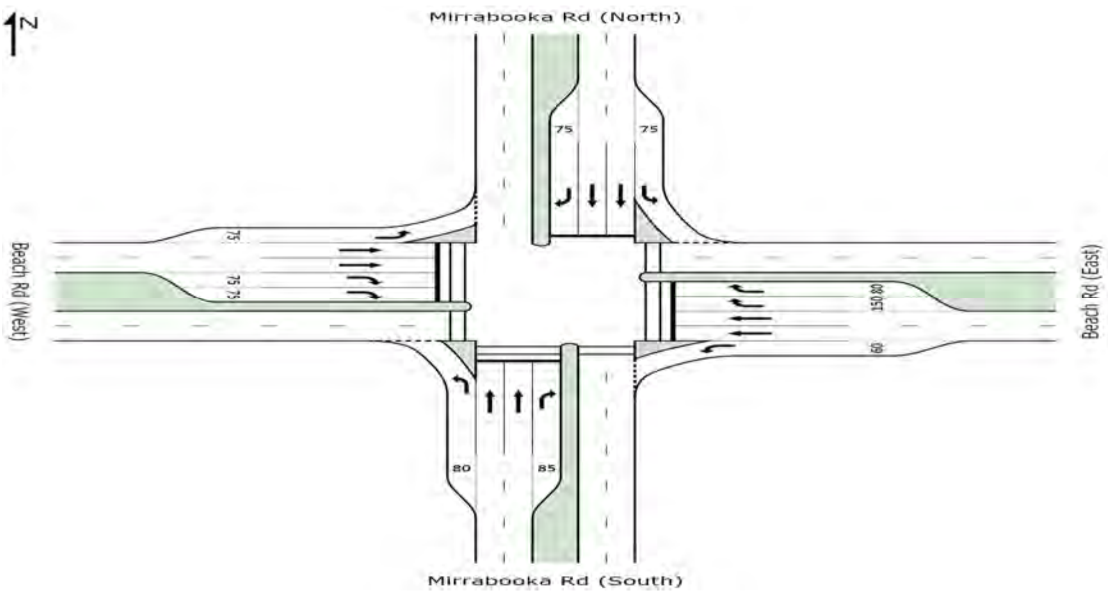
**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Rd (South) | | | | | | | | | | | |
| 1 | L | 308 | 4.0 | 0.387 | 16.1 | LOS B | 6.7 | 48.6 | 0.52 | 0.73 | 41.8 |
| 2 | T | 1117 | 4.0 | 0.864 | 41.6 | LOS D | 29.2 | 211.6 | 1.00 | 1.02 | 26.8 |
| 3 | R | 122 | 4.0 | 0.845 | 65.3 | LOS E | 6.7 | 48.6 | 1.00 | 0.95 | 21.6 |
| Approach | | 1547 | 4.0 | 0.864 | 38.4 | LOS D | 29.2 | 211.6 | 0.91 | 0.96 | 28.3 |
| East: Beach Rd (East) | | | | | | | | | | | |
| 4 | L | 124 | 4.0 | 0.207 | 11.1 | LOS B | 1.6 | 11.5 | 0.34 | 0.67 | 46.1 |
| 5 | T | 946 | 4.0 | 0.889 | 49.1 | LOS D | 26.4 | 191.1 | 1.00 | 1.06 | 24.5 |
| 6 | R | 404 | 4.0 | 0.861 | 63.1 | LOS E | 11.1 | 80.5 | 1.00 | 0.99 | 22.1 |
| Approach | | 1475 | 4.0 | 0.889 | 49.8 | LOS D | 26.4 | 191.1 | 0.94 | 1.01 | 24.8 |
| North: Mirrabooka Rd (North) | | | | | | | | | | | |
| 7 | L | 408 | 4.0 | 0.449 | 10.1 | LOS B | 4.8 | 34.5 | 0.33 | 0.69 | 47.0 |
| 8 | T | 678 | 4.0 | 0.525 | 28.6 | LOS C | 13.3 | 96.5 | 0.86 | 0.74 | 32.1 |
| 9 | R | 256 | 4.0 | 0.885 | 68.3 | LOS E | 7.3 | 52.5 | 1.00 | 1.00 | 21.0 |
| Approach | | 1342 | 4.0 | 0.885 | 30.6 | LOS C | 13.3 | 96.5 | 0.72 | 0.77 | 32.0 |
| West: Beach Rd (West) | | | | | | | | | | | |
| 10 | L | 507 | 4.0 | 0.803 | 28.5 | LOS C | 16.9 | 122.4 | 0.78 | 0.91 | 33.9 |
| 11 | T | 294 | 4.0 | 0.368 | 37.0 | LOS D | 6.2 | 45.1 | 0.90 | 0.73 | 28.5 |
| 12 | R | 162 | 4.0 | 0.748 | 63.9 | LOS E | 4.3 | 31.4 | 1.00 | 0.86 | 21.9 |
| Approach | | 963 | 4.0 | 0.803 | 37.0 | LOS D | 16.9 | 122.4 | 0.85 | 0.85 | 29.5 |
| All Vehicles | | 5327 | 4.0 | 0.889 | 39.3 | LOS D | 29.2 | 211.6 | 0.86 | 0.90 | 28.2 |

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include double turn lanes on the eastern, western and northern approaches. It is noted that the reserve on Mirrabooka Road north would not appear to be wide enough to

accommodate a double right turn and significant land acquisition would likely be required.
A compromise design with a reduced performance is therefore recommended as follows. It should be noted however that the analysis indicates lengthy queues and some movements will not clear the intersection within a single cycle.

## Possible Geometry (if no land resumption)




Beach Mirabooka 2031 with LHS am
Signals - Fixed Time    Cycle Time = 150 seconds (Practical Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Rd (South) | | | | | | | | | | | |
| 1 | L | 227 | 4.0 | 0.416 | 15.9 | LOS B | 5.7 | 41.2 | 0.42 | 0.70 | 41.9 |
| 2 | T | 593 | 4.0 | 0.478 | 42.9 | LOS D | 17.1 | 124.1 | 0.85 | 0.73 | 26.5 |
| 3 | R | 122 | 4.0 | 0.413 | 55.8 | LOS E | 7.1 | 51.5 | 0.84 | 0.78 | 23.9 |
| Approach | | 942 | 4.0 | 0.478 | 38.1 | LOS D | 17.1 | 124.1 | 0.75 | 0.73 | 28.7 |
| East: Beach Rd (East) | | | | | | | | | | | |
| 4 | L | 114 | 4.0 | 0.343 | 25.8 | LOS C | 4.0 | 29.2 | 0.56 | 0.71 | 35.3 |
| 5 | T | 506 | 4.0 | 0.799 | 69.1 | LOS E | 18.8 | 136.1 | 1.00 | 0.92 | 20.0 |
| 6 | R | 322 | 4.0 | 0.955 | 111.2 | LOS F | 14.8 | 107.4 | 1.00 | 1.12 | 14.9 |
| Approach | | 942 | 4.0 | 0.955 | 78.3 | LOS E | 18.8 | 136.1 | 0.95 | 0.96 | 18.8 |
| North: Mirrabooka Rd (North) | | | | | | | | | | | |
| 7 | L | 464 | 4.0 | 0.784 | 17.1 | LOS B | 12.8 | 92.5 | 0.43 | 0.73 | 41.1 |
| 8 | T | 1262 | 4.0 | 1.022 | 151.9 | LOS F | 79.4 | 574.6 | 1.00 | 1.48 | 11.4 |
| 9 | R | 264 | 4.0 | 1.000[3] | 63.8 | LOS E | 16.9 | 122.4 | 0.99 | 0.84 | 21.9 |
| Approach | | 1990 | 4.0 | 1.022 | 108.8 | LOS F | 79.4 | 574.6 | 0.87 | 1.22 | 14.8 |
| West: Beach Rd (West) | | | | | | | | | | | |
| 10 | L | 286 | 4.0 | 0.501 | 13.9 | LOS B | 6.4 | 46.0 | 0.38 | 0.70 | 43.6 |
| 11 | T | 607 | 4.0 | 0.958 | 100.7 | LOS F | 28.7 | 207.7 | 1.00 | 1.21 | 15.5 |
| 12 | R | 337 | 4.0 | 1.000[3] | 130.2 | LOS F | 16.9 | 122.4 | 1.00 | 1.15 | 13.2 |
| Approach | | 1230 | 4.0 | 1.000 | 88.6 | LOS F | 28.7 | 207.7 | 0.86 | 1.08 | 17.3 |
| All Vehicles | | 5104 | 4.0 | 1.022 | 85.2 | LOS F | 79.4 | 574.6 | 0.86 | 1.05 | 17.7 |

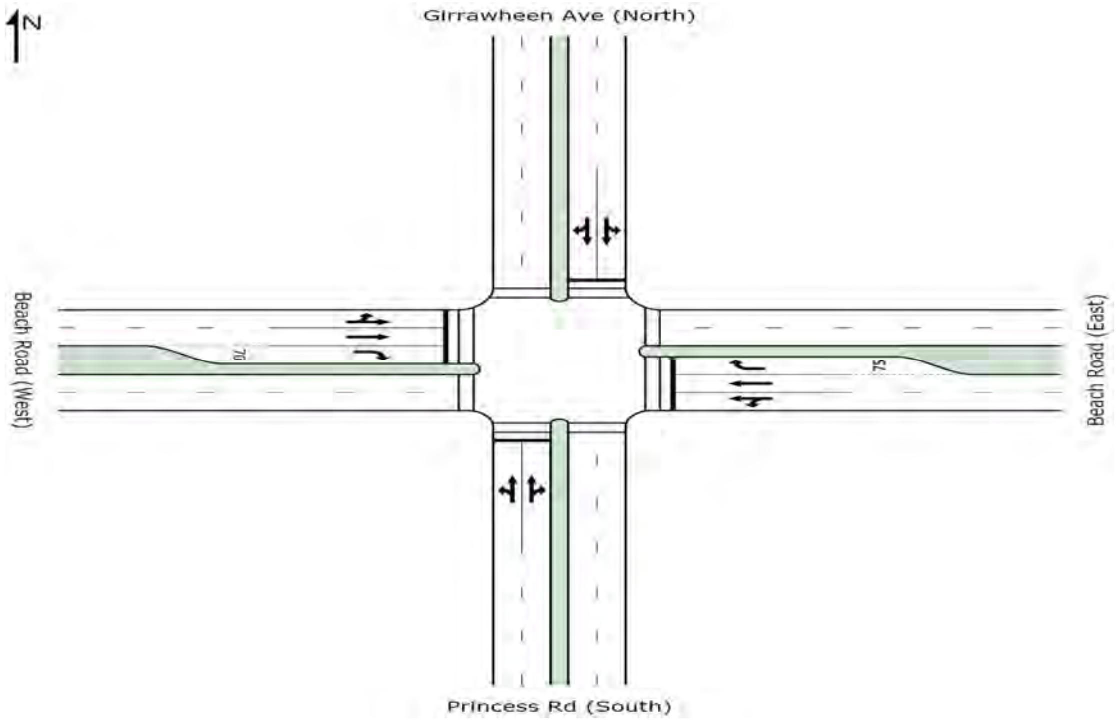
Beach Mirabooka 2031 with LHS pm
Signals - Fixed Time    Cycle Time = 150 seconds (Practical Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Rd (South) | | | | | | | | | | | |
| 1 | L | 293 | 4.0 | 0.643 | 23.0 | LOS C | 10.2 | 74.2 | 0.56 | 0.74 | 37.0 |
| 2 | T | 1061 | 4.0 | 0.891 | 64.2 | LOS E | 41.7 | 302.1 | 1.00 | 1.01 | 21.0 |
| 3 | R | 116 | 4.0 | 0.433 | 67.2 | LOS E | 7.6 | 54.7 | 0.93 | 0.79 | 21.2 |
| Approach | | 1470 | 4.0 | 0.891 | 56.2 | LOS E | 41.7 | 302.1 | 0.91 | 0.94 | 23.0 |
| East: Beach Rd (East) | | | | | | | | | | | |
| 4 | L | 118 | 4.0 | 0.220 | 12.0 | LOS B | 2.0 | 14.7 | 0.30 | 0.67 | 45.3 |
| 5 | T | 899 | 4.0 | 0.959 | 95.7 | LOS F | 43.0 | 311.5 | 1.00 | 1.22 | 16.1 |
| 6 | R | 384 | 4.0 | 0.997 | 128.5 | LOS F | 20.5 | 148.2 | 1.00 | 1.14 | 13.3 |
| Approach | | 1401 | 4.0 | 0.997 | 97.7 | LOS F | 43.0 | 311.5 | 0.94 | 1.16 | 16.1 |
| North: Mirrabooka Rd (North) | | | | | | | | | | | |
| 7 | L | 388 | 4.0 | 0.535 | 10.8 | LOS B | 6.3 | 45.6 | 0.30 | 0.68 | 46.4 |
| 8 | T | 648 | 4.0 | 0.544 | 45.5 | LOS D | 19.5 | 140.9 | 0.88 | 0.76 | 25.7 |
| 9 | R | 239 | 4.0 | 1.000[3] | 72.3 | LOS E | 16.9 | 122.4 | 1.00 | 0.83 | 20.2 |
| Approach | | 1275 | 4.0 | 1.000 | 40.0 | LOS D | 19.5 | 140.9 | 0.73 | 0.75 | 28.1 |
| West: Beach Rd (West) | | | | | | | | | | | |
| 10 | L | 416 | 4.0 | 1.000[3] | 26.1 | LOS C | 16.9 | 122.7 | 0.65 | 0.78 | 35.1 |
| 11 | T | 345 | 4.0 | 0.372 | 50.2 | LOS D | 10.5 | 76.2 | 0.88 | 0.73 | 24.2 |
| 12 | R | 154 | 4.0 | 0.400 | 76.9 | LOS E | 5.4 | 39.0 | 0.98 | 0.77 | 19.4 |
| Approach | | 915 | 4.0 | 1.000 | 43.8 | LOS D | 16.9 | 122.7 | 0.79 | 0.76 | 26.9 |
| All Vehicles | | 5061 | 4.0 | 1.000 | 61.3 | LOS E | 43.0 | 311.5 | 0.85 | 0.92 | 22.0 |

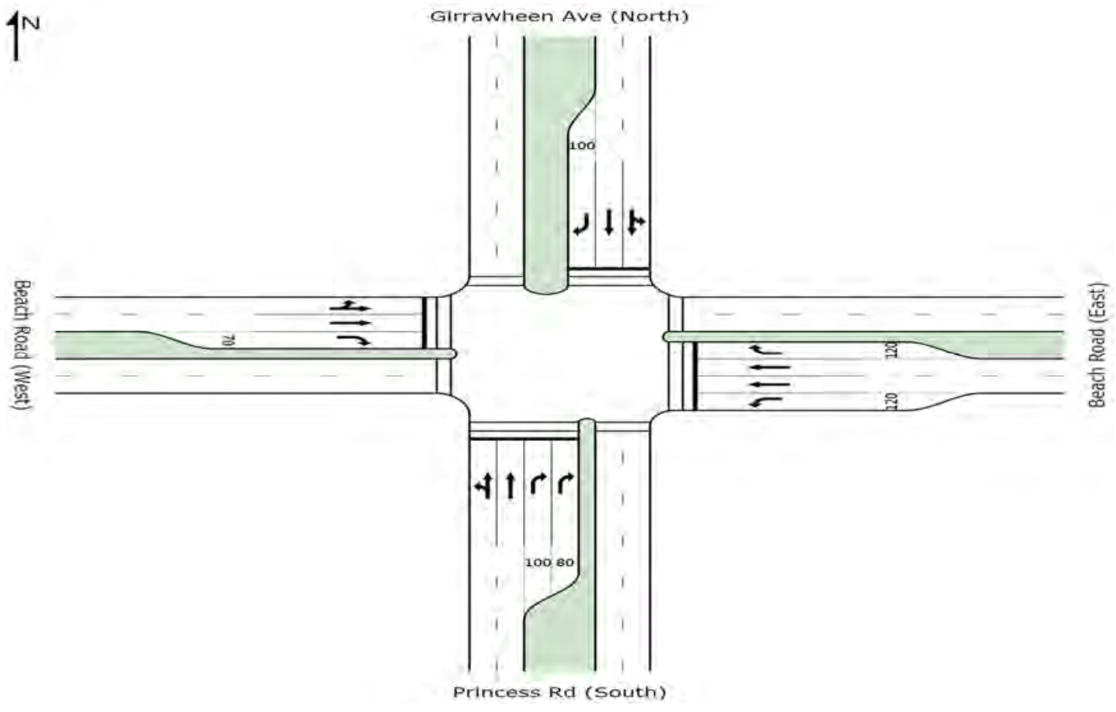
**Girrawheen/Beach Road Intersection 2031**

Existing Geometry




Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry



Girrawheen Avenue / Beach Road / Princess Rd 2031 with LHS am
Signals - Fixed Time    Cycle Time = 111 seconds (Practical Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Princess Rd (South) | | | | | | | | | | | |
| 1 | L | 170 | 2.0 | 0.535 | 44.9 | LOS D | 12.9 | 91.5 | 0.90 | 0.84 | 27.3 |
| 2 | T | 396 | 2.0 | 0.535 | 36.7 | LOS D | 13.2 | 94.3 | 0.90 | 0.76 | 28.4 |
| 3 | R | 188 | 2.0 | 0.518 | 61.3 | LOS E | 5.1 | 36.0 | 0.99 | 0.78 | 22.4 |
| Approach | | 754 | 2.0 | 0.535 | 44.7 | LOS D | 13.2 | 94.3 | 0.92 | 0.79 | 26.4 |
| East: Beach Road (East) | | | | | | | | | | | |
| 4 | L | 416 | 2.0 | 0.901 | 66.7 | LOS E | 26.5 | 188.8 | 1.00 | 1.00 | 21.1 |
| 5 | T | 474 | 2.0 | 0.488 | 38.4 | LOS D | 11.0 | 78.5 | 0.90 | 0.76 | 28.0 |
| 6 | R | 244 | 2.0 | 0.870 | 68.0 | LOS E | 14.9 | 106.0 | 1.00 | 0.98 | 21.0 |
| Approach | | 1134 | 2.0 | 0.901 | 55.1 | LOS E | 26.5 | 188.8 | 0.96 | 0.89 | 23.5 |
| North: Girrawheen Ave (North) | | | | | | | | | | | |
| 7 | L | 285 | 2.0 | 0.925 | 71.3 | LOS E | 32.7 | 232.8 | 1.00 | 1.10 | 20.6 |
| 8 | T | 695 | 2.0 | 0.925 | 62.6 | LOS E | 33.5 | 238.7 | 1.00 | 1.14 | 21.1 |
| 9 | R | 153 | 2.0 | 0.843 | 69.4 | LOS E | 9.2 | 65.4 | 1.00 | 0.96 | 20.7 |
| Approach | | 1133 | 2.0 | 0.925 | 65.7 | LOS E | 33.5 | 238.7 | 1.00 | 1.11 | 20.9 |
| West: Beach Road (West) | | | | | | | | | | | |
| 10 | L | 82 | 2.0 | 0.781 | 53.0 | LOS D | 20.0 | 142.2 | 0.99 | 0.92 | 25.3 |
| 11 | T | 672 | 2.0 | 0.781 | 44.7 | LOS D | 20.2 | 143.6 | 0.99 | 0.91 | 25.7 |
| 12 | R | 189 | 2.0 | 0.674 | 57.7 | LOS E | 10.1 | 71.7 | 1.00 | 0.84 | 23.3 |
| Approach | | 943 | 2.0 | 0.781 | 48.0 | LOS D | 20.2 | 143.6 | 0.99 | 0.90 | 25.1 |
| All Vehicles | | 3964 | 2.0 | 0.925 | 54.5 | LOS D | 33.5 | 238.7 | 0.97 | 0.94 | 23.5 |

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement

Girrawheen Avenue / Beach Road / Princess Rd 2031 with LHS pm
Signals - Fixed Time    Cycle Time = 127 seconds (Practical Cycle Time)

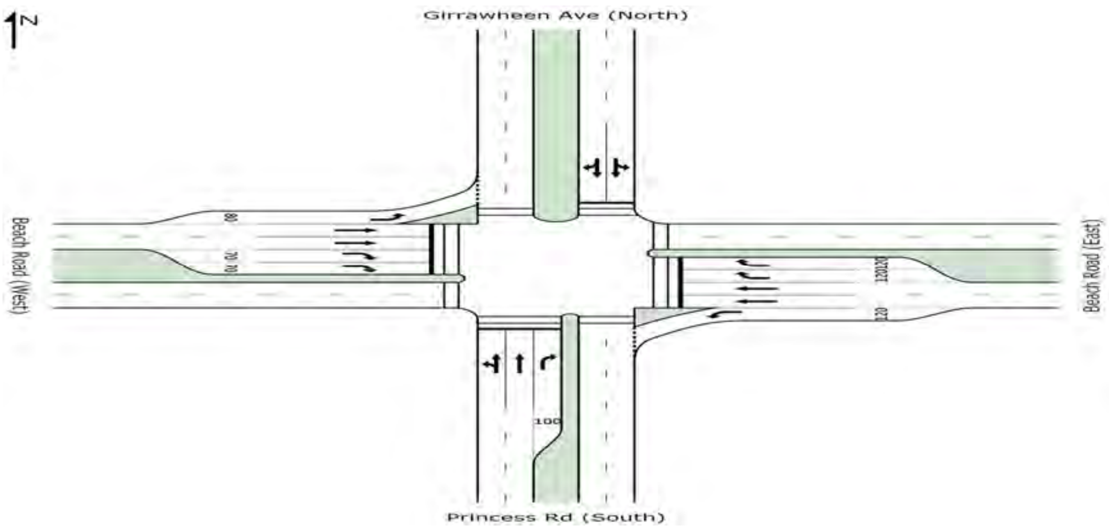
**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Princess Rd (South) | | | | | | | | | | | |
| 1 | L | 317 | 2.0 | 0.904 | 69.1 | LOS E | 36.9 | 262.6 | 1.00 | 1.02 | 21.0 |
| 2 | T | 736 | 2.0 | 0.904 | 60.5 | LOS E | 37.8 | 269.4 | 1.00 | 1.06 | 21.6 |
| 3 | R | 451 | 2.0 | 0.869 | 75.9 | LOS E | 15.5 | 110.5 | 1.00 | 0.97 | 19.5 |
| Approach | | 1504 | 2.0 | 0.904 | 66.9 | LOS E | 37.8 | 269.4 | 1.00 | 1.03 | 20.8 |
| East: Beach Road (East) | | | | | | | | | | | |
| 4 | L | 206 | 2.0 | 0.493 | 54.4 | LOS D | 11.2 | 79.6 | 0.92 | 0.82 | 24.0 |
| 5 | T | 799 | 2.0 | 0.909 | 67.7 | LOS E | 28.9 | 205.9 | 1.00 | 1.10 | 20.3 |
| 6 | R | 220 | 2.0 | 0.898 | 80.7 | LOS F | 15.7 | 112.0 | 1.00 | 1.01 | 18.7 |
| Approach | | 1225 | 2.0 | 0.909 | 67.8 | LOS E | 28.9 | 205.9 | 0.99 | 1.03 | 20.5 |
| North: Girrawheen Ave (North) | | | | | | | | | | | |
| 7 | L | 197 | 2.0 | 0.631 | 48.9 | LOS D | 19.3 | 137.5 | 0.92 | 0.86 | 26.1 |
| 8 | T | 539 | 2.0 | 0.631 | 40.6 | LOS D | 19.8 | 141.2 | 0.92 | 0.80 | 27.0 |
| 9 | R | 107 | 2.0 | 0.412 | 62.6 | LOS E | 6.2 | 44.0 | 0.96 | 0.79 | 22.1 |
| Approach | | 843 | 2.0 | 0.631 | 45.4 | LOS D | 19.8 | 141.2 | 0.92 | 0.81 | 26.0 |
| West: Beach Road (West) | | | | | | | | | | | |
| 10 | L | 106 | 2.0 | 0.593 | 55.7 | LOS E | 14.2 | 101.2 | 0.95 | 0.84 | 24.3 |
| 11 | T | 410 | 2.0 | 0.593 | 47.4 | LOS D | 14.5 | 103.3 | 0.95 | 0.80 | 24.9 |
| 12 | R | 127 | 2.0 | 0.518 | 64.4 | LOS E | 7.5 | 53.5 | 0.98 | 0.80 | 21.8 |
| Approach | | 643 | 2.0 | 0.593 | 52.1 | LOS D | 14.5 | 103.3 | 0.95 | 0.81 | 24.1 |
| All Vehicles | | 4215 | 2.0 | 0.909 | 60.6 | LOS E | 37.8 | 269.4 | 0.97 | 0.95 | 22.0 |

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include double

turn lanes on the southern approach and additional through and turn lanes. It is noted that the reserve on Girrawheen Ave north would not appear to be wide enough to accommodate the proposed modifications and significant land acquisition would likely be required.
A compromise is therefore recommended as follows, the performance is poor in comparison but the site is constrained.

## Possible Geometry (if no land resumption)




Girrawheen Avenue / Beach Road / Princess Rd 2031 with LHS am
Signals - Fixed Time    Cycle Time = 117 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

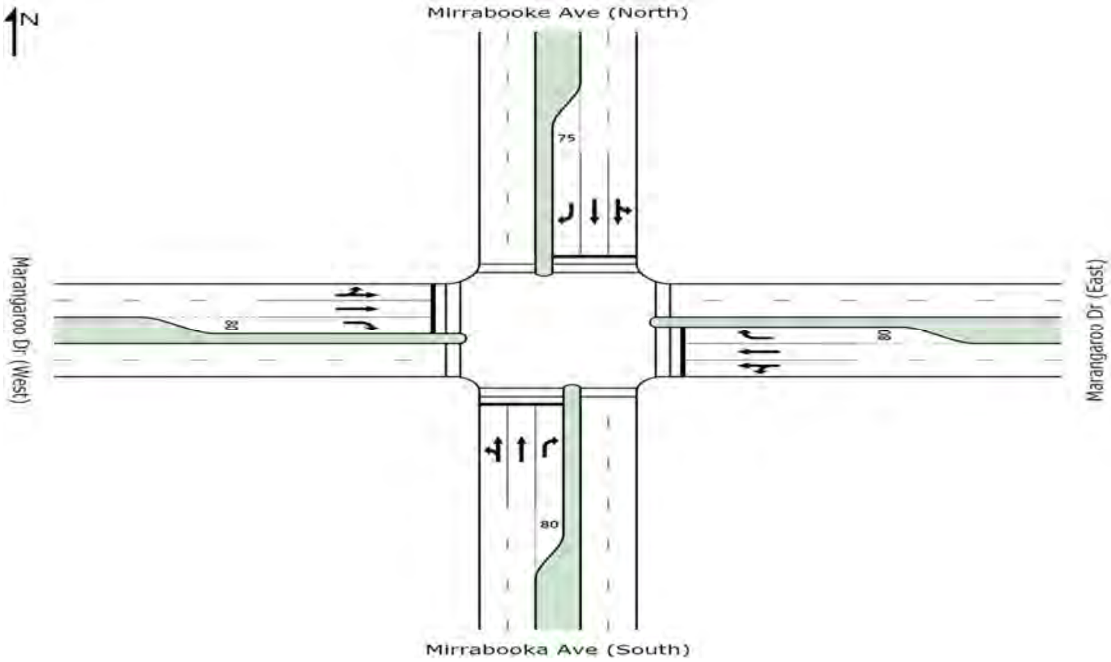
| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Princess Rd (South) | | | | | | | | | | | |
| 1 | L | 170 | 2.0 | 0.794 | 61.6 | LOS E | 16.3 | 116.1 | 1.00 | 0.92 | 22.6 |
| 2 | T | 396 | 2.0 | 0.794 | 53.2 | LOS D | 16.8 | 119.4 | 1.00 | 0.92 | 23.2 |
| 3 | R | 188 | 2.0 | 0.546 | 54.8 | LOS D | 9.9 | 70.4 | 0.96 | 0.81 | 24.1 |
| Approach | | 754 | 2.0 | 0.794 | 55.5 | LOS E | 16.8 | 119.4 | 0.99 | 0.90 | 23.3 |
| East: Beach Road (East) | | | | | | | | | | | |
| 4 | L | 416 | 2.0 | 0.531 | 15.9 | LOS B | 9.9 | 70.7 | 0.52 | 0.75 | 41.8 |
| 5 | T | 474 | 2.0 | 0.626 | 47.0 | LOS D | 12.6 | 89.6 | 0.97 | 0.81 | 25.1 |
| 6 | R | 244 | 2.0 | 0.866 | 76.0 | LOS E | 7.9 | 56.0 | 1.00 | 0.98 | 19.4 |
| Approach | | 1134 | 2.0 | 0.866 | 41.9 | LOS D | 12.6 | 89.6 | 0.81 | 0.82 | 27.5 |
| North: Girrawheen Ave (North) | | | | | | | | | | | |
| 7 | L | 285 | 2.0 | 0.900 | 62.7 | LOS E | 36.8 | 262.4 | 1.00 | 1.03 | 22.5 |
| 8 | T | 695 | 2.0 | 0.900 | 54.3 | LOS D | 37.2 | 265.0 | 1.00 | 1.05 | 22.8 |
| 9 | R | 153 | 2.0 | 0.900 | 62.0 | LOS E | 37.2 | 265.0 | 1.00 | 1.06 | 22.9 |
| Approach | | 1133 | 2.0 | 0.900 | 57.5 | LOS E | 37.2 | 265.0 | 1.00 | 1.04 | 22.7 |
| West: Beach Road (West) | | | | | | | | | | | |
| 10 | L | 82 | 2.0 | 0.107 | 11.8 | LOS B | 1.2 | 8.5 | 0.33 | 0.66 | 45.4 |
| 11 | T | 672 | 2.0 | 0.888 | 61.6 | LOS E | 21.8 | 155.3 | 1.00 | 1.06 | 21.5 |
| 12 | R | 189 | 2.0 | 0.671 | 68.8 | LOS E | 5.6 | 40.1 | 1.00 | 0.82 | 20.8 |
| Approach | | 943 | 2.0 | 0.888 | 58.7 | LOS E | 21.8 | 155.3 | 0.94 | 0.98 | 22.4 |
| All Vehicles | | 3964 | 2.0 | 0.900 | 52.9 | LOS D | 37.2 | 265.0 | 0.93 | 0.94 | 23.9 |

Girrawheen Avenue / Beach Road / Princess Rd 2031 with LHS pm
Signals - Fixed Time    Cycle Time = 126 seconds (Optimum Cycle Time - Minimum Delay)

| Movement Performance - Vehicles | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Princess Rd (South) | | | | | | | | | | | |
| 1 | L | 317 | 2.0 | 0.956 | 89.1 | LOS F | 44.8 | 319.1 | 1.00 | 1.15 | 17.6 |
| 2 | T | 774 | 2.0 | 0.956 | 80.4 | LOS F | 45.8 | 326.1 | 1.00 | 1.21 | 18.0 |
| 3 | R | 413 | 2.0 | 1.000 [3] | 51.8 | LOS D | 22.9 | 163.2 | 0.99 | 0.87 | 24.9 |
| Approach | | 1504 | 2.0 | 1.000 | 74.4 | LOS E | 45.8 | 326.1 | 1.00 | 1.10 | 19.4 |
| East: Beach Road (East) | | | | | | | | | | | |
| 4 | L | 206 | 2.0 | 0.228 | 12.1 | LOS B | 3.4 | 24.0 | 0.34 | 0.68 | 45.1 |
| 5 | T | 799 | 2.0 | 0.968 | 93.0 | LOS F | 34.4 | 245.0 | 1.00 | 1.30 | 16.4 |
| 6 | R | 220 | 2.0 | 0.946 | 94.7 | LOS F | 8.4 | 59.8 | 1.00 | 1.12 | 16.7 |
| Approach | | 1225 | 2.0 | 0.968 | 79.7 | LOS E | 34.4 | 245.0 | 0.89 | 1.16 | 18.5 |
| North: Girrawheen Ave (North) | | | | | | | | | | | |
| 7 | L | 197 | 2.0 | 0.969 | 101.4 | LOS F | 36.4 | 259.3 | 1.00 | 1.24 | 16.1 |
| 8 | T | 539 | 2.0 | 0.969 | 93.0 | LOS F | 36.8 | 261.8 | 1.00 | 1.28 | 16.2 |
| 9 | R | 107 | 2.0 | 0.969 | 100.7 | LOS F | 36.8 | 261.8 | 1.00 | 1.30 | 16.4 |
| Approach | | 843 | 2.0 | 0.969 | 95.9 | LOS F | 36.8 | 261.8 | 1.00 | 1.27 | 16.2 |
| West: Beach Road (West) | | | | | | | | | | | |
| 10 | L | 106 | 2.0 | 0.186 | 17.3 | LOS B | 2.5 | 17.7 | 0.46 | 0.69 | 40.8 |
| 11 | T | 410 | 2.0 | 0.497 | 47.2 | LOS D | 11.2 | 79.5 | 0.93 | 0.77 | 25.1 |
| 12 | R | 127 | 2.0 | 0.546 | 73.4 | LOS E | 4.0 | 28.6 | 1.00 | 0.76 | 19.9 |
| Approach | | 643 | 2.0 | 0.546 | 47.4 | LOS D | 11.2 | 79.5 | 0.87 | 0.76 | 25.5 |
| All Vehicles | | 4215 | 2.0 | 1.000 | 76.1 | LOS E | 45.8 | 326.1 | 0.95 | 1.10 | 19.1 |

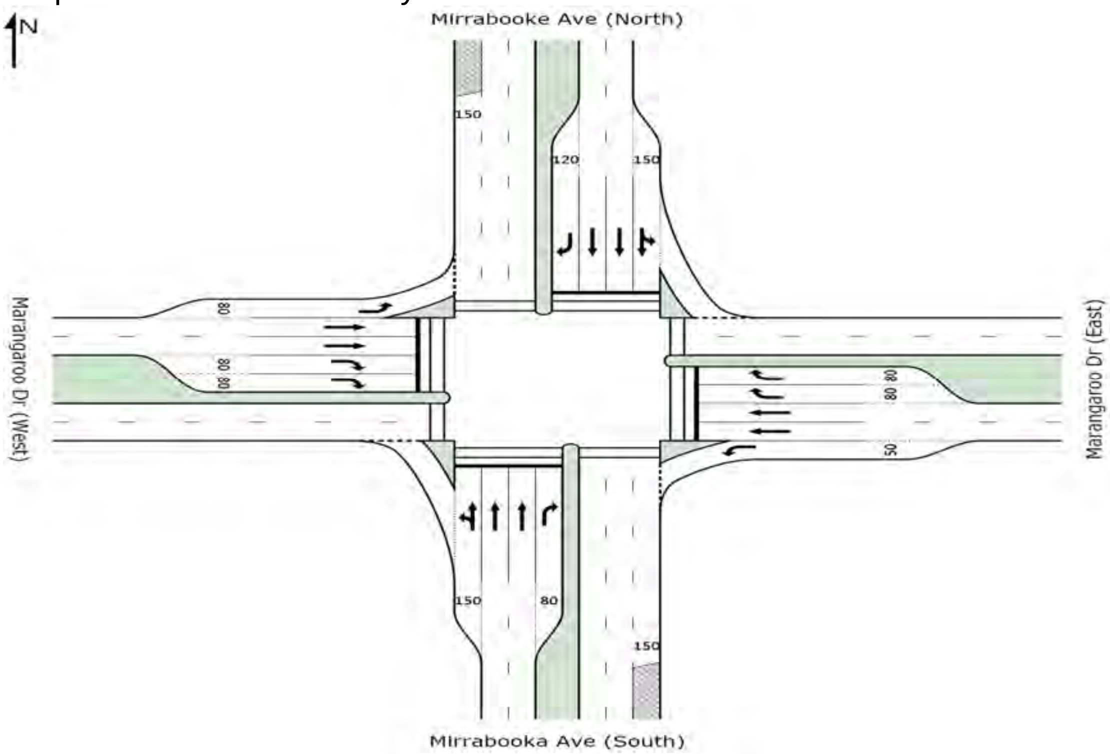
**Mirabooka/Marangaroo Ave Intersection 2031**

Exiting Geometry




Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry



Marangaroo Dr / Mirrabooka Ave
Signals - Fixed Time    Cycle Time = 130 seconds (Practical Cycle Time) pm 2031

| Movement Performance - Vehicles | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Ave (South) | | | | | | | | | | | |
| 1 | L | 276 | 4.0 | 0.495 | 28.5 | LOS C | 10.8 | 78.0 | 0.75 | 0.87 | 34.0 |
| 2 | T | 731 | 4.0 | 0.563 | 38.3 | LOS D | 17.7 | 128.5 | 0.88 | 0.76 | 28.0 |
| 3 | R | 81 | 4.0 | 0.269 | 52.9 | LOS D | 4.2 | 30.6 | 0.86 | 0.76 | 24.6 |
| Approach | | 1087 | 4.0 | 0.563 | 36.9 | LOS D | 17.7 | 128.5 | 0.84 | 0.79 | 29.0 |
| East: Marangaroo Dr (East) | | | | | | | | | | | |
| 4 | L | 254 | 4.0 | 0.653 | 21.3 | LOS C | 8.2 | 59.3 | 0.56 | 0.74 | 38.1 |
| 5 | T | 379 | 4.0 | 0.498 | 50.2 | LOS D | 10.8 | 78.0 | 0.94 | 0.78 | 24.3 |
| 6 | R | 141 | 4.0 | 0.462 | 71.6 | LOS E | 4.4 | 32.2 | 0.99 | 0.77 | 20.3 |
| Approach | | 774 | 4.0 | 0.653 | 44.6 | LOS D | 10.8 | 78.0 | 0.83 | 0.76 | 26.5 |
| North: Mirrabooke Ave (North) | | | | | | | | | | | |
| 7 | L | 188 | 4.0 | 0.792 | 50.0 | LOS D | 25.3 | 183.0 | 0.94 | 0.95 | 26.0 |
| 8 | T | 1353 | 4.0 | 0.901 | 55.6 | LOS E | 38.1 | 275.9 | 0.99 | 1.02 | 22.8 |
| 9 | R | 340 | 4.0 | 0.874 | 71.5 | LOS E | 23.6 | 171.1 | 1.00 | 0.97 | 20.4 |
| Approach | | 1881 | 4.0 | 0.901 | 57.9 | LOS E | 38.1 | 275.9 | 0.99 | 1.00 | 22.6 |
| West: Marangaroo Dr (West) | | | | | | | | | | | |
| 10 | L | 122 | 4.0 | 0.196 | 11.8 | LOS B | 2.0 | 14.3 | 0.32 | 0.67 | 45.4 |
| 11 | T | 368 | 4.0 | 0.485 | 50.0 | LOS D | 10.4 | 75.6 | 0.94 | 0.77 | 24.3 |
| 12 | R | 276 | 4.0 | 0.903 | 85.7 | LOS F | 10.1 | 72.9 | 1.00 | 1.01 | 18.0 |
| Approach | | 766 | 4.0 | 0.903 | 56.8 | LOS E | 10.4 | 75.6 | 0.86 | 0.84 | 23.1 |
| All Vehicles | | 4508 | 4.0 | 0.903 | 50.4 | LOS D | 38.1 | 275.9 | 0.90 | 0.88 | 24.6 |

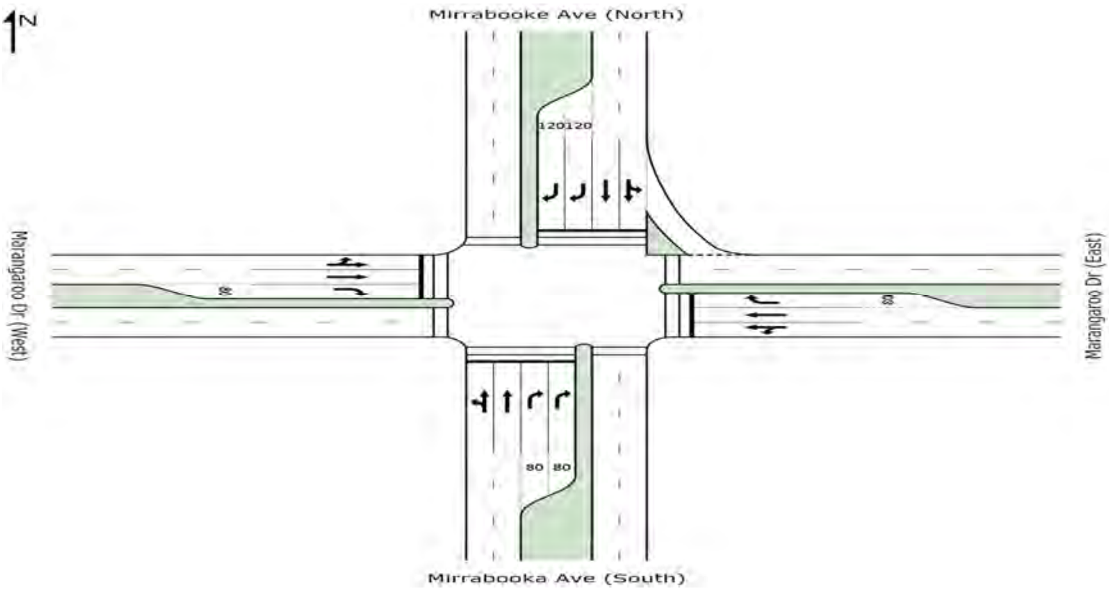
Marangaroo Dr / Mirrabooka Ave
Signals - Fixed Time    Cycle Time = 130 seconds (Practical Cycle Time) pm 2031

| Movement Performance - Vehicles | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Ave (South) | | | | | | | | | | | |
| 1 | L | 283 | 4.0 | 0.794 | 47.6 | LOS D | 24.6 | 178.3 | 0.93 | 1.00 | 26.5 |
| 2 | T | 1404 | 4.0 | 0.902 | 53.8 | LOS D | 42.5 | 307.9 | 0.99 | 1.02 | 23.2 |
| 3 | R | 183 | 4.0 | 0.599 | 62.5 | LOS E | 10.9 | 79.2 | 0.98 | 0.82 | 22.3 |
| Approach | | 1871 | 4.0 | 0.902 | 53.7 | LOS D | 42.5 | 307.9 | 0.98 | 1.00 | 23.6 |
| East: Marangaroo Dr (East) | | | | | | | | | | | |
| 4 | L | 103 | 4.0 | 0.266 | 33.3 | LOS C | 4.0 | 28.9 | 0.65 | 0.75 | 31.4 |
| 5 | T | 466 | 4.0 | 0.613 | 51.6 | LOS D | 13.6 | 98.7 | 0.97 | 0.81 | 23.9 |
| 6 | R | 182 | 4.0 | 0.546 | 71.2 | LOS E | 5.7 | 41.6 | 1.00 | 0.78 | 20.4 |
| Approach | | 752 | 4.0 | 0.613 | 53.8 | LOS D | 13.6 | 98.7 | 0.93 | 0.79 | 23.7 |
| North: Mirrabooke Ave (North) | | | | | | | | | | | |
| 7 | L | 103 | 4.0 | 0.410 | 37.9 | LOS D | 9.8 | 71.3 | 0.76 | 0.89 | 30.2 |
| 8 | T | 774 | 4.0 | 0.466 | 33.8 | LOS C | 15.3 | 110.4 | 0.81 | 0.71 | 29.8 |
| 9 | R | 261 | 4.0 | 0.854 | 73.1 | LOS E | 17.9 | 129.7 | 1.00 | 0.95 | 20.1 |
| Approach | | 1138 | 4.0 | 0.854 | 43.2 | LOS D | 17.9 | 129.7 | 0.85 | 0.78 | 26.8 |
| West: Marangaroo Dr (West) | | | | | | | | | | | |
| 10 | L | 397 | 4.0 | 0.698 | 25.6 | LOS C | 14.4 | 104.1 | 0.67 | 0.83 | 35.5 |
| 11 | T | 372 | 4.0 | 0.489 | 50.1 | LOS D | 10.5 | 76.3 | 0.94 | 0.77 | 24.3 |
| 12 | R | 281 | 4.0 | 0.843 | 79.2 | LOS E | 9.8 | 70.6 | 1.00 | 0.94 | 19.0 |
| Approach | | 1049 | 4.0 | 0.843 | 48.6 | LOS D | 14.4 | 104.1 | 0.85 | 0.84 | 25.5 |
| All Vehicles | | 4809 | 4.0 | 0.902 | 50.1 | LOS D | 42.5 | 307.9 | 0.91 | 0.88 | 24.7 |

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include double

turn lanes on Marangaroo Drive and additional left turn lanes on each approach. It is noted that the reserve on Marangaroo Drive and Mirabooka Ave north would not appear to be wide enough to accommodate the proposed modifications and significant land acquisition would likely be required.
A compromise is therefore recommended as follows, the performance is poor in comparison but the site is constrained. Significant queuing on Mirrabooka Ave north and south is forecast.

### Possible Geometry (if no land resumption)




Marangaroo Dr / Mirrabooka Ave 2031 with LHS am
Signals - Fixed Time    Cycle Time = 140 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Ave (South) | | | | | | | | | | | |
| 1 | L | 262 | 4.0 | 0.595 | 36.5 | LOS D | 20.6 | 149.5 | 0.70 | 0.86 | 30.5 |
| 2 | T | 694 | 4.0 | 0.595 | 28.1 | LOS C | 21.2 | 153.7 | 0.70 | 0.62 | 32.3 |
| 3 | R | 77 | 4.0 | 0.230 | 73.2 | LOS E | 2.4 | 17.7 | 0.94 | 0.74 | 20.0 |
| Approach | | 1033 | 4.0 | 0.595 | 33.6 | LOS C | 21.2 | 153.7 | 0.72 | 0.69 | 30.5 |
| East: Marangaroo Dr (East) | | | | | | | | | | | |
| 4 | L | 241 | 4.0 | 0.983 | 113.6 | LOS F | 27.5 | 198.7 | 1.00 | 1.14 | 14.6 |
| 5 | T | 360 | 4.0 | 0.983 | 104.6 | LOS F | 28.5 | 206.3 | 1.00 | 1.23 | 15.0 |
| 6 | R | 134 | 4.0 | 0.520 | 68.9 | LOS E | 8.4 | 60.7 | 0.95 | 0.80 | 20.8 |
| Approach | | 735 | 4.0 | 0.983 | 101.1 | LOS F | 28.5 | 206.3 | 0.99 | 1.12 | 15.7 |
| North: Mirrabooke Ave (North) | | | | | | | | | | | |
| 7 | L | 179 | 4.0 | 0.914 | 65.7 | LOS E | 54.8 | 396.7 | 1.00 | 1.06 | 22.1 |
| 8 | T | 1285 | 4.0 | 0.916 | 56.9 | LOS E | 56.9 | 412.3 | 1.00 | 1.05 | 22.4 |
| 9 | R | 323 | 4.0 | 0.963 | 109.7 | LOS F | 14.3 | 103.8 | 1.00 | 1.14 | 15.0 |
| Approach | | 1787 | 4.0 | 0.963 | 67.3 | LOS E | 56.9 | 412.3 | 1.00 | 1.07 | 20.6 |
| West: Marangaroo Dr (West) | | | | | | | | | | | |
| 10 | L | 116 | 4.0 | 0.763 | 71.3 | LOS E | 15.5 | 112.0 | 0.99 | 0.87 | 20.7 |
| 11 | T | 354 | 4.0 | 0.763 | 62.8 | LOS E | 15.8 | 114.6 | 0.99 | 0.87 | 21.1 |
| 12 | R | 258 | 4.0 | 1.000 [3] | 74.2 | LOS E | 18.1 | 130.8 | 1.00 | 0.84 | 19.8 |
| Approach | | 728 | 4.0 | 1.000 | 68.2 | LOS E | 18.1 | 130.8 | 1.00 | 0.86 | 20.6 |
| All Vehicles | | 4283 | 4.0 | 1.000 | 65.1 | LOS E | 56.9 | 412.3 | 0.93 | 0.95 | 21.1 |

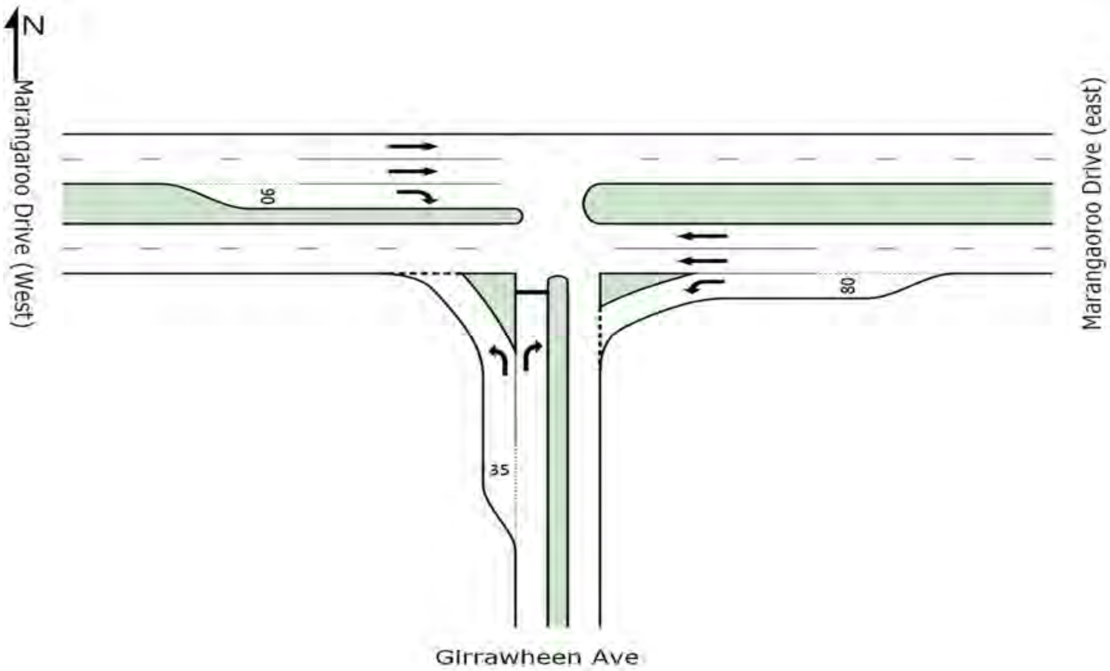
Marangaroo Dr / Mirrabooka Ave 2031 with LHS pm
Signals - Fixed Time    Cycle Time = 149 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Mirrabooka Ave (South) | | | | | | | | | | | |
| 1 | L | 269 | 4.0 | 1.006 | 117.1 | LOS F | 88.5 | 641.0 | 1.00 | 1.26 | 14.5 |
| 2 | T | 1334 | 4.0 | 1.006 | 108.4 | LOS F | 89.9 | 650.5 | 1.00 | 1.30 | 14.7 |
| 3 | R | 174 | 4.0 | 0.718 | 86.3 | LOS F | 6.6 | 47.4 | 1.00 | 0.82 | 17.8 |
| Approach | | 1777 | 4.0 | 1.006 | 107.6 | LOS F | 89.9 | 650.5 | 1.00 | 1.25 | 14.9 |
| East: Marangaroo Dr (East) | | | | | | | | | | | |
| 4 | L | 98 | 4.0 | 0.714 | 68.8 | LOS E | 17.8 | 129.1 | 0.96 | 0.85 | 21.3 |
| 5 | T | 443 | 4.0 | 0.714 | 60.4 | LOS E | 18.1 | 131.4 | 0.96 | 0.82 | 21.6 |
| 6 | R | 173 | 4.0 | 0.649 | 73.5 | LOS E | 11.8 | 85.3 | 0.97 | 0.82 | 20.0 |
| Approach | | 714 | 4.0 | 0.714 | 64.7 | LOS E | 18.1 | 131.4 | 0.96 | 0.82 | 21.2 |
| North: Mirrabooke Ave (North) | | | | | | | | | | | |
| 7 | L | 98 | 4.0 | 0.523 | 43.7 | LOS D | 21.2 | 153.7 | 0.79 | 0.91 | 28.2 |
| 8 | T | 735 | 4.0 | 0.525 | 34.6 | LOS C | 22.4 | 162.0 | 0.79 | 0.71 | 29.4 |
| 9 | R | 248 | 4.0 | 1.023 | 168.2 | LOS F | 14.4 | 103.9 | 1.00 | 1.31 | 10.7 |
| Approach | | 1081 | 4.0 | 1.023 | 66.1 | LOS E | 22.4 | 162.0 | 0.84 | 0.87 | 20.9 |
| West: Marangaroo Dr (West) | | | | | | | | | | | |
| 10 | L | 377 | 4.0 | 1.037 | 178.5 | LOS F | 47.2 | 342.0 | 1.00 | 1.24 | 10.1 |
| 11 | T | 353 | 4.0 | 0.924 | 78.7 | LOS E | 29.1 | 210.4 | 1.00 | 1.06 | 18.4 |
| 12 | R | 267 | 4.0 | 1.000 [3] | 77.8 | LOS E | 19.8 | 143.3 | 1.00 | 0.84 | 19.2 |
| Approach | | 997 | 4.0 | 1.037 | 116.2 | LOS F | 47.2 | 342.0 | 1.00 | 1.07 | 14.2 |
| All Vehicles | | 4569 | 4.0 | 1.037 | 93.0 | LOS F | 89.9 | 650.5 | 0.96 | 1.05 | 16.6 |

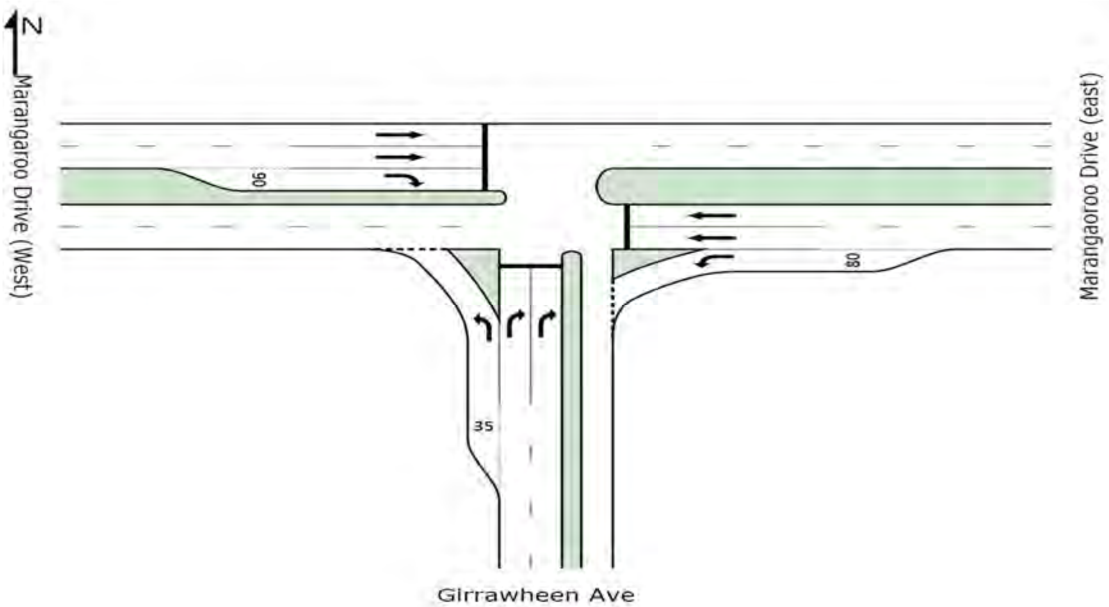
**Marangaroo Drive/Girawheen Ave Intersection 2031**

Existing Geometry




Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry



Marangaroo Drive / Girrawheen Avenue
Signals - Fixed Time Cycle Time = 100 seconds (User-Given Cycle Time) am 2031

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Girrawheen Ave | | | | | | | | | | | |
| 1 | L | 518 | 4.0 | 0.861 | 16.1 | LOS B | 8.0 | 57.6 | 0.64 | 0.82 | 41.9 |
| 3 | R | 147 | 4.0 | 0.680 | 62.9 | LOS E | 3.9 | 28.1 | 1.00 | 0.82 | 22.0 |
| Approach | | 665 | 4.0 | 0.861 | 26.4 | LOS C | 8.0 | 57.6 | 0.72 | 0.82 | 35.0 |
| East: Marangaoroo Drive (east) | | | | | | | | | | | |
| 4 | L | 403 | 4.0 | 0.608 | 13.4 | LOS B | 8.2 | 59.1 | 0.55 | 0.76 | 44.1 |
| 5 | T | 722 | 4.0 | 0.863 | 49.5 | LOS D | 19.5 | 141.3 | 1.00 | 1.02 | 24.4 |
| Approach | | 1125 | 4.0 | 0.863 | 36.5 | LOS D | 19.5 | 141.3 | 0.84 | 0.92 | 29.1 |
| West: Marangaroo Drive (West) | | | | | | | | | | | |
| 11 | T | 595 | 4.0 | 0.191 | 2.0 | LOS A | 3.0 | 21.9 | 0.23 | 0.20 | 55.7 |
| 12 | R | 632 | 4.0 | 0.870 | 30.1 | LOS C | 20.3 | 146.9 | 0.68 | 0.91 | 32.9 |
| Approach | | 1226 | 4.0 | 0.870 | 16.5 | LOS B | 20.3 | 146.9 | 0.46 | 0.57 | 41.1 |
| All Vehicles | | 3017 | 4.0 | 0.870 | 26.2 | LOS C | 20.3 | 146.9 | 0.66 | 0.76 | 34.5 |

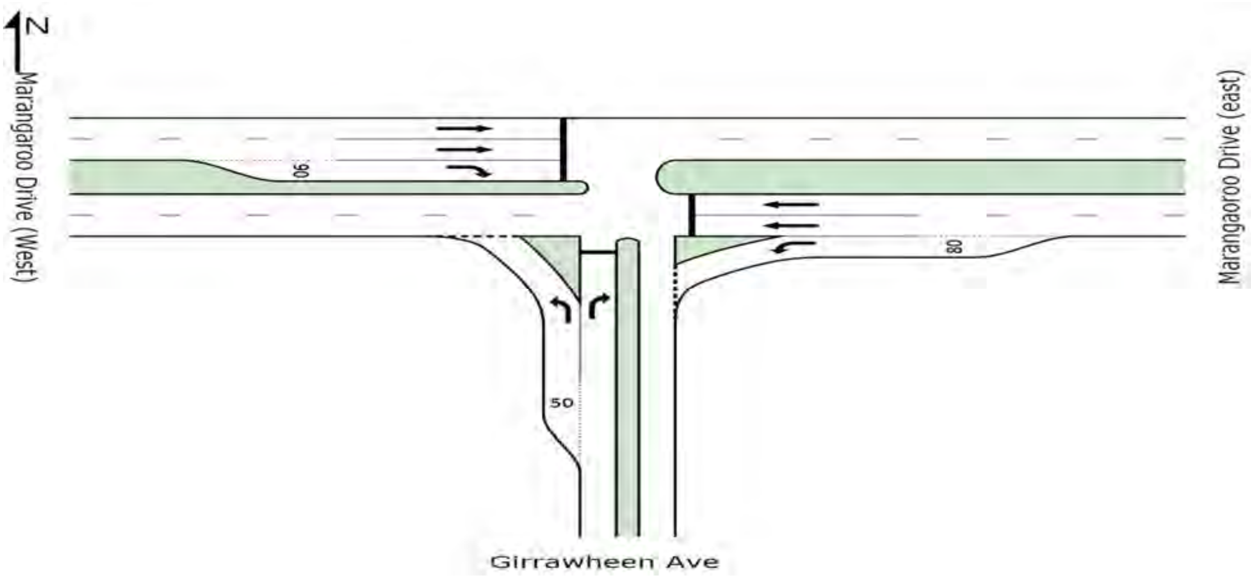
Marangaroo Drive / Girrawheen Avenue
Signals - Fixed Time Cycle Time = 120 seconds (User-Given Cycle Time) pm 2031

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Girrawheen Ave | | | | | | | | | | | |
| 1 | L | 478 | 4.0 | 0.906 | 18.5 | LOS B | 8.7 | 62.8 | 0.68 | 0.84 | 40.0 |
| 3 | R | 287 | 4.0 | 0.682 | 65.9 | LOS E | 8.5 | 61.5 | 1.00 | 0.83 | 21.4 |
| Approach | | 765 | 4.0 | 0.906 | 36.3 | LOS D | 8.7 | 62.8 | 0.80 | 0.84 | 30.2 |
| East: Marangaoroo Drive (east) | | | | | | | | | | | |
| 4 | L | 211 | 4.0 | 0.303 | 10.1 | LOS B | 2.4 | 17.7 | 0.30 | 0.68 | 47.2 |
| 5 | T | 768 | 4.0 | 0.898 | 62.2 | LOS E | 25.7 | 185.9 | 1.00 | 1.06 | 21.4 |
| Approach | | 979 | 4.0 | 0.898 | 51.0 | LOS D | 25.7 | 185.9 | 0.85 | 0.97 | 24.3 |
| West: Marangaroo Drive (West) | | | | | | | | | | | |
| 11 | T | 923 | 4.0 | 0.310 | 3.9 | LOS A | 7.5 | 54.6 | 0.31 | 0.28 | 52.8 |
| 12 | R | 453 | 4.0 | 0.741 | 22.7 | LOS C | 12.1 | 87.8 | 0.65 | 0.83 | 37.1 |
| Approach | | 1376 | 4.0 | 0.741 | 10.1 | LOS B | 12.1 | 87.8 | 0.42 | 0.46 | 46.3 |
| All Vehicles | | 3120 | 4.0 | 0.906 | 29.3 | LOS C | 25.7 | 185.9 | 0.65 | 0.71 | 32.7 |

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include signalising the intersection and providing a double right turn lanes on Girrawheen Avenue. It is noted that the reserve on Girawheen Ave would not appear to be wide enough to accommodate the proposed double right turn and significant land acquisition would be likely. The following geometry is therefore recommended.

## Possible Geometry (if no land resumption)




Marangaroo Drive / Girrawheen Avenue 2031 with LHS am
Signals - Fixed Time Cycle Time = 120 seconds (User-Given Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Girrawheen Ave | | | | | | | | | | | |
| 1 | L | 490 | 4.0 | 0.738 | 14.2 | LOS B | 8.1 | 58.4 | 0.45 | 0.76 | 43.4 |
| 3 | R | 140 | 4.0 | 0.846 | 74.9 | LOS E | 9.1 | 65.6 | 1.00 | 0.95 | 19.6 |
| Approach | | 630 | 4.0 | 0.846 | 27.7 | LOS C | 9.1 | 65.6 | 0.57 | 0.80 | 34.3 |
| East: Marangaoroo Drive (east) | | | | | | | | | | | |
| 4 | L | 383 | 4.0 | 0.673 | 13.0 | LOS B | 8.1 | 58.5 | 0.48 | 0.74 | 44.4 |
| 5 | T | 686 | 4.0 | 0.902 | 65.5 | LOS E | 23.4 | 169.5 | 1.00 | 1.09 | 20.7 |
| Approach | | 1069 | 4.0 | 0.902 | 46.7 | LOS D | 23.4 | 169.5 | 0.81 | 0.96 | 25.7 |
| West: Marangaroo Drive (West) | | | | | | | | | | | |
| 11 | T | 565 | 4.0 | 0.184 | 2.7 | LOS A | 3.6 | 26.2 | 0.24 | 0.21 | 54.6 |
| 12 | R | 600 | 4.0 | 0.915 | 28.8 | LOS C | 20.3 | 146.9 | 0.65 | 0.88 | 33.5 |
| Approach | | 1165 | 4.0 | 0.915 | 16.2 | LOS B | 20.3 | 146.9 | 0.45 | 0.55 | 41.3 |
| All Vehicles | | 2864 | 4.0 | 0.915 | 30.1 | LOS C | 23.4 | 169.5 | 0.61 | 0.76 | 32.4 |

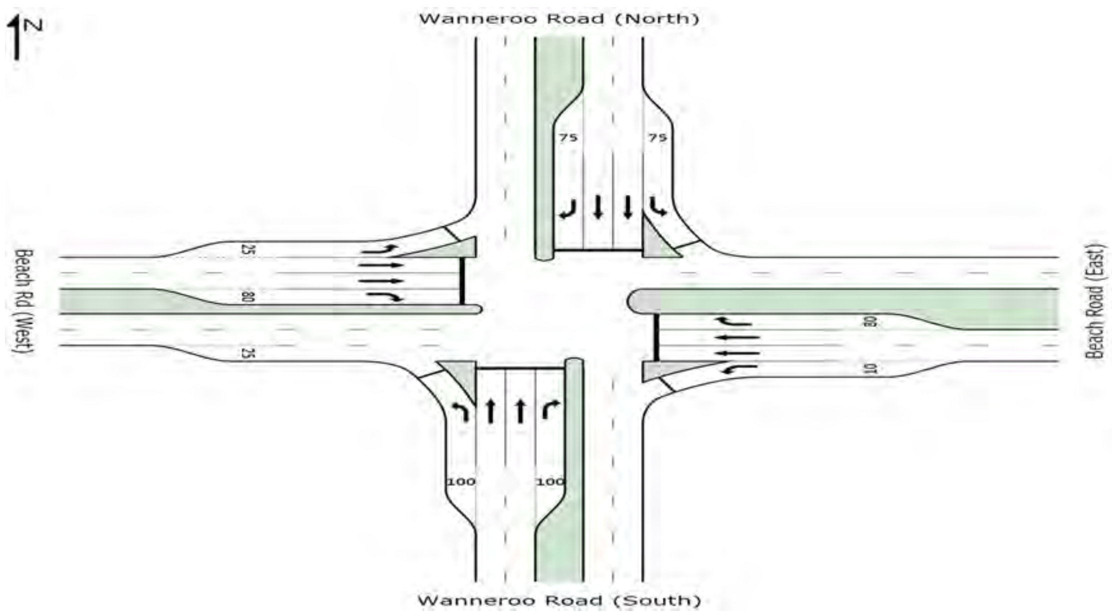
Marangaroo Drive / Girrawheen Avenue 2031 with LHS pm
Signals - Fixed Time Cycle Time = 120 seconds (User-Given Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Girrawheen Ave | | | | | | | | | | | |
| 1 | L | 454 | 4.0 | 0.676 | 14.1 | LOS B | 9.0 | 65.1 | 0.46 | 0.75 | 43.5 |
| 3 | R | 273 | 4.0 | 0.756 | 59.9 | LOS E | 15.8 | 114.7 | 1.00 | 0.88 | 22.7 |
| Approach | | 727 | 4.0 | 0.756 | 31.3 | LOS C | 15.8 | 114.7 | 0.66 | 0.80 | 32.4 |
| East: Marangaoroo Drive (east) | | | | | | | | | | | |
| 4 | L | 200 | 4.0 | 0.266 | 10.2 | LOS B | 2.3 | 16.6 | 0.30 | 0.68 | 47.1 |
| 5 | T | 730 | 4.0 | 0.743 | 45.3 | LOS D | 20.1 | 145.7 | 0.98 | 0.87 | 25.6 |
| Approach | | 930 | 4.0 | 0.743 | 37.8 | LOS D | 20.1 | 145.7 | 0.83 | 0.83 | 28.4 |
| West: Marangaroo Drive (West) | | | | | | | | | | | |
| 11 | T | 877 | 4.0 | 0.330 | 7.4 | LOS A | 9.8 | 70.8 | 0.42 | 0.37 | 48.2 |
| 12 | R | 430 | 4.0 | 0.766 | 27.2 | LOS C | 13.1 | 95.1 | 0.77 | 0.87 | 34.4 |
| Approach | | 1307 | 4.0 | 0.766 | 13.9 | LOS B | 13.1 | 95.1 | 0.54 | 0.54 | 42.6 |
| All Vehicles | | 2964 | 4.0 | 0.766 | 25.7 | LOS C | 20.1 | 145.7 | 0.66 | 0.69 | 34.5 |

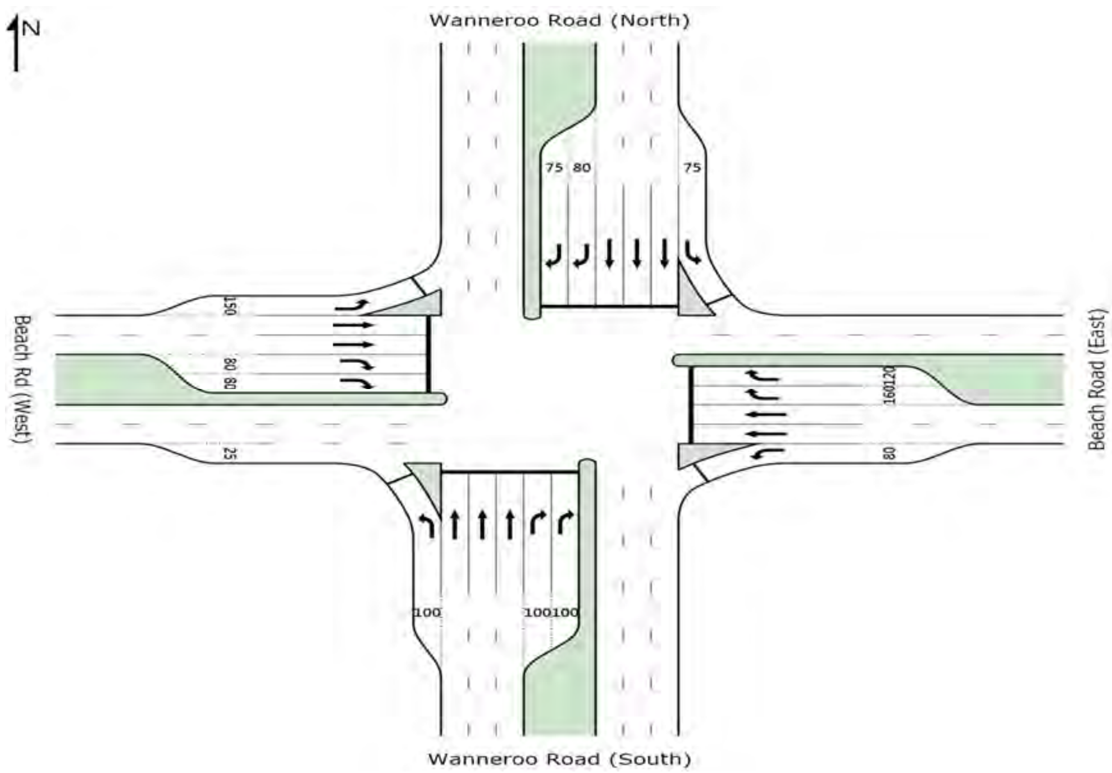
## Beach Road/Wanneroo Road Intersection 2031

Existing Geometry




Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

## Proposed Ultimate Geometry - Recommended



Wanneroo Beach with LHS 2031 am
Signals - Fixed Time    Cycle Time = 130 seconds (Practical Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Road (South) | | | | | | | | | | | |
| 1 | L | 108 | 4.0 | 0.169 | 17.6 | LOS B | 2.6 | 18.9 | 0.42 | 0.69 | 40.7 |
| 2 | T | 874 | 4.0 | 0.311 | 20.9 | LOS C | 10.9 | 78.8 | 0.64 | 0.55 | 36.6 |
| 3 | R | 71 | 4.0 | 0.320 | 74.0 | LOS E | 2.3 | 16.5 | 0.99 | 0.73 | 20.0 |
| Approach | | 1053 | 4.0 | 0.320 | 24.2 | LOS C | 10.9 | 78.8 | 0.64 | 0.58 | 35.0 |
| East: Beach Road (East) | | | | | | | | | | | |
| 4 | L | 216 | 4.0 | 0.669 | 49.6 | LOS D | 11.3 | 82.0 | 0.87 | 0.81 | 25.6 |
| 5 | T | 408 | 4.0 | 0.634 | 55.0 | LOS D | 12.2 | 88.6 | 0.98 | 0.81 | 23.0 |
| 6 | R | 291 | 4.0 | 0.873 | 81.7 | LOS F | 10.4 | 75.0 | 1.00 | 1.00 | 18.7 |
| Approach | | 915 | 4.0 | 0.873 | 62.2 | LOS E | 12.2 | 88.6 | 0.96 | 0.87 | 21.9 |
| North: Wanneroo Road (North) | | | | | | | | | | | |
| 7 | L | 283 | 4.0 | 0.540 | 18.7 | LOS B | 7.7 | 55.6 | 0.47 | 0.72 | 39.9 |
| 8 | T | 2490 | 4.0 | 0.887 | 40.2 | LOS D | 52.9 | 383.1 | 0.98 | 0.97 | 27.3 |
| 9 | R | 197 | 4.0 | 0.886 | 85.7 | LOS F | 7.1 | 51.7 | 1.00 | 1.00 | 18.0 |
| Approach | | 2970 | 4.0 | 0.887 | 41.2 | LOS D | 52.9 | 383.1 | 0.93 | 0.95 | 27.2 |
| West: Beach Rd (West) | | | | | | | | | | | |
| 10 | L | 210 | 4.0 | 0.420 | 49.1 | LOS D | 10.9 | 78.9 | 0.87 | 0.81 | 25.8 |
| 11 | T | 574 | 4.0 | 0.892 | 70.2 | LOS E | 20.7 | 149.7 | 1.00 | 1.05 | 19.8 |
| 12 | R | 283 | 4.0 | 0.849 | 79.5 | LOS E | 9.9 | 71.5 | 1.00 | 0.97 | 19.1 |
| Approach | | 1067 | 4.0 | 0.892 | 68.5 | LOS E | 20.7 | 149.7 | 0.97 | 0.98 | 20.5 |
| All Vehicles | | 6005 | 4.0 | 0.892 | 46.3 | LOS D | 52.9 | 383.1 | 0.89 | 0.88 | 25.8 |

Wanneroo Beach 2031 with LHS pm
Signals - Fixed Time    Cycle Time = 110 seconds (Optimum Cycle Time - Minimum Delay)

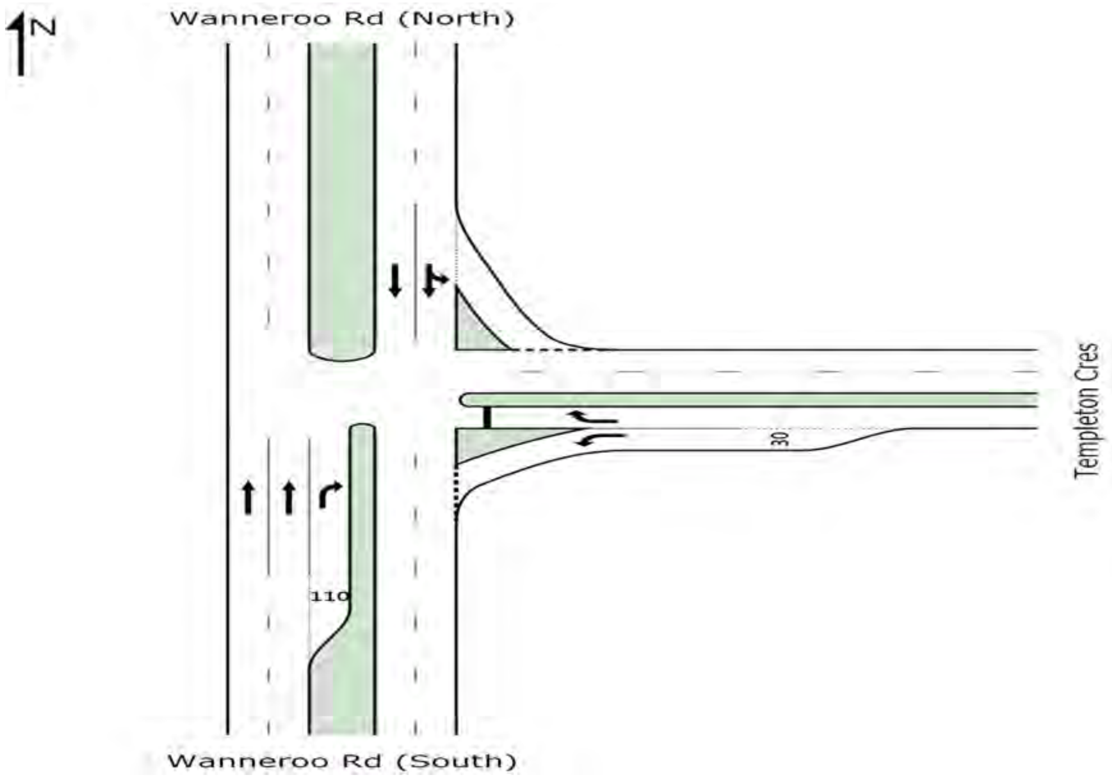
**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Road (South) | | | | | | | | | | | |
| 1 | L | 166 | 4.0 | 0.265 | 20.4 | LOS C | 4.3 | 31.1 | 0.52 | 0.72 | 38.7 |
| 2 | T | 2244 | 4.0 | 0.902 | 44.8 | LOS D | 45.3 | 328.1 | 1.00 | 1.06 | 25.8 |
| 3 | R | 111 | 4.0 | 0.376 | 62.0 | LOS E | 3.0 | 21.5 | 0.99 | 0.75 | 22.4 |
| Approach | | 2521 | 4.0 | 0.902 | 43.9 | LOS D | 45.3 | 328.1 | 0.97 | 1.02 | 26.2 |
| East: Beach Road (East) | | | | | | | | | | | |
| 4 | L | 98 | 4.0 | 0.275 | 43.5 | LOS D | 4.2 | 30.5 | 0.84 | 0.76 | 27.6 |
| 5 | T | 572 | 4.0 | 0.752 | 47.4 | LOS D | 15.2 | 110.2 | 1.00 | 0.90 | 25.0 |
| 6 | R | 508 | 4.0 | 0.910 | 73.6 | LOS E | 16.4 | 118.8 | 1.00 | 1.08 | 20.0 |
| Approach | | 1178 | 4.0 | 0.910 | 58.4 | LOS E | 16.4 | 118.8 | 0.99 | 0.96 | 22.7 |
| North: Wanneroo Road (North) | | | | | | | | | | | |
| 7 | L | 244 | 4.0 | 0.404 | 16.1 | LOS B | 5.3 | 38.1 | 0.44 | 0.71 | 41.8 |
| 8 | T | 1066 | 4.0 | 0.428 | 22.9 | LOS C | 13.1 | 94.9 | 0.74 | 0.64 | 35.2 |
| 9 | R | 271 | 4.0 | 0.917 | 78.2 | LOS E | 8.8 | 63.4 | 1.00 | 1.09 | 19.2 |
| Approach | | 1581 | 4.0 | 0.917 | 31.4 | LOS C | 13.1 | 94.9 | 0.74 | 0.73 | 31.5 |
| West: Beach Rd (West) | | | | | | | | | | | |
| 10 | L | 362 | 4.0 | 0.817 | 55.3 | LOS E | 20.1 | 145.2 | 1.00 | 0.93 | 24.0 |
| 11 | T | 374 | 4.0 | 0.902 | 66.1 | LOS E | 11.8 | 85.3 | 1.00 | 1.07 | 20.6 |
| 12 | R | 175 | 4.0 | 0.762 | 68.5 | LOS E | 5.1 | 37.0 | 1.00 | 0.87 | 21.0 |
| Approach | | 911 | 4.0 | 0.902 | 62.3 | LOS E | 20.1 | 145.2 | 1.00 | 0.98 | 21.9 |
| All Vehicles | | 6191 | 4.0 | 0.917 | 46.2 | LOS D | 45.3 | 328.1 | 0.92 | 0.93 | 25.8 |

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS to a reasonable LoS. Most traffic will clear the intersection in a single cycle. Upgrade will include additional through lanes on Wanneroo Road and the provision of double right turns on the north, south, east and west approaches. No land acquisition would appear to be required. (To be confirmed as part of a concept design)

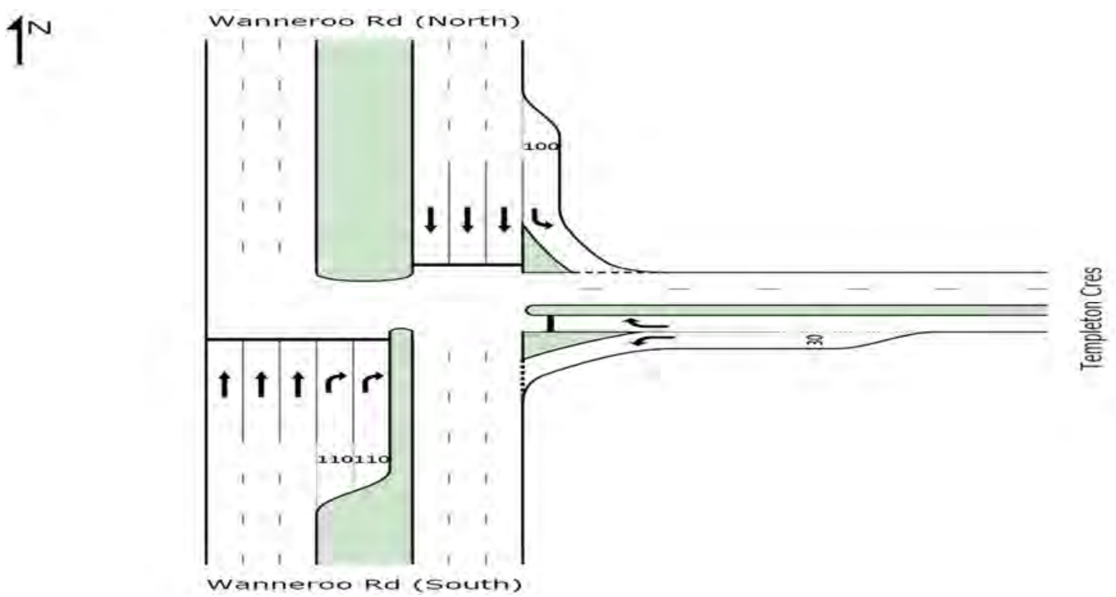
## Wanneroo Road/Templeton Road Intersection 2031

Existing Geometry




Analysis for 2031 indicates this intersection will not accommodate the forecast traffic volumes to 2031.

### Proposed Ultimate Geometry – Recommended



Wanneroo Rd/ Templeton Cres AM 2031 with LHS Signals
Signals - Fixed Time Cycle Time = 120 seconds (User-Given Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 2 | T | 1223 | 4.0 | 0.292 | 5.7 | LOS A | 7.9 | 57.2 | 0.37 | 0.32 | 50.3 |
| 3 | R | 153 | 4.0 | 0.726 | 73.9 | LOS E | 4.8 | 34.9 | 1.00 | 0.84 | 19.9 |
| Approach | | 1376 | 4.0 | 0.726 | 13.3 | LOS B | 7.9 | 57.2 | 0.44 | 0.38 | 43.0 |
| East: Templeton Cres | | | | | | | | | | | |
| 4 | L | 214 | 4.0 | 1.000 [3] | 20.4 | LOS C | 6.8 | 49.1 | 0.62 | 0.76 | 38.6 |
| 6 | R | 210 | 4.0 | 0.697 | 60.8 | LOS E | 12.0 | 87.1 | 1.00 | 0.85 | 22.6 |
| Approach | | 424 | 4.0 | 1.000 | 40.4 | LOS D | 12.0 | 87.1 | 0.81 | 0.81 | 28.7 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 107 | 4.0 | 0.082 | 8.3 | LOS A | 0.6 | 4.0 | 0.15 | 0.63 | 48.9 |
| 8 | T | 2607 | 4.0 | 0.732 | 16.5 | LOS B | 34.6 | 250.4 | 0.75 | 0.69 | 39.3 |
| Approach | | 2714 | 4.0 | 0.732 | 16.1 | LOS B | 34.6 | 250.4 | 0.73 | 0.69 | 39.6 |
| All Vehicles | | 4514 | 4.0 | 1.000 | 17.5 | LOS B | 34.6 | 250.4 | 0.65 | 0.61 | 39.1 |

Wanneroo Rd/ Templeton Cres PM 2031 with LHS Signals
Signals - Fixed Time Cycle Time = 120 seconds (User-Given Cycle Time)

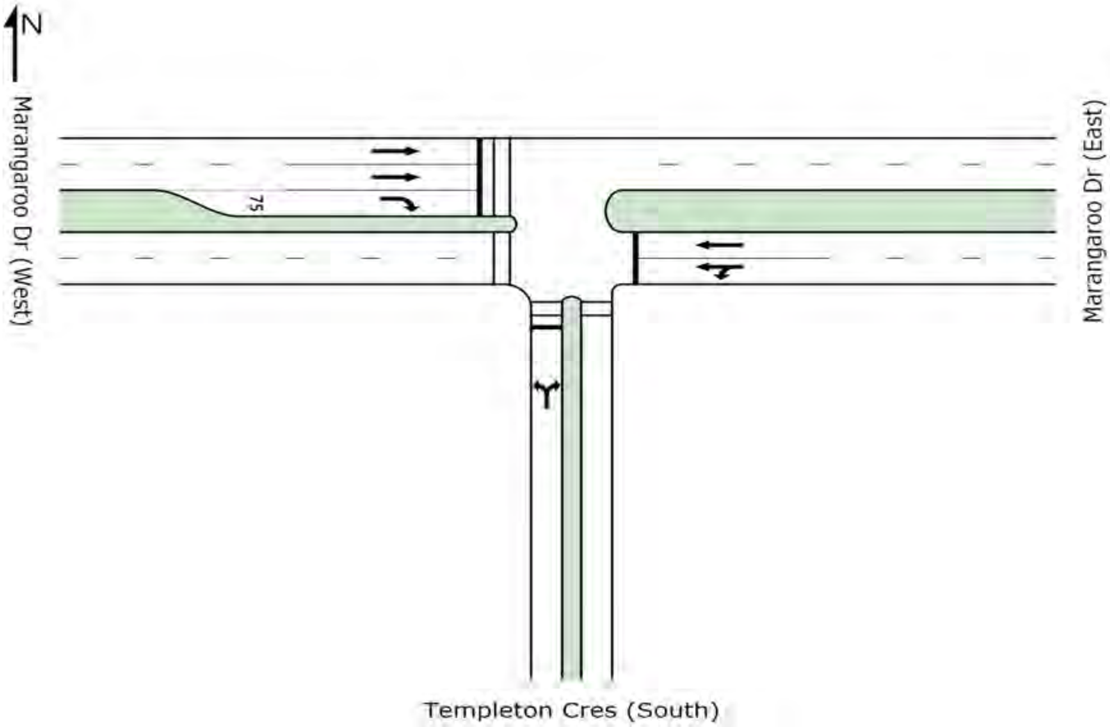
**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 2 | T | 2520 | 4.0 | 0.541 | 3.8 | LOS A | 15.8 | 114.3 | 0.36 | 0.33 | 52.7 |
| 3 | R | 622 | 4.0 | 0.629 | 38.4 | LOS D | 13.7 | 99.0 | 0.81 | 0.81 | 29.3 |
| Approach | | 3142 | 4.0 | 0.629 | 10.6 | LOS B | 15.8 | 114.3 | 0.45 | 0.43 | 45.5 |
| East: Templeton Cres | | | | | | | | | | | |
| 4 | L | 190 | 4.0 | 0.529 | 12.2 | LOS B | 3.1 | 22.2 | 0.36 | 0.68 | 45.1 |
| 6 | R | 88 | 4.0 | 0.585 | 68.1 | LOS E | 5.2 | 37.9 | 1.00 | 0.79 | 21.0 |
| Approach | | 278 | 4.0 | 0.585 | 29.9 | LOS C | 5.2 | 37.9 | 0.56 | 0.72 | 33.1 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 129 | 4.0 | 0.162 | 10.1 | LOS B | 1.5 | 10.7 | 0.26 | 0.66 | 47.1 |
| 8 | T | 1395 | 4.0 | 0.625 | 31.4 | LOS C | 21.8 | 157.8 | 0.86 | 0.76 | 30.8 |
| Approach | | 1524 | 4.0 | 0.625 | 29.6 | LOS C | 21.8 | 157.8 | 0.81 | 0.75 | 31.7 |
| All Vehicles | | 4944 | 4.0 | 0.629 | 17.6 | LOS B | 21.8 | 157.8 | 0.57 | 0.54 | 39.4 |

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include additional through lanes on Wanneroo Road and the provision of a double right turns on the south approach and a left turn lane in Wanneroo Road north. No land acquisition would appear to be required.

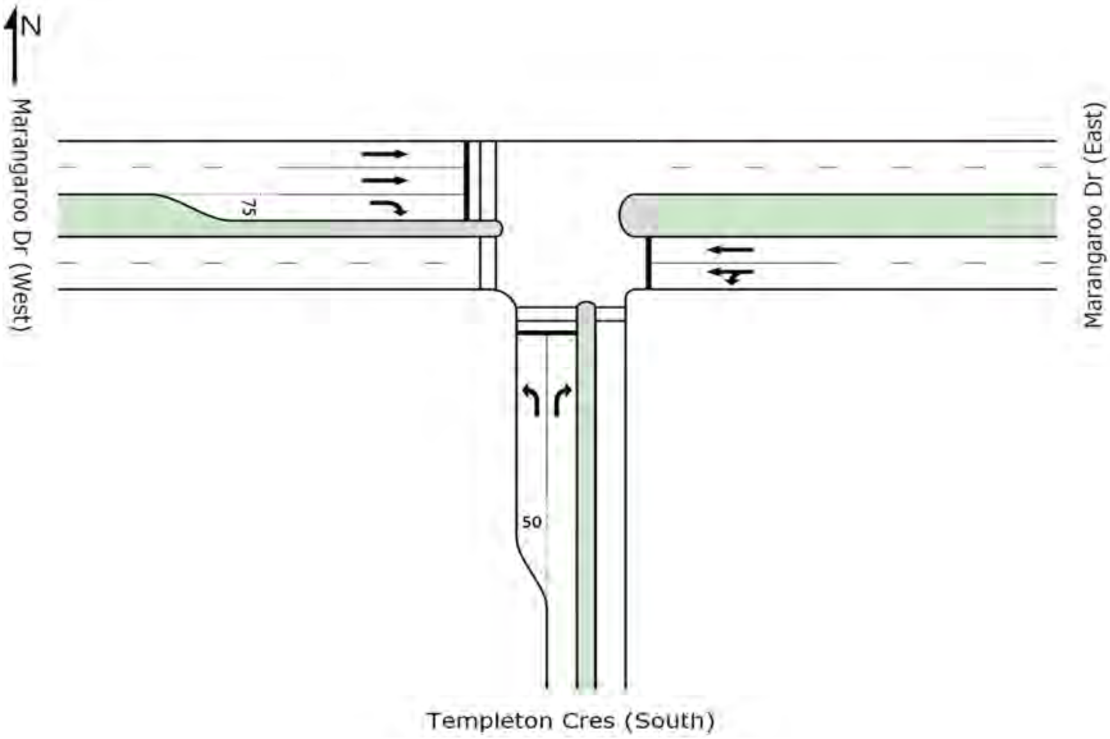
**Marangaroo Dr/Templeton Crescent Intersection 2031**

Existing Geometry




The existing geometry will operate to a reasonable performance however pm queue lengths in Templeton Crescent are forecast to exceed 200m. Further analysis has therefore been undertaken of a modified geometry.

**Proposed Ultimate Geometry - Recommended**



Marangaroo Drive / Templeton Crescent with LHS Signals am 2031
Signals - Fixed Time    Cycle Time = 80 seconds (User-Given Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Templeton Cres (South) | | | | | | | | | | | |
| 1 | L | 78 | 4.0 | 0.245 | 33.1 | LOS C | 2.4 | 17.2 | 0.81 | 0.75 | 31.4 |
| 3 | R | 221 | 4.0 | 0.466 | 35.6 | LOS D | 7.4 | 53.6 | 0.89 | 0.81 | 30.4 |
| Approach | | 299 | 4.0 | 0.466 | 34.9 | LOS C | 7.4 | 53.6 | 0.87 | 0.80 | 30.6 |
| East: Marangaroo Dr (East) | | | | | | | | | | | |
| 4 | L | 189 | 4.0 | 0.575 | 19.4 | LOS B | 15.3 | 110.9 | 0.67 | 0.90 | 40.7 |
| 5 | T | 1085 | 4.0 | 0.575 | 11.0 | LOS B | 15.5 | 112.6 | 0.67 | 0.60 | 43.5 |
| Approach | | 1274 | 4.0 | 0.575 | 12.3 | LOS B | 15.5 | 112.6 | 0.67 | 0.65 | 43.1 |
| West: Marangaroo Dr (West) | | | | | | | | | | | |
| 11 | T | 618 | 4.0 | 0.277 | 8.7 | LOS A | 5.9 | 42.6 | 0.53 | 0.45 | 46.5 |
| 12 | R | 60 | 4.0 | 0.312 | 27.9 | LOS C | 1.8 | 12.7 | 0.73 | 0.77 | 34.0 |
| Approach | | 678 | 4.0 | 0.312 | 10.4 | LOS B | 5.9 | 42.6 | 0.54 | 0.48 | 45.1 |
| All Vehicles | | 2251 | 4.0 | 0.575 | 14.7 | LOS B | 15.5 | 112.6 | 0.66 | 0.62 | 41.4 |

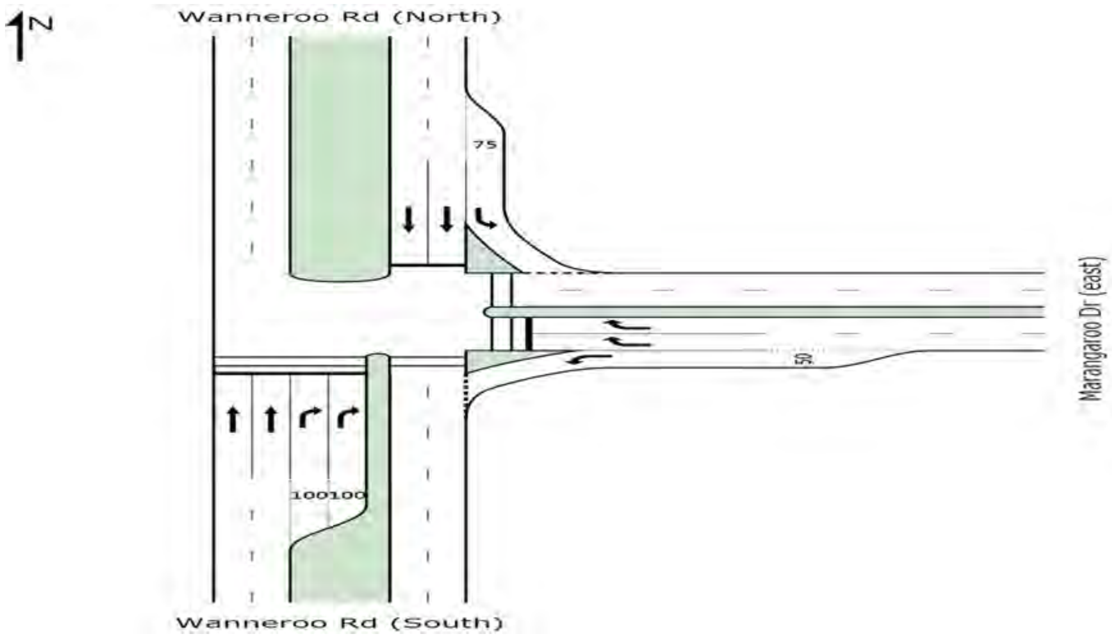
Marangaroo Drive / Templeton Crescent with LHS Signals pm 2031
Signals - Fixed Time    Cycle Time = 80 seconds (User-Given Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Templeton Cres (South) | | | | | | | | | | | |
| 1 | L | 181 | 4.0 | 0.428 | 21.5 | LOS C | 4.1 | 29.7 | 0.62 | 0.76 | 37.8 |
| 3 | R | 670 | 4.0 | 0.781 | 29.4 | LOS C | 23.3 | 168.3 | 0.90 | 0.90 | 33.2 |
| Approach | | 851 | 4.0 | 0.781 | 27.7 | LOS C | 23.3 | 168.3 | 0.84 | 0.87 | 34.1 |
| East: Marangaroo Dr (East) | | | | | | | | | | | |
| 4 | L | 156 | 4.0 | 0.770 | 34.4 | LOS C | 19.8 | 143.4 | 0.94 | 0.93 | 32.1 |
| 5 | T | 934 | 4.0 | 0.770 | 26.0 | LOS C | 20.1 | 145.3 | 0.94 | 0.88 | 32.9 |
| Approach | | 1090 | 4.0 | 0.770 | 27.2 | LOS C | 20.1 | 145.3 | 0.94 | 0.89 | 32.8 |
| West: Marangaroo Dr (West) | | | | | | | | | | | |
| 11 | T | 664 | 4.0 | 0.466 | 20.5 | LOS C | 9.9 | 71.6 | 0.81 | 0.69 | 36.5 |
| 12 | R | 89 | 4.0 | 0.684 | 49.6 | LOS D | 3.8 | 27.3 | 1.00 | 0.87 | 25.4 |
| Approach | | 753 | 4.0 | 0.684 | 24.0 | LOS C | 9.9 | 71.6 | 0.83 | 0.71 | 34.7 |
| All Vehicles | | 2694 | 4.0 | 0.781 | 26.5 | LOS C | 23.3 | 168.3 | 0.88 | 0.83 | 33.7 |

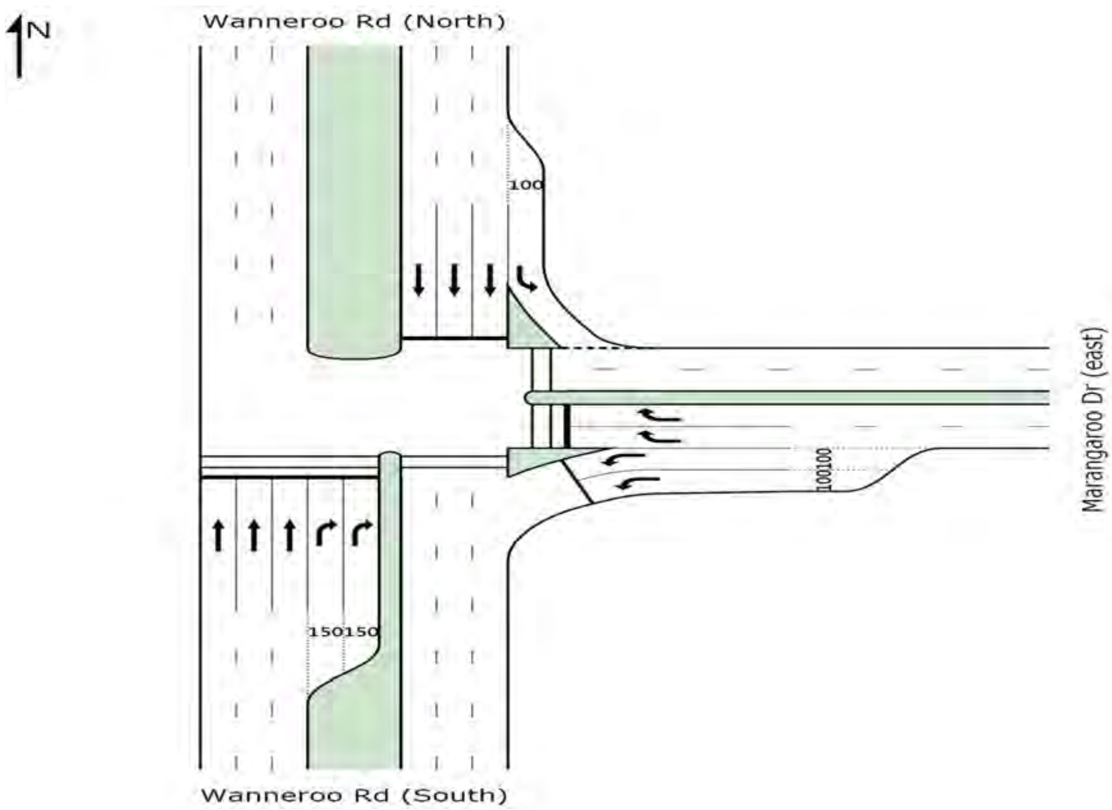
The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include a 50m widening along the Templeton Crescent approach to accommodate two lanes of traffic. No land acquisition would appear to be required.

**Wanneroo Road/Marangaroo Road Intersection 2031**
Existing Geometry




Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

**Proposed Ultimate Geometry – Recommended**



Marangaroo Dr / Wanneroo Rd with LHS 2031 AM Upgraded Geometrey
Signals - Fixed Time    Cycle Time = 114 seconds (Practical Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 2 | T | 1158 | 5.0 | 0.319 | 9.8 | LOS A | 9.5 | 69.5 | 0.49 | 0.43 | 45.6 |
| 3 | R | 407 | 5.0 | 0.863 | 70.1 | LOS E | 12.7 | 92.4 | 1.00 | 0.99 | 20.6 |
| Approach | | 1565 | 5.0 | 0.863 | 25.5 | LOS C | 12.7 | 92.4 | 0.62 | 0.57 | 34.6 |
| East: Marangaroo Dr (east) | | | | | | | | | | | |
| 4 | L | 722 | 5.0 | 0.879 | 63.2 | LOS E | 22.2 | 162.4 | 1.00 | 1.00 | 22.2 |
| 6 | R | 380 | 5.0 | 0.417 | 46.4 | LOS D | 8.9 | 64.8 | 0.88 | 0.81 | 26.5 |
| Approach | | 1102 | 5.0 | 0.879 | 57.4 | LOS E | 22.2 | 162.4 | 0.96 | 0.93 | 23.5 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 351 | 5.0 | 0.332 | 9.8 | LOS A | 3.8 | 28.0 | 0.28 | 0.67 | 47.4 |
| 8 | T | 2337 | 5.0 | 0.904 | 44.8 | LOS D | 48.6 | 354.5 | 1.00 | 1.06 | 25.8 |
| Approach | | 2688 | 5.0 | 0.904 | 40.3 | LOS D | 48.6 | 354.5 | 0.91 | 1.01 | 27.4 |
| All Vehicles | | 5355 | 5.0 | 0.904 | 39.5 | LOS D | 48.6 | 354.5 | 0.83 | 0.86 | 28.1 |

Marangaroo Dr / Wanneroo Rd with LHS 2031 PM Upgraded Geometry
Signals - Fixed Time    Cycle Time = 87 seconds (Practical Cycle Time)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 2 | T | 2460 | 5.0 | 0.821 | 21.7 | LOS C | 31.4 | 229.2 | 0.90 | 0.87 | 35.6 |
| 3 | R | 694 | 5.0 | 0.886 | 55.9 | LOS E | 17.5 | 127.8 | 1.00 | 1.04 | 23.8 |
| Approach | | 3154 | 5.0 | 0.886 | 29.2 | LOS C | 31.4 | 229.2 | 0.92 | 0.91 | 32.1 |
| East: Marangaroo Dr (east) | | | | | | | | | | | |
| 4 | L | 531 | 5.0 | 0.487 | 32.4 | LOS C | 8.9 | 65.0 | 0.83 | 0.80 | 32.0 |
| 6 | R | 443 | 5.0 | 0.371 | 31.9 | LOS C | 7.2 | 52.6 | 0.81 | 0.80 | 32.1 |
| Approach | | 974 | 5.0 | 0.487 | 32.2 | LOS C | 8.9 | 65.0 | 0.82 | 0.80 | 32.1 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 316 | 5.0 | 0.327 | 11.6 | LOS B | 4.1 | 30.1 | 0.42 | 0.71 | 45.6 |
| 8 | T | 1206 | 5.0 | 0.882 | 45.7 | LOS D | 19.9 | 145.6 | 1.00 | 1.08 | 25.5 |
| Approach | | 1522 | 5.0 | 0.882 | 38.6 | LOS D | 19.9 | 145.6 | 0.88 | 1.00 | 28.1 |
| All Vehicles | | 5650 | 5.0 | 0.886 | 32.3 | LOS C | 31.4 | 229.2 | 0.89 | 0.92 | 30.9 |

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include an additional lane in Wanneroo Road and a signalised double left turn lane in Marrangaroo Drive. Intersection C/D is achieved and Stop rates generally below 1. The degree of saturation is 0.904 for the am peak hour. No land acquisition would appear to be required.

# Appendix G - Council and Main Roads Response to Draft Measures and GHD Commentary

**From: HOLMES Rob (RPO) [rob.holmes@mainroads.wa.gov.au]**

**Sent: Monday, 26 November 2012 6:40 AM**

**To: Koroveshi, Jordan**

**Cc: Zamir, Marzia; BROADHURST Lindsay (MRP); MCKIRDY Justin (URPM)**

**Subject: TRIM: Local Housing Strategies -Girrawheen-Koondoola Housing Precinct & Wanneroo Housing Precinct**

**Hi Jordan**

**I refer to your email dated 5 November 2012 providing copies the following documents:**

**Draft Report for Wanneroo Housing Precinct Traffic Impact Assessment – September 2012; and .**

**Draft Report for Girrawheen-Koondoola Housing Precinct Traffic Impact Assessment – September 2012.**

**Please note that we were not provided a copy of Appendix A, C and D for either draft report so we are unable to provide feedback on the data / information contained within these sections.**

**I also make reference to our meeting on 5 November 2012 where discussion focused on the changes in R- Coding around the Wanneroo Centre and Girrawheen-Koondoola precincts, resulting from the implementation of Local Planning Policy 3.1, and the effect this will have on road networks.**

**It is our understanding that the City of Wanneroo is keen to understand future implications of the R-Coding changes with the intention of being able to progressively move toward an appropriate outcome. Main Roads is very supportive of this approach and is keen to remain involved in the process. The following comments are provided in response to your request for comments and are intended to be constructive without being a detailed critique:**

**General Comments**

**1. The draft reports appear to be a good start and provide some good information. We consider some of the recommendations debatable and worthy of further consideration and discussion.**

**2.Network analysis seems to have jumped to ‘single solutions’ too fast. What network options were considered and tested?**

***GHD Response***

***The planned road network as provided was analysed additional road networks are beyond the scope of this project.***

**The City and Main Roads should be aiming to make the most appropriate use of the road hierarchy. For example:**

**Within the Girrawheen-Koondoola Housing precinct, instead of assuming Templeton Cr (a local distributor road) should be automatically signalised to deal with its capacity constraints at Wanneroo Rd, how else might the broader network be able to cater for this demand.**

***GHD Response***

***Based on the forecast traffic volumes the intersection of Templeton Cr/Wanneroo Rd will ultimately need to be upgraded. A review of the 5 year crash history at this intersection indicates there have been 25 crashes in 5 years , 7 crashes involve right angle and right through indicating there may already be a safety issue involving turning movements. As traffic volumes increase this will be exacerbated.***

***Analysis for the signalised intersections at Wanneroo Road/Beach Road and Wanneroo Road/Marrangaroo Drive intersections indicate that these upgraded intersections will operate satisfactorily as traffic volumes increase, therefore a strategy that includes upgrade to the major intersections first is recommended and further upgrade to the Templeton Crescent intersection is reviewed as development occurs.***

State Frequency Rank No. 919 State Cost Rank No. 994 Intersection No. 14048

| Summary of Intersection Crashes | | | |
|---|---|---|---|
| Street 1 | WANNEROO RD | Authority Name | WANNEROO (C) |
| Street 2 | TEMPLETON CR | Region | METROPOLITAN |
| Street 3 | | Cost | $1,119,772 |
| Intersection Classification | State and Local Roads | Total Crashes | 25 |

| Crash Details | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Rear End | Side Swipe | Right Angle | Right Thru | Wet | Night | Ped | Cycle | Truck | Motorcycle | Casualty |
| 12 | 1 | 2 | 5 | 4 | 4 | 0 | 0 | 0 | 1 | 6 |

**Within the Wanneroo Housing Precinct, a similar question can be put to the proposed signalising of the Wanneroo Rd and Ariti Ave and similarly for some of the other locations.**

***GHD Response***

***See note for Templeton Crescent above. Strategy to improve major intersections first.***

**3. If demand in particular areas is considered to exceed the capacity of the network, then there are three options available to manage this issue; those being:.**

- **Expand the capacity of the road network – if possible (difficulty in adopting this option has been highlighted in the draft Wanneroo Housing Precinct Report);**
- **Provide opportunities for other modes of transport to cater for an increased proportion of the demand; and**
- **Limit to scale of development.**

***GHD Response***

***Whilst improve public transport will go some way to reducing demand, it should be recognised that the scale of development should be limited and network impacts regularly monitored and updated. GHD's/Main Roads modelling assume the full build out by 2031. Even without the increased housing density the analysis indicates that the network is forecast to be under pressure. The network could be further tested using a reduced housing density, GHD would be pleased to provide an estimate for this work.***

*A recommended strategy would be to limit the scale of development.*

*Agree that increased shift to PT, and assumed reduction in private vehicle trips, could reduce or at least postpone some of the suggested network upgrades. However, our analysis (and scope) has offered a like-for-like comparison between with/without the proposed local housing strategies, so as to provide an indication to council of the direct impact of the proposed density increases. Any heightened push towards PT usage would assist either scenario.*

**4. With regards to the second option reflected in Point 3, there appears to be no consideration of how other modes may be used to cater for some of the future demands. For example: .**

**a) If light rail is introduced to Mirrabooka Ave in relation to the Girrawheen-Koondoola Housing Precinct.**

**b) If new or upgraded public transport services are implemented within the Wanneroo Housing Precinct.**

**c) Promotion of walking and cycling for localised trips (especially those which may require a short trip crossing a regional road).**

*GHD Response*

*The modelling ROM/GHD takes no account of mode split changes due to the above and was not included or intended as part of the scope for this study.*

*Mode share options would require further modelling with the ROM modelling and Paramics modelling as this will impact on the study areas and the broader area.*

**5. Further to Point 4, it is understood that a number of reports (one example being ARRB's North West Corridor Structure Plan Review – Strategic Assessment of Regional Transport Requirements – October 2009) have identified the importance of achieving a significant increase in public transport use and employment self sufficiencies (ESS) in assisting the existing and planned regional transport network to adequately service the proposed development within the North West Corridor. The role of ESS in relation to this proposed development is not reflected in the draft reports.**

*GHD Response*

*Noted, this is not built in to any modelling.*

**6. The SIDRA analysis completed to date may well be correct, given the assumptions that have been made. However, we have not verified the cycle times utilised and how these relate to current settings.**

**It is also possible that future road operations will see greater priority given to the movement of traffic on higher order roads within the road hierarchy, resulting in the traffic on lower order connecting roads being required to accept a lower level of service and longer delays.**

*GHD Response*

*Noted.*

*The Paramics modelling incorporated current cycle time data as supplied by Main Roads and the Sidra modelling duplicated the results with recommended layouts. As previously mentioned priority should be given to the major intersections accepting some delays on the minor roads and a strategy to upgrade should reflect this. The priority for upgrade will be addressed in the report.*

**7. Main Roads' Transport Modelling Branch are currently reviewing the 'Paramics Base Model Validation Report' associated with each draft report. It is anticipated that this review will be completed by the 30 November 2012. It is planned that any review comments will be provided to the City shortly after its completion.**

**Comments now received. These have been copied to the end of this document and responses provided.**

***8. It is acknowledged that future predicted volumes, especially on Wanneroo Rd, suggest the need to consider upgrading this road to six lanes, however current ultimate planning is for four lanes. Current thinking would suggest, if any additional lanes are introduced then they would be for public transport purposes, such as bus lanes. Additionally, the extra demand predicted may actually result in peak spreading with the demand being forced to utilise the infrastructure available. Reference to ARRB's North West Corridor Structure Plan Review – Strategic Assessment of Regional Transport Requirements – October 2009 has not been made in the draft Girrawheen-Koondoola Housing Precinct report as it was in the draft Wanneroo Housing Precinct, however, this review concluded /recommended that four lanes for Wanneroo Rd through the Girrawheen area will be required by 2031 but accepting it will be operating at a level of service F during peak periods.***

***GHD Response***

***Noted***

**9. Agree that the Wanneroo Rd and Beach Rd intersection should be considered for double right turns on each approach in the future. As previously advised, the Public Transport Authority are currently progressing a study to provide bus priority measures at this intersection which may constrain future plans to provide these double right turns for general traffic.**

***GHD Response***

***Noted.***

***The recommendation will be for upgrade to include double right turns on each approach noting the PTA study.***

**10. The following network considerations are presented for investigation and discussion:**

**a) Make Warwick Rd / Marangaroo Dr a four way intersection, however noting the following:**

**- May need to research why the staggered arrangement was initially created. There appears to be available road reserve to allow this to occur.**

**This will create a long straight approach from the east and west to Wanneroo Rd which may have some safety concerns.**

***GHD Response***

***Not included in scope of work. GHD happy to provide a price to consider this option.***

**b) Main Roads does not support the signalising of the Wanneroo Rd and Templeton Cr intersection. Suggest converting Templeton Cr intersection into a left in / left out junction and promote the use of Blackmore Ave and Templeton Cr connection to the existing east west regional roads to access Girrawheen instead of direct access via Templeton Cr to Wanneroo Rd -that is use the road hierarchy approach to determine access**

**arrangements which will assist in retaining the integrity of Wanneroo Rd as a primary regional road.**

***GHD Response***

***As previously mentioned give priority to the major intersection upgrades and consider the Main Roads option as a future strategy.***

**c) Convert Montrose Ave and Koondoola Ave to left in / left out at their junction with Mirrabooka Ave and promote distribution of traffic to the existing east west regional roads, which have existing controlled connections to Wanneroo Rd.**

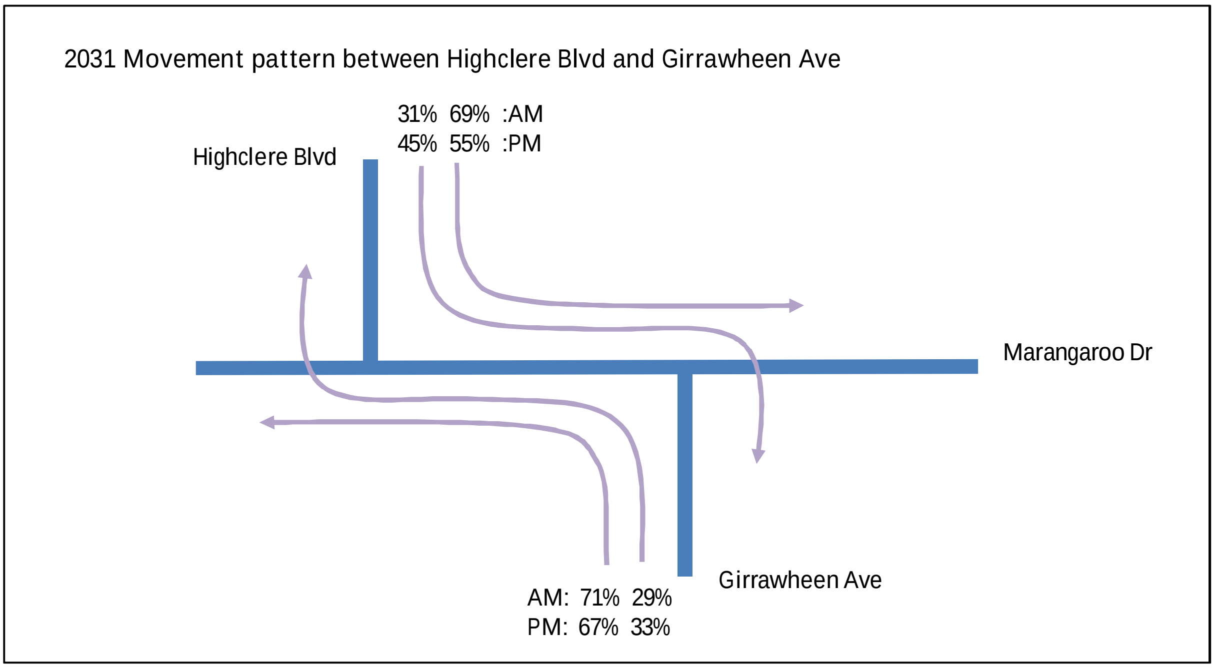
***GHD Response***

***If Main Roads are not supportive of signals a preferred option is to convert the Koondoola Ave and Montrose Ave approaches to left in/out when the intersection is at capacity.***

**11. If Girrawheen Ave is signalised at Marangaroo Dr, how does this proposal impact Highclere Bvd (currently signalised)? What is the relationship between these intersections in terms of movement patterns? The separation between these intersections is only approximately 280m.**

***GHD Response***

***The movement pattern between these two roads is indicated on the figure below. Observed of the modelled 2031 upgraded configurations shows queuing is not expected to extend from one junction to the upstream junction. Nor were any weaving issues identified.***




Thank you for informing Main Roads of these proposals and for the opportunity to comment. It is hoped that the City finds this feedback beneficial. The opportunity to discuss our feedback would also be welcomed should the City desire. If you require any further information please contact Justin McKirdy, Urban Road Planning Manager North, on 9323 4991.

Regards

Lindsay Broadhurst

Manager Road Planning

### City of Wanneroo Comments

1. **Local roads – Comment re local road impacts.**

***Will add comments re local roads as per GHD email.***

***The above analysis considers road requirements to the key road network, i.e Local Distributor classification and above, there are however a number of Access Streets within the internal road network and commentary on these roads is provided as follows.***

***The WAPC document 'Liveable Neighbourhoods' indicates the anticipated traffic volumes for residential streets:***

***Access Street Type C (single carriageway 7.2m to 7.5m wide): 3,000vpd***

***Access Street Type D (single carriageway, 5.5m to 6m wide): 1,000vpd***

***The physical capacity of a single carriageway road is 8,000-12,000vpd at a good level of service C, based on the assessment of the precinct it is clear considerable capacity is available within the lower order roads in the study area and the planned increased residential density is unlikely to adversely impact these roads requiring the need to upgrade.***

***The following intersection thresholds are indicated by Austroads below which capacity analysis is unnecessary.***

| ***Major Road Flow*** | ***Minor Road Flow*** |
|---|---|
| ***400vph*** | ***250vph*** |
| ***500vph*** | ***200vph*** |
| ***650vph*** | ***100vph*** |

***Based on the above thresholds, minor road intersections within the precinct are not expected to exceed these volumes on full development and therefore not anticipated to require significant upgrade for capacity reasons.***

2. **Traffic apportioning and clarity**

***Will add to report as suggested by City.***

3. **Upgrade trigger/threshold**

***GHD have undertaken a staging analysis (looking at 25% and 50% development horizons). This analysis has been included into the body of the report.***

4. **Cost apportioning should be b-a/b**

***Noted will add to report.***

5. **Involvement of Main Roads. Confirm consultation.**

***Will add to report.***

6. **Consistency, Wanneroo Rd/Celestine not recommended for signals in Appendix. Remove mention of traffic signals.**

   ***Noted re Wanneroo Rd/Celestine will amend report.***

7. **Cost estimates**

   **Will prepare conceptual design for each location following  CoW confirmation of agreed measure.**

   **Six designs allowed for in tender.**

**Main Roads Transport Modelling team comments:**

- The greatest strength of Paramics is its dynamic assignment.  This works to reroute traffic in response to congestion.  However, the two models developed by GHD have little to none sensible route choices available, (acknowledged in sections 3.7).  Furthermore SCATS is showing little congestion is occurring around this area (low saturation flow rates).  This means traffic assignment becomes redundant.  In my opinion, if you are building a model without route choice and with standard (4 leg & 3 leg) signalised intersections, Paramics isn't necessary, you might as well stick with SIDRA.

  ***GHD Response***
  *It is agreed that the networks being assessed have little logical alternate route choices (and no route choice at all in the case of the Wanneroo study network).  However, one of the biggest drawbacks of using SIDRA analyses only is that the interaction and impact of upstream and downstream intersections cannot be efficiently considered.  The microsimulation model enables the network to be considered as an integrated system and the interaction between junctions can be evaluated.  In the case of the corridor network of the Wanneroo study area, the impact of queuing, vehicle platooning and signal co-ordination was easily considered within microsimulation framework.  Additionally, the ability to visual see the simulation model in operation enables a greater understanding (particularly to non-technical persons) of the anticipated network performance.*
- GHD have used fixed time signals rather than vehicle actuated signals.  If traffic demand increases dramatically in the 2031 scenarios, the signal phasings may need to be modified.

  *GHD Response*
  *During the 2031 scenario testing phase times were modified from the existing times to account for change in volumes, if required.  Sidra models were initially run to obtain the starting point for signal operations, and then modified further through inspections of the models in operation.*

- Heavy vehicles have been considered which is good.

- The reports are not clear whether or not public transport (bus routes) have been considered.

  *GHD Response*
  *Bus routes were not coded into the models, as public transport operations were not critical to the traffic model component of the study.*

- The calibration results are excellent.  However this isn't surprising given the models have limited route choice.
  *GHD Response*
  *Agree, given the study area neworks a high level of calibration could be reasonably expected.*

- The travel time validation criteria is stated as "*Percentage difference between total observed and total modelled journey times for each route should be less than 15% or 1-minute (whichever is greater).*" I am not sure where this criteria has come from. Is a reference available?

  *GHD Response*
  *This travel time validation criteria is from the Design Manual for Roads and Bridges (DMRB) (prublished by Highways Agency, UK) and is also stated within the latest RMS (previously RTA) Traffic Modelling Guidelines (to be officially released shortly).*

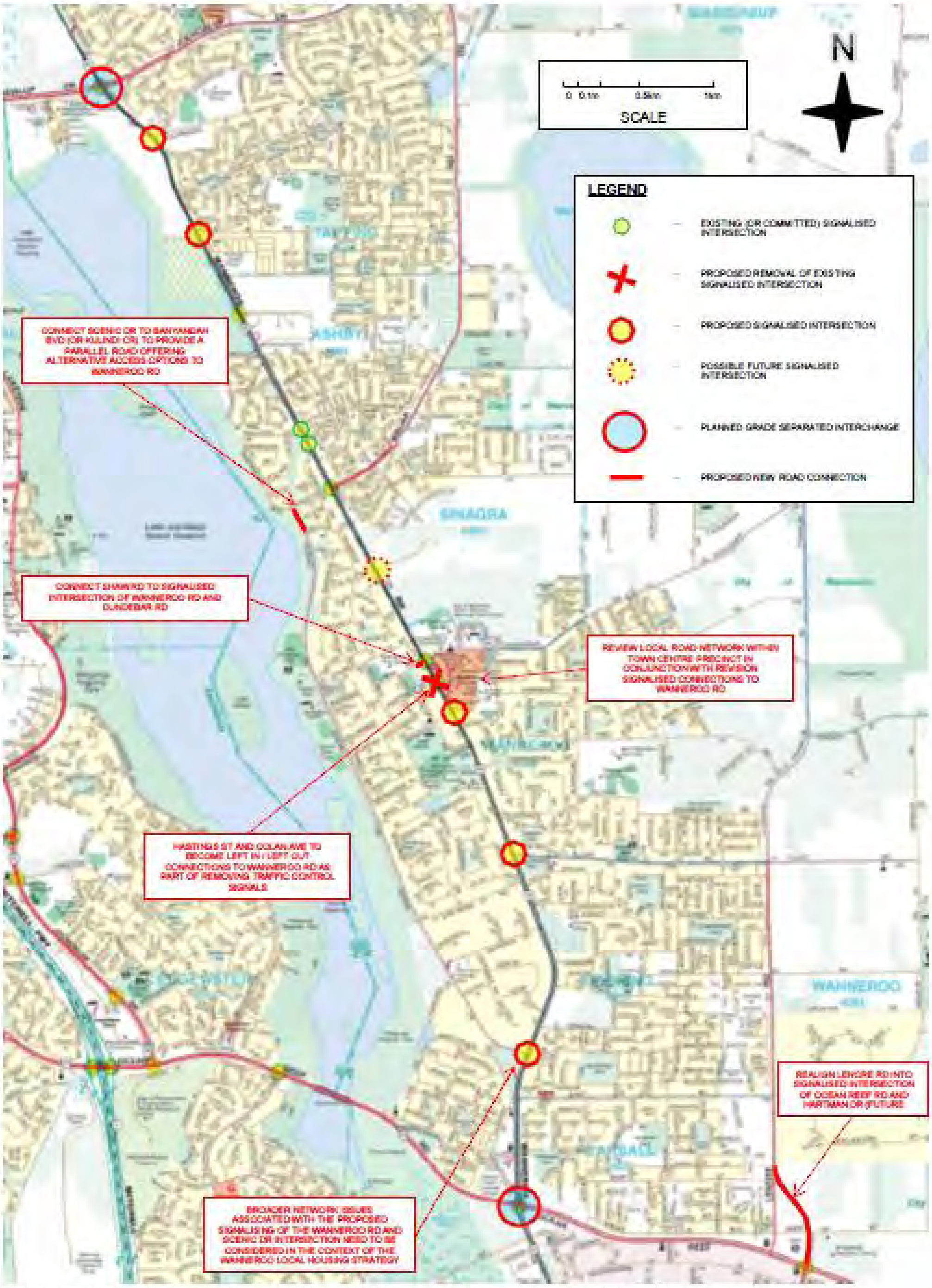
- The report is not clear whether the observed journey times where measured once each, or are averaged over multiple runs. Best practice is to measure multiple journey times on site, and then calculate both an average and a confidence interval for each journey (as per the RTA guidelines).

  *GHD Response*
  *Observed travel times were the result (average) of multiple runs of a floating car travel time survey. The Wanneroo study area consisted 5 recordings for each direction and the Girrawheen study area 2 recordings for each network section (Note, there were 14 sections in total).*

- GHD have used an Azalient Ceejazz plugin which isn't owned by Main Roads. This means the model runs cannot be run by Main Roads (unless we purchase a plugin of our own)
  *GHD Response*
  *These plugins enhance the functionality of the core simulation software (and are available from Azalient at a modest cost).*

- Sections 5.3 demonstrates that the model is stable (no gridlocking) which is good.

A copy of Main Roads preferred signal strategy for Wanneroo Road and road network option is shown overleaf.




**WANNEROO HOUSING PRECINCT - POSSIBLE ALTERNATIVE ROAD NETWORK OPTION 1**

MAIN ROADS Western Australia
Wanneroo Local Housing Strategy – Possible Alternative Road Network Option 1

GHD

GHD House, 239 Adelaide Tce. Perth, WA 6004
P.O. Box 3106, Perth WA 6832
T: 61 8 6222 8222   F: 61 8 6222 8555   E: permail@ghd.com.au



\\ghdnet\ghd\AU\Perth\Projects\61\28180\WP\128871.docx

Document Status

| Rev No. | Author | Reviewer | | Approved for Issue | | |
|---|---|---|---|---|---|---|
| | | Name | Signature | Name | Signature | Date |
| 0 | S McDermott<br>S Bennet | P Fisher | *Paul Fisher* | P Fisher | *Paul Fisher* | *21-1-2013* |
| | | | | | | |
| | | | | | | |

www.ghd.com

# City of Wanneroo

## Wanneroo Housing Precinct
## Traffic Impact Assessment

January 2013

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

# Table of contents



# Table index

# Figure index



# Appendices

# 1. Introduction

The City of Wanneroo is proposing increases to R Coding in the Wanneroo Housing Precinct. This will result in a significant increase in the number of dwellings and population in this area, which will impact on the number of trips generated.

A plan showing the location of the Wanneroo Housing Precinct is shown in Figure 1-1 and Figure 1-2.

As a result, a traffic impact assessment (TIA) is required for the road network to satisfy MRWA and Department of Planning and for the local road network which is the City's responsibility. The broad requirements of the TIA are identified as follows:

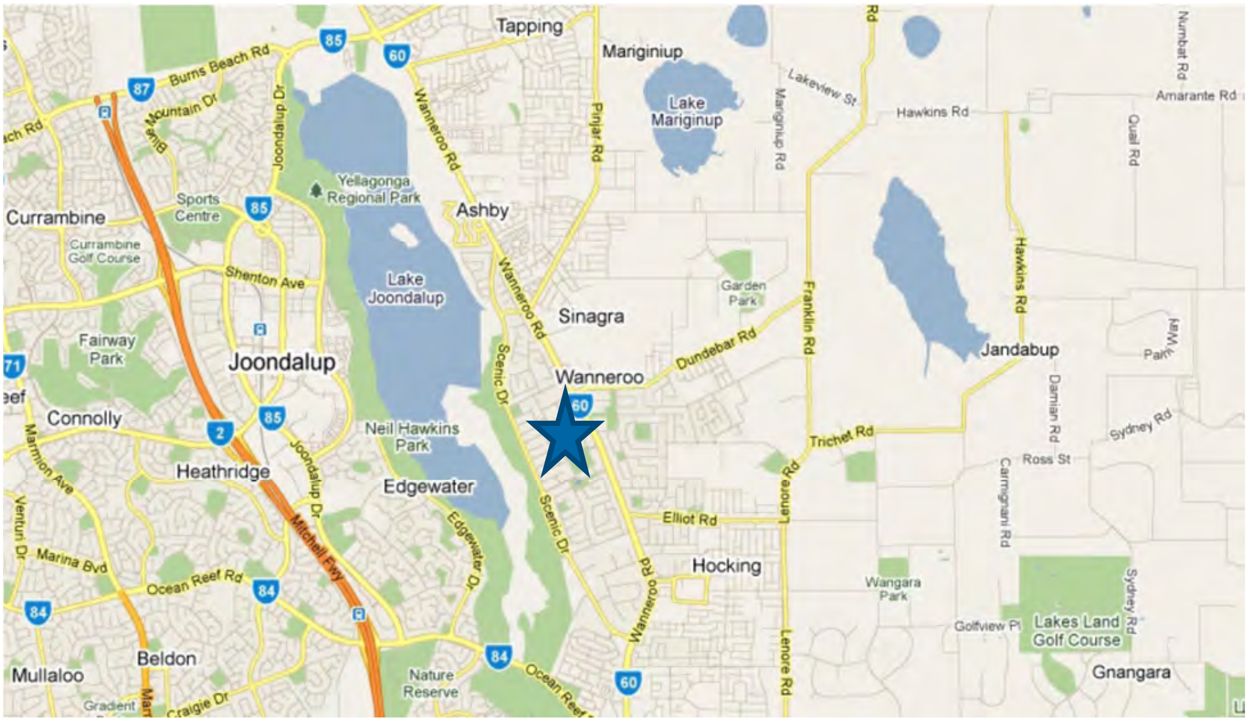
- Assess impacts of this additional traffic on the immediate regional road network as well as the local road network.
- Recommend improvements which may be required to those road networks to address the impacts.
- Estimate for each of these improvements, the proportion of that improvement which can be considered attributable to the density increases in the Wanneroo Precinct, as distinct from population and traffic increases occurring in the wider region.
- Estimate costs for the undertaking of each of the recommended road network improvements and then applying the proportions estimated to each cost estimate.

## 1.1 Scope of work

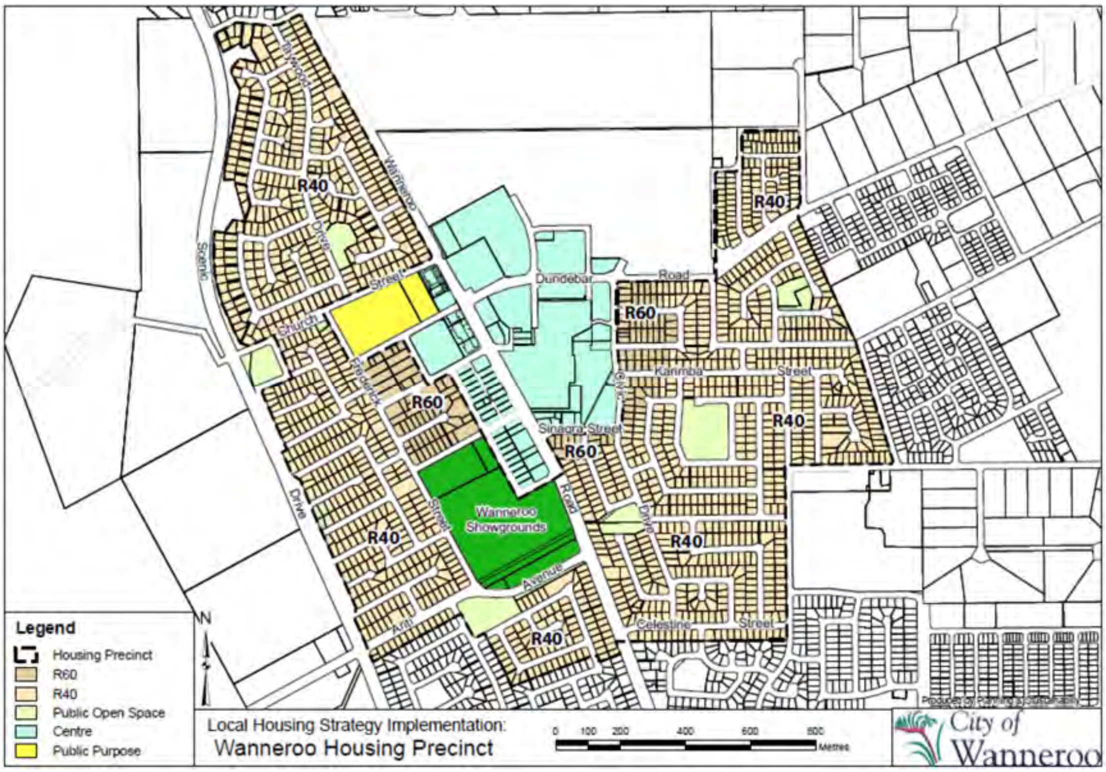
The following scope of work has been undertaken:

- Land Use Input to Main Roads Regional Operations Model (ROM) to allow Main Roads to model the increased densities.
- Undertake localised modelling.
- Undertake Sidra intersection analysis for the following scenarios:
  - Existing layout to 2031, no local housing strategy (LHS) forecast traffic volumes
  - Proposed layout using future traffic volumes 2031 with LHS
- Make recommendations for road network improvements.
- Prepare concept designs for improvements.
- Prepare cost estimates.
- Apportion costs based on ROM modelling.
- Review Wanneroo Town Centre area local traffic study.
- Prepare final report.

### Figure 1-1 General location of study area




### Figure 1-2 Housing strategy area



# 2. Stakeholder liaison

## 2.1 City of Wanneroo

The following summarises the consultation with the City of Wanneroo.

- An inception meeting was held with Planning Officers at the City of Wanneroo. The following was discussed.
  - Base aerial photo, high res. - Council will arrange.
  - Traffic data - Planners were liaising with Council's engineers and will provide any available information.
  - Intersection Counts – Main Roads have been asked for SCATS info at all relevant signals. GHD will need to arrange others up to the provisional sum value.
  - Council were asked for their construction rates for our subsequent costing of measures.
  - Council can provide suitable base for any conceptual design.
  - Shawmac report for Wanneroo Town Centre has been provided.
  - GHD's Planning Officer to follow up with Council regarding Structure Plans.
  - Council were advised GHD can provide estimate of costs for land acquisition (based on Council advice regarding land costs), design costs and survey costs. However we cannot provide costs for services implications only flag issues. Council were advised that costing for relocation, protection etc is impossible at this stage. GHD will flag issues based on One Call Info and allow a contingency based on experience elsewhere (subject to exclusions and qualifications).
  - Council advised that the contact for liaison with DoT is Mohsin Mutaqui.
  - Council advised that the contacts at Main Roads are John Van Luen, David van Den Dries, Wes Soet (Modelling)

Council advised recent road upgrades include:

  - Pinjar Rd/Wanneroo Rd signals
  - Dundebar Rd/Wanneroo Rd, double right turn from Dundebar Road is underway.
  - There are plans for Wanneroo Rd north of Dundebar Rd.
  - Wanneroo Rd (Ashby to Tapping recently upgraded)
  - Grade separation of Ocean Reef Rd/Wanneroo Rd long term plan (discuss timing with Main Roads)
  - Ocean Reef Road now connects with Gnangara Road.

Council confirmed:

  - Important to look specifically at traffic volume increase within the precincts of Wanneroo and Girrawheen - Koondoola and their impacts.
  - East Wanneroo to be included as per brief.
  - Keep client advised of progress and any issues.
  - Council were advised of likely delays in ROM modelling turnaround in view of Main Roads commitments in this area.

- The City was consulted regarding the content of the land use input to the ROM model and asked for acceptance of the results prior to asking Main Roads to run the ROM model

## 2.2 Main Roads Western Australia (MRWA)

Contact was made with Main Roads as follows:

- Main Roads was contacted for base traffic data including:
  - SCATS information
  - ROM model traffic zones for land use input
  - Traffic signal information
- Main Roads was also consulted regarding confirmation of the extent of Paramics modelling and ROM areas to be modelled.
- Main Roads was asked to advise of any road upgrades planned in the future and GHD were advised that no works were planned that would impact on this study.

## 2.3 Department of Transport (DoT)

Contact was made with DoT regarding the East Wanneroo North-South Road (EWNSR) and the following provides a summary of the current status:

- Department of Planning has completed a route alignment study for the East Wanneroo N-S Road between East Wanneroo and Tonkin Highway. There is more work to be done.
- The route will be a freight route and Primary Regional Road.
- The route is justified within the study.
- This has now been handed over to Main Roads. (Lindsay Broadhurst/Justin McKirdy)
- The N-S route will connect with Tonkin Highway along the new section of Hepburn Avenue.
- There will be no connection to Marshall Road; this will be a fly over.
- EWNSR joins Perth Darwin National Highway north of Reid Highway. There will be an interchange at Hepburn Ave.
- There will be an interchange at N-S Road/Reid Highway/Tonkin Highway
- The treatment and intersections of Beechboro Road is uncertain at this stage.
- The N-S road is likely within 20 years and may or may not include grade separation in the first stage.
- The will be no connection to Hepburn Avenue (new N-S Route) permitted.
- Main Roads will probably commence their Planning Study in 2012 and anticipate this will take 12-18 months to complete.

# 3. Literature review

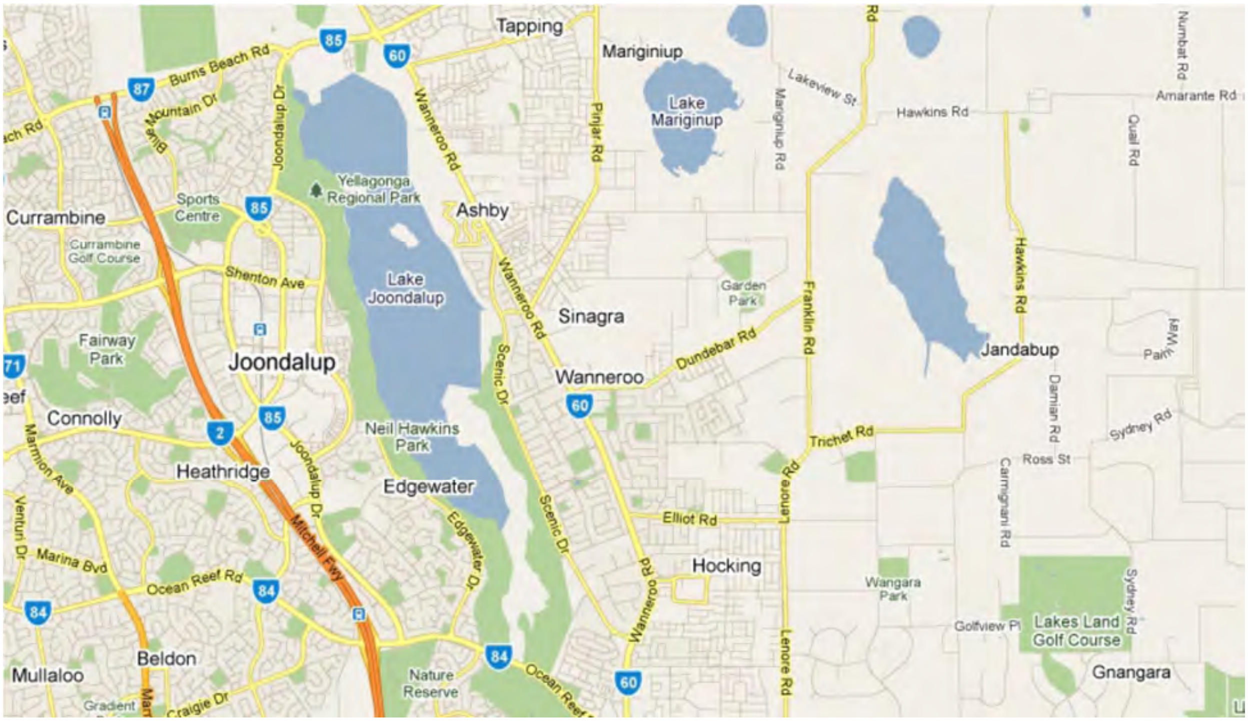
## 3.1 Transport assessment – Wanneroo town centre, (22 September 2011)

The City of Wanneroo has previously engaged Shawmac to undertake a local traffic study for a section of the Wanneroo town centre area.

### 3.1.1 Study area

The study area for the Wanneroo Town Centre Transport Assessment is shown in Figure 3-1.

Figure 3-1 General location of study area



### 3.1.2 Road hierarchy

Figure 3-2 identifies the existing road hierarchy

- Light Blue – Primary Distributor
- Green – District Distributor A
- Dark Blue - District Distributor B
- Brown - Local Distributor

Figure 3-2 Road hierarchy

### 3.1.3 Future road network

The road network will be expanded as shown in Figure 3-3 to accommodate planned development i.e Roads 1 to Road 7.

Figure 3-3 Future road network in Wanneroo town centre


### 3.1.4 Regional considerations

The Department of Planning, Urban Transport Systems Directorate commissioned a planning study entitled North West Corridor Structure Plan Review - Strategic Assessment of Regional Transport Requirements (2009) which was conducted in the context of the proposals for residential, industrial and commercial developments in the Region such as St. Andrews, Alkimos-Eglinton, Neerabup Industrial Area and East Wanneroo. These developments are expected to generate substantial traffic and will therefore have a significant impact on transport infrastructure and service requirements in the North West Corridor.

This study recommends Wanneroo Road to remain as four lanes, with provision for bicycle and public transport as required. This study also recommends additional north south traffic capacity along Lenore-Franklin Roads and a new high standard road east of East Wanneroo.

### 3.1.5 Proposed road hierarchy

The report recommends the road hierarchy shown in Figure 3-4.

Figure 3-4 Proposed road hierarchy


### 3.1.6 Conclusions and recommendations

The report provides the following conclusions and recommendations:

- Based on an expected trip generation rate, it is estimated that the WTC will generate approximately 11,000 trips per day and attract approximately 27,800 trips per day. Assuming a distribution based on predicted desire lines based on the MRWA OD Matrix it is expected that flows on Dundebar Road could increase to approximately 21,800 vehicles per day (vpd) near the intersection with Wanneroo Road.
- It is anticipated that the intersection of Wanneroo Road and Dundebar Road will be at a level of service F in peak hours if two lanes per carriageway on Wanneroo Road is maintained. The upgrading of this intersection and the section of Wanneroo Road adjacent to the intersection is currently being investigated by State Government agencies.
- The future development scenario of East Wanneroo envisages that the road alignment of Franklin - Lenore Road will be upgraded to a dual carriageway 4-lane cross section with medians and turn pockets. Existing roads and intersections except the intersection of Wanneroo Road and Dundebar Road are predicted to perform satisfactorily under the increased traffic load and no upgrading of existing infrastructure is required.

- The future widening of Wanneroo Road between Dundebar Road and Wallawa Street currently under investigation may require additional land area east of Wanneroo Road as road reserve; and if this proposal proceeds the development land area will be reduced.
- The proposed mixed use development fronting Wanneroo Road will be accessed from lane ways servicing the lots and connect to local side roads. No new crossovers will be created for these developments.
- Roundabout on Neighbourhood Connectors can be supported on the grounds of moderating operating speed and improve safety. Intersections within the Residential Precinct can be configured as unchannelised intersections without loss of serviceability.
- Footpaths network are recommend for all local roads within the Residential Precinct given the density of the development and to encourage residents to walk to WTC and access public transport services.
- A shared footway is to be provided on Friars Drive linking the Residential Precinct with the adjacent development area in Sinagra.

## 3.2 Planning documents

GHD has reviewed planning documents as follows:

- Mirrabooka Local Area Plan
- City of Wanneroo Local Housing Strategy, Estimated Rates of Development of New Dwellings in Wanneroo and Girrawheen-Koondoola Precincts.
- Wanneroo Local Area Strategy Plan, Planning and Sustainability, Local Planning Policy Framework, Local Planning Policy 3.1: Local Housing Strategy Implementation.

# 4. Land use update

## 4.1 Planning investigation

Main Roads Western Australia has provided GHD with details of the traffic zones within the ROM model for the study area including a 1km buffer around the Wanneroo Housing Precinct.

GHD's Planners have updated the landuse for each of the traffic zones following a review of local structure plans, relevant planning documents, liaison with the City of Wanneroo and Main Roads Western Australia. The City of Wanneroo have reviewed and agreed the planned landuse inputs and assumptions.

A spreadsheet showing the content of the ROM traffic zones for 2031 with and without the R Code Increases is shown in Appendix A.

Main Roads WA has subsequently run the ROM model incorporating the increased R Code for use in the transport assessment for the Wanneroo Housing Precinct.

The land use inputs include:

- Population.
- Occupied dwellings.
- Households.
- Manufacturing, commercial and retail employment numbers.
- School attendee numbers.

The Paramics model also includes the increased R codes and ROM output and is discussed further in Section 5.

# 5. Network modelling

A localised network model of the central Wanneroo area was required in order to assess the impacts of forecast traffic volumes.  The development of models simulating both 'with density increase' (with LHS) and 'without density increase' (without LHS) scenarios was undertaken to allow a clear comparison to be drawn that isolates the traffic impacts attributable to the proposed changes in R-coding.

Paramics microsimulation traffic modelling software has been used in conjunction with Azalient Ceejazz plugins.

## 5.1 Localised network modelling study area

GHD has developed models that include the key Wanneroo Road corridor, and its intersections with the following:

- Pinjar Road.
- Church Street.
- Dundebar Road.
- Celestine Street.
- Ariti Avenue; and
- Elliot Road.

The modelled network is displayed in Figure 5-1.

Figure 5-1 Simulation model network

## 5.2 Base models

Base models were initially developed to represent the current on-site conditions through the study area. These AM and PM peak models were calibrated to traffic volume data and validated against recorded on-site sectional travel times to ensure they provided a comprehensive representation of the existing conditions.

A detailed model validation report has been prepared which documents the inputs, methodology, and results of the base model development and calibration. This validation report is attached as Appendix B The key elements of the validation process are summarised below.

### 5.2.1 Data inputs

The key data sources and inputs into the base model included the following:

- Traffic volume data: Data included manual turning movement surveys, SCATS detector loop counts and historical tube counts.
- Traffic signal information: SCATS data was sourced from Main Roads (including IDM files, Traffic Control Signal (TCS) graphics and intersection timing charts).
- Travel time data: Sectional travel times were recorded for the key sections along Wanneroo Road; and
- ROM outputs: Main Roads provided strategic model sub-area trip matrices from the ROM.

Public transport data i.e. bus routes, were not coded into the model network as operationally they were not considered critical to the traffic modelling component.

### 5.2.2 Base trip matrices

Trip matrices for both the AM and PM periods were developed by combining the known turning movement volumes (from recent surveys) with the routing patterns and trip distributions obtained from the ROM sub-area cordon outputs. These trip matrices were refined and entered into the simulation model as demand inputs. (Further information regarding the trip matrix developed is in Appendix B).

### 5.2.3 Calibration/validation results

Each recorded turning movement count was compared against the equivalent model output to assess whether the model was representing on-site conditions. The statistical GEH measure was used as the primary acceptance criteria (the GEH statistic is explained in detail in Appendix B), whereby comparisons should produce a GEH value less than 5 to be considered a reasonable fit. Table 5-1 summarises the AM and PM Base model calibration results. Modelled results are the average of five seed runs.

Table 5-1 Base model turning volume calibration results summary

| Time Period | Number of Observations | Observations with GEH < 5 | Average GEH | R2 and Slope | Exceeds Criteria? |
|---|---|---|---|---|---|
| AM Peak | 40 | 40 (100%) | 1.53 | 0.99, 1.039 | Yes |
| PM Peak | 40 | 40 (100%) | 1.19 | 0.99, 0.969 | Yes |

Travel time recordings were also compared against the modelled equivalent as a validation check following the traffic volume calibration process. Modelled travel times within 15% or 1 minute of the recorded time were considered to represent a reasonable fit. This validation criteria is adopted from the Design Manual for Roads and Bridges (DMRB) (and is also stated within the latest RMS NSW Traffic Modelling Guidelines, to be release shortly). Table 5-2 summarises the AM and PM Base model travel time validation results. It should be noted that observed journey times were the result (average) of multiple runs of a floating car travel time survey (5 recordings for each direction for each time period).

Table 5-2 Base model travel time validation results summary

| Time Period | Number of recorded travel time sections | Observations within 15% or 1-minute | Exceeds Criteria? |
|---|---|---|---|
| AM Peak | 6 | 6 (100%) | Yes |
| PM Peak | 6 | 6 (100%) | Yes |

Both the AM and PM Base models were found to represent observed on-site conditions closely, and were hence considered a robust platform against which to assess the future year scenarios.

***Shared model space: Wanneroo and Girrawheen***

It should be noted that this Wanneroo model network has been developed at the same time as a Girrawheen study area model has been developed also for City of Wanneroo. Given the close proximity of these two areas, the two models have been developed within the same Paramics model space. The models can be run together (although the two networks do not interact with each other) or separately (by specifying demands for an individual network).

## 5.3 Forecast traffic volumes

### 5.3.1 Trip matrix

The calibrated base model trip matrices were taken as the starting point for determining the forecast 2031 demand matrices. AM and PM peak hour periods were analysed separately. The methodology implemented was as follows:

- The base model demand matrices were factored based upon the updated ROM outputs.
- Trip attractions and productions for individual zones based upon the existing, and proposed, land uses were assessed and applied to the corresponding zones within the simulation model network.
- The movements to/from zones within the Paramics model (which represent roads connecting into the study area) were consequently scaled based upon the revised land uses of the areas feeding these road connections.
- The escalation of trip attractions and trip productions were applied separately and the resulting demand matrix balanced to ensure any changes to distributions were incorporated into the 2031 matrices.

The above process was applied for the AM and PM peak hour matrices for the ’with LHS’ and ‘without LHS’ scenarios.

***ROM outputs***

Main Roads’ Regional Operations Model (ROM) data was provided as a sub-area cordon trip matrix for the alternate scenarios. The coarseness of the zone structure as well as the 24-hour time period which ROM operates meant that the outputs were not used as a direct input into the simulation model. Instead the ROM outputs were used to evaluate the magnitude of forecast trip volume escalations as well as providing an initial distribution of trips across the study area.

Main Roads incorporated the revised and updated lane use figures (discussed in Section 4) for the alternate scenarios into ROM, and subsequently provided the corresponding 2031 trip matrices for the with and without LHS options. These outputs were then used in the simulation model trip matrix development as described above.

***Development north of Dundebar Road***

The proposed development north of Dundebar Road and east of Wanneroo Road (including Wanneroo Town Centre) is expected to generate a substantial volume of traffic once developed. This development has been included into the updated land use forecasts and consequently into ROM. Accordingly, the forecast 2031 traffic volumes used for the simulation modelling (for both with and without LHS scenarios) include the trips associated with this development area. It is noted that a previous study has focussed specifically on the proposed Wanneroo Town Centre residential development (*Transport Assessment – Wanneroo Town Centre, Wanneroo, Shawmac, September 2011*). For the purposes for the simulation modelling to assess the network impacts expected to occur due to the broader increase in housing densities, the Wanneroo Town Centre trips needed to be included into the forecast trip matrix development.

Connections from the proposed development area onto Wanneroo Road do not currently exist, as such the movements to and from this area could not be calibrated or recorded as part of the Base modelling. Also, the ROM zone for the development area in question connects onto the wider network through a single connector onto Dundebar Road. A review of the aforementioned traffic report (Shawmac, September 2011) revealed that the proposed development traffic would access the broader area via not only Dundebar Road, but also Wanneroo Road (through a new direct connection and intersection) and Pinjar Road. For the purposes of the trip matrix development it was assumed that half of the new development traffic would connect onto Dundebar Road, with the remaining movements shared equally between Wanneroo Road (through a new intersection) and Pinjar Road.

### 5.3.2 Turning movement volumes

Following the determination of trip matrices, the corresponding forecast turning movement volumes were then analysed. The 2031 turning movement volumes were determined by applying the demand files (trip matrices) to the simulation network and recording the turning movements. The resulting 2031 forecast turning movement volumes for key intersections within the study network are presented in Appendix C. These display the forecast AM and PM volumes for both the 'with LHS' and 'without LHS' scenarios.

## 5.4 Scenario testing

A sequential and staged approach was implemented for the various scenario tests to assess the impact to the road network with, and without, the increased R-coding ratings i.e. with/without the local housing strategy (LHS) in place. Consequently the following scenarios were assessed within the simulation model (note, the following scenarios all consisted of a 2031 horizon year):

- Existing network (plus currently planned modifications) 'without LHS' volumes;
- Existing network (plus currently planned modifications) 'with LHS' volumes;
- Suggested network upgrades to facilitate 'without LHS' volumes;
- Suggested network upgrades for 'without LHS' with 'with LHS' volumes; and
- Suggested network upgrades to facilitate 'with LHS' volumes.

***Known and committed network upgrades***

It is understood that there are currently plans to upgrade the intersection of Wanneroo Road and Dundebar Road to include a double right turn from Dundebar Road to Wanneroo Road. As this modification is believed to be committed, it has been included in the future 'existing network' scenario tests. Accordingly these scenarios have been referred to as 'Do-Minimum' (DM), which represents the existing on-site network configuration plus the double right turn from Dundebar Road to Wanneroo Road.

### 5.4.1 Methodology for capacity enhancements

The process adopted to determine the network upgrades necessary to provide an acceptable level of service under the various scenarios, was as follows:

- Forecast traffic volumes were initially applied to the existing network configuration without any upgrades or capacity enhancements.
- The models were visually observed in operation to assess performance.
- Key areas of deficiencies within the network were identified, i.e. areas exhibiting substantial congestion or oversaturated conditions.
- Signal operation adjustments or refinements were implemented to improve the efficiency of the network. That is, congested conditions within the network were initially attempted to be resolved through the refinement of signal operations in the first instance. The dynamic nature of the SCATS signalling functionality on-site would attempt to optimise signal operations in a similar manner. Furthermore, adjustments to signal operations were preferable over capacity increases requiring infrastructure works.
- The performance of the network was evaluated through quantitative model outputs and qualitative model observations to determine where network capacity increases were required.
- Network upgrades were implemented into model network and then the assessment process repeated. That is, visual observations of the simulation model combined with quantitative outputs were used to evaluate the proposed intersection and mid-block modifications. Throughout the iterative process of determining required intersection upgrades, a level of service (LOS) D was targeted as the junction performance measure.

During this process, selected Sidra models were developed to assist with determining necessary upgrades. These Sidra models were used to determine broad capacity requirements and suggested signal operations, which were then taken into the Paramics microsimulation model and assessed as part of an integrated and connected road network.

The process described above was undertaken in an iterative manner to account for the fact that deficiencies within the network were not always initially identifiable. Due to the integrated network of intersections within the simulation model, congestion at neighbouring intersections can obscure or mask the actual performance of a given site. As such, the process above was conducted iteratively do address the most critical areas of concern first.

Following the simulation model scenario testing, and identification of broad network upgrade requirements, comprehensive Sidra models were run and analysed for the key sites throughout the network. These are discussed and presented in detail in Section 6.

- The modelling process outlined above was undertaken to determine the following;
- The upgrades likely to be required by 2031 assuming no change to current R-code ratings or density levels i.e. without implementation of the local housing strategy; and
- The further upgrades likely to be required if the local housing strategy is implemented and R-coding designations are increased to allow higher density developments.

The resulting suggested upgrade requirements from the modelling assessment were as follows for the scenario ***without LHS***:

- Wanneroo Road; Additional lane in each direction i.e. three lanes northbound and southbound, between Pinjar Road and Sinagra Street.
- Wanneroo Road/Pinjar Road; Double right turn from Wanneroo Road into Pinjar Road (i.e. south to east), double left turn from Pinjar Road to Wanneroo Road (i.e. east to south) and extended right turn lane (east to north). Southbound approach flaring to three through lanes.
- Signalisation of the following junctions with Wanneroo Road: Church Street, Ariti Avenue.

It is noted Main Roads do not support these measures and prefer a reconfiguration of access arrangements within the Town Precinct. Warrants for traffic signals at Ariti Avenue are not met as alternative access is available.  .

Signalisation of Wanneroo Road/Elliot Road. (Main Roads feedback is discussed further in Section 6).

New signalised intersection connecting into the area to be developed on the eastern side of Wanneroo Road, north of Dundebar Road.

It is noted Main Roads do not support this measure and comment as follows:

**"Future development of the land north of the Wanneroo town site in Sinagra will likely necessitate a new connection to Wanneroo Road. The report suggests Road 2, connecting Wanneroo Road opposite Hart Court, should be signalised. Main Roads does not support this suggestion due to its proximity to Church Street and Dundebar Road intersections. Planning work associated with the Wanneroo Road MRS amendment suggests a more appropriate location for a new connection may be within the vicinity of the existing Inghams Enterprises entrance. This location would be preferable to the Road 2 location because it will result in a more efficient arrangement of access along Wanneroo Road. Nevertheless, at a spacing of approximately 500m from up and downstream signalised intersections, such an outcome would be detrimental to the operation of Wanneroo Road. Consideration of implementing a parallel road connecting Pinjar Road and Dundebar Road may reduce the demand for this new connection and allow the proposed land development to access Wanneroo Road via existing signalised connections"**

Main Roads Western Australia

Section 6 of this report considers the operation of Pinjar Road/Wanneroo Road and Dundebar Road/Wanneroo Road intersections, the analysis indicates these intersections will be under pressure even without higher densities. It will be important to maintain at least left in/out to Wanneroo Road from any new access to Wanneroo Road. Analysis assumes a signalised intersection at Road 2 but the concerns of Main Roads regarding the proximity to other signalised intersections are acknowledged.

Main Roads also wish to promote the use of the Lenore Road/Franklin Road and the proposed East Wanneroo North-South Route. It is considered that traffic is likely to divert to this route as congestion increases on Wanneroo Road.

- Wanneroo Road/Dundebar Road; Double right turn lanes into and from Dundebar Road, extended left turn lane into and out of Dundebar Road.

Main Roads feedback is discussed further in Section 6.

Signal adjustments as required, i.e. phase times and some cycle times, to cater for changed traffic volumes/movements.  Removal of 'all-pedestrian' phase at Wanneroo Road/Hastings Street/Conlan Avenue.  The intention is not to remove all pedestrian movements; rather remove them from one crossing leg only, and to remove the scatter-phase (i.e all-ped phase).

Additional upgrades required to facilitate the 2031 ***with LHS***:

- The analysis has shown Wanneroo Road/Celestine Avenue would benefit from upgrading. (However, an alternative approach would be to encourage use of alternate routes as per Main Roads comment discussed further in Section 6)
- Signal adjustments as required.

It should be noted that the suggested upgrades above did not consider the available land on-site at these locations. The proposed configurations represent the ultimate junction layouts which would provide an acceptable level of service based upon the forecast traffic volumes. Consideration has been given to site constraints during the detailed intersection assessments discussed in Section 6.

The modelled intersection configurations of the three scenarios (i.e. Base, upgrades without LHS and upgrades with LHS) are presented in Appendix D.

## 5.5 Model results

Each scenario model was run five times with different seed values and the results extracted from each model. Statistical outputs were then averaged across the five seed value runs.

Results are presented in the sections below and show comparisons across the different scenarios for the following statistical outputs and performance measures:

- Intersection levels of service (LOS);
- Blocked (unreleased) vehicle summary for each zone; and
- Modelled travel time recordings for key routes through the network.

In addition to the quantitative results listed above, video files of the simulation models in operation have also been produced.

The result summary tables in the sections below display the following abbreviated scenario names:

- **BASE**: Existing conditions as per the calibrated Base model (current 2012 volumes).
- **DM w/o LHS**: Existing network i.e. Do-Minimum (DM), 'without LHS' volumes.
- **DM w/ LHS**: Existing network i.e. Do-Minimum (DM), 'with LHS' volumes.
- **NU w/o LHS**: Suggested network upgrades (NU) necessary to facilitate 'without LHS' volumes.
- **NU w/o LHS, w/ LHS vols**: Suggested network upgrades (NU) for 'without LHS', but modelled with 'with LHS' volumes.
- **NU w/ LHS**: Suggested network upgrades (NU) to facilitate 'with LHS' volumes.

Level of Service

The key statistical performance measure which has been used to evaluate the network and individual junctions is delay, which has subsequently been converted into a level of service (LOS). The intersections which have been analysed using the simulation model include a mixture of signalised and priority controlled sites. The average approach delay thresholds and corresponding LOS categories which have been utilised are as shown in Table 5-3.

Table 5-3 Level of service/delay categories

| Level of Service | Signals | Priority Control |
|---|---|---|
| A | 0s – 10s | 0s – 10s |
| B | 10s – 20s | 10s – 15s |
| C | 20s – 35s | 15s – 25s |
| D | 35s – 55s | 25s – 35s |
| E | 55s – 80s | 35s – 50s |
| F | 80s+ | 50s+ |

Table 5-4 outlines the recorded LOS for the AM peak scenario tests.

Table 5-4 Intersection level of service results: AM peak

| | BASE | DM w/o LHS | DM w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| Wanneroo Road / Dundebar Road | C | D | F | C | C | C |
| Wanneroo Road / Pinjar Road | B | F | F | C | C | D |
| Wanneroo Road / Hastings Street / Conlan Avenue | C | E | D | B | B | B |
| Wanneroo Road / Church Street | B | E | F | C | C | C |
| Wanneroo Road / Ariti Avenue | B | C | D | A | B | B |
| Wanneroo Road / Celestine Street | A | B | C | C | F | C |
| Wanneroo Road / Elliot Road | A | D | F | B | B | A |

Table 5-5 outlines the recorded LOS for the PM peak scenario tests.

Table 5-5 Intersection level of service results: PM peak

| | BASE | DM w/o LHS | DM w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| Wanneroo Road / Dundebar Road | B | D | D | C | C | C |
| Wanneroo Road / Pinjar Road | B | F | F | D | D | D |
| Wanneroo Road / Hastings Street / Conlan Avenue | C | F | D | C | E | D |
| Wanneroo Road / Church Street | B | F | D | B | B | B |
| Wanneroo Road / Ariti Avenue | F | F | E | A | B | B |
| Wanneroo Road / Celestine Street | A | A | A | A | B | A |
| Wanneroo Road / Elliot Road | A | F | F | B | B | B |

It can be seen from Table 5-4 and Table 5-5 that the anticipated performance of the network without any intersection upgrades (i.e. the Do-Nothing scenarios) is expected to be poor with numerous sites exhibiting LOS E and F. This is due to the forecast increase in traffic volumes, irrespective of an increase in density of the residential zones within the study area. Applying the recommended network upgrades results in acceptable levels of service for both the with/without LHS scenarios. Again, it is noted that the majority of upgrades are required regardless of the proposed housing density increases.

### 5.5.1 Blocked vehicle summary

Blocked (or 'unreleased') vehicles occur within the simulation when the full extent of the traffic demand cannot be loaded onto the model network. These blocked vehicles occur due to downstream network congestion or insufficient capacity on the link which connects the zone onto the model network. Blocked vehicles essentially represent the length of queue (in terms of number of vehicles) extending off the study area network.

Table 5-6 displays the modelled blocked vehicle summary for each zone across the various scenarios for the AM period. Note; only zones which exhibited blocked vehicles in at least one scenario have been included in Table 5-6.

Table 5-6 Blocked vehicle summary: AM peak

| Model Entry Zone | BASE | DM w/o LHS | DM w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| Wanneroo Road north | 0 | 317 | 481 | 0 | 0 | 0 |
| Pinjar Road | 0 | 330 | 519 | 0 | 0 | 0 |
| Church Street | 0 | 0 | 76 | 0 | 0 | 0 |
| Dundebar Road | 0 | 310 | 418 | 0 | 0 | 0 |
| Hastings Street | 0 | 4 | 61 | 0 | 0 | 0 |
| Celestine Street | 0 | 0 | 0 | 0 | 29 | 0 |
| Total | 0 | 960 | 1555 | 0 | 29 | 0 |

Table 5-6 displays the blocked vehicle summaries for the various scenarios for the PM period. Note; only zones which exhibited blocked vehicles in at least one scenario have been included in Table 5-6.

Table 5-7 Blocked vehicle summary: PM peak

| Model Entry Zone | BASE | DM w/o LHS | DM w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| Wanneroo Rd north | 0 | 161 | 256 | 0 | 0 | 0 |
| Pinjar Road | 0 | 178 | 245 | 0 | 0 | 0 |
| Dundebar Road | 0 | 1286 | 1395 | 0 | 76 | 0 |
| Hastings Street | 0 | 38 | 21 | 0 | 7 | 0 |
| Conlan Avenue | 0 | 364 | 624 | 0 | 55 | 0 |
| Elliot Road | 0 | 212 | 214 | 0 | 0 | 0 |
| Wanneroo Road south | 0 | 162 | 392 | 0 | 98 | 0 |
| Total | 0 | 2400 | 3147 | 0 | 236 | 0 |

It can be seen from Table 5-6 and Table 5-7 that the anticipated performance of the network without any intersection upgrades (i.e. the Do-Nothing scenarios) is expected to be poor with substantial numbers of trips unable to be access the network due to congestion. In particular Dundebar Road (as well as other connections onto Wanneroo Road) is expected to experience substantial congestion unless the network is upgraded.

### 5.5.2 Travel times

Modelled travel times for key Wanneroo Road sections have been extracted from each of the scenarios. The recorded sections are consistent with the sections recorded (and validated against) during the Base model development.

Table 5-8 shows the modelled travel time comparisons between each scenario for the AM period.

### Table 5-8 Modelled travel time result (seconds): AM peak

| Location | BASE | DM w/o LHS | DM w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| Southbound | | | | | | |
| Pinjar Road to Dundebar Road | 100 | 137 | 264 | 181 | 192 | 131 |
| Dundebar Road to Conlan Road | 16 | 21 | 23 | 22 | 23 | 20 |
| Conlan Road to Elliot Road | 73 | 74 | 74 | 99 | 100 | 115 |
| Northbound | | | | | | |
| Elliot Road to Hastings Street | 84 | 126 | 98 | 101 | 102 | 102 |
| Hastings Street to Dundebar Road | 28 | 49 | 39 | 32 | 32 | 32 |
| Dundebar Road to Pinjar Road | 79 | 124 | 120 | 111 | 129 | 113 |

Table 5-9 shows the modelled travel time comparisons between each scenario for the PM period.

### Table 5-9 Modelled travel time results (seconds): PM peak

| Location | BASE | DM w/o LHS | DM w/ LHS | NU w/o LHS | NU w/o LHS, w/ LHS vols | NU w/ LHS |
|---|---|---|---|---|---|---|
| Southbound | | | | | | |
| Pinjar Road to Dundebar Road | 98 | 138 | 139 | 131 | 124 | 125 |
| Dundebar Road to Conlan Road | 17 | 14 | 15 | 24 | 32 | 33 |
| Conlan Road to Elliot Road | 72 | 73 | 73 | 95 | 95 | 108 |
| Northbound | | | | | | |
| Elliot Road to Hastings Street | 96 | 188 | 116 | 141 | 192 | 147 |
| Hastings Street to Dundebar Road | 20 | 55 | 44 | 39 | 41 | 41 |
| Dundebar Road to Pinjar Road | 85 | 225 | 195 | 172 | 180 | 149 |

Observations of the travel time results presented in Table 5-8 and Table 5-9 reveal the following trends:

- All sections are expected to experience increased vehicle journey times along the Wanneroo Road corridor if no network modifications are applied; and
- Adopting the suggested network upgrades would provide the least increase in travel times through the study area. However increased journey times compared to current conditions would still be expected.

## 5.6 Trigger Points

A number of horizon year sensitivity tests were undertaken to determine the required staging of the suggested upgrades. Five and ten year horizons were adopted to determine the intersections requiring treatment within the short/medium term. The trigger/threshold assessments were undertaken separately for the scenarios with and without the proposed LHS. The following methodology was employed for this assessment:

- The escalation of traffic between the current (2012 Base) scenario and 2031 forecast year (i.e. 20 year horizon) was determined for without and with LHS scenarios;
- A linear escalation of the forecast traffic volume increases was assumed, such that 25% of the increase would occur over the next 5 years, and similarly 50% of the forecast increase would occur over ten years;
- The traffic demands corresponding to 5 and 10 year horizons were calculated separately for AM and PM peak periods.
- The calculated interim year traffic volumes were applied to the simulation model with the current road configuration to assess the anticipated network performance.

**Table 5-10** and Table 5-11 present the modelled intersection performance results of the scenario testing without LHS and with LHS respectively.

The recommended staging of intersection treatments is discussed in Section 7.

Table 5-10 Intersection Performance – Without LHS

| | 5 year | | 10 year | |
|---|---|---|---|---|
| | AM peak | PM peak | AM peak | PM peak |
| Wanneroo Rd / Dundebar Rd | C | C | D | D |
| Wanneroo Rd / Pinjar Rd | B | B | C | D |
| Wanneroo Rd / Church St | D | D | F | F |
| Wanneroo Rd / Ariti Ave | B | F | E | F |
| Wanneroo Rd / Celestine St | B | A | B | A |
| Wanneroo Rd / Elliot Rd | B | A | C | C |

Table 5-11 Intersection Performance – With LHS

| | 5 year | | 10 year | |
|---|---|---|---|---|
| | AM peak | PM peak | AM peak | PM peak |
| Wanneroo Rd / Dundebar Rd | C | C | E | D |
| Wanneroo Rd / Pinjar Rd | B | B | D | C |
| Wanneroo Rd / Church St | C | C | C | F |
| Wanneroo Rd / Ariti Ave | F | D | F | F |
| Wanneroo Rd / Celestine St | C | F | D | F |
| Wanneroo Rd / Elliot Rd | B | A | C | A |

# 6. Intersection analysis and road network improvements

The following section considers the intersection requirements based on the forecast traffic volumes from both the Paramics modelling and ROM modelling and subsequent Sidra modelling.

The following Sidra analysis has been undertaken

- Undertake Sidra intersection analysis for two scenarios:
  - Existing layout to 2031, no LHS forecast traffic volumes
  - Proposed layout using future traffic volumes 2031 with increased R Code

A summary of all Sidra analysis for scenarios with and without LHS to 2031 is shown in Appendix E and F.

The following intersections have been analysed:

- Wanneroo Road/Dundebar Road Intersection 2031.
- Wanneroo Road/Hastings Road Intersection 2031.
- Wanneroo Road/Elliot Road Intersection 2031.
- Wanneroo Road/Celestine Road Intersection 2031.
- Wanneroo Road/Ariti Ave Intersection 2031.
- Wanneroo Road/Pinjar Road Intersection 2031.

## 6.1 Wanneroo Road cross section

Main Roads have provided the following comment regarding the cross section of Wanneroo Road.

**"Wanneroo Road Metropolitan Region Scheme (MRS) amendment from Wallawa Street to Dundebar Road involves widening the road reservation to be consistent with the existing reserve width north and south of the Wanneroo town site. This widening is intended to provide the opportunity of an additional lane in each direction. However, this lane is currently identified as a bus lane and therefore the existing four lane configuration should be utilised as the future configuration for Wanneroo Road within this area.**

**Further, ARRB's North West Corridor Structure Plan Review – Strategic Assessment of Regional Transport Requirements – October 2009 concluded / recommended that:**

**Wanneroo Road consist of four lanes through Wanneroo town site, with widening for turn lanes, but accepting it will be about 10% overloaded in 2031; and**

**Additional north south capacity through the area is required and can be achieved by improvements to Lenore Road/Franklin Road and the proposed East Wanneroo North South Route "**

Main Roads Western Australia

## 6.2 Intersection analysis 2031 (existing layout with no LHS)

This section summarises the analysis of the current geometry at key intersections to 2031 with No LHS. It indicates whether the existing geometry needs to be upgraded. Full analysis and intersection layouts are shown in Appendix F. Intersection layouts are not repeated here.

*It should be noted that most intersections considered are forecast to require upgrade based on the surrounding traffic growth without the increased traffic generation due to the planned increased housing density.*

### 6.2.1 Wanneroo Road/Dundebar Road intersection 2031

The analysis with no LHS indicates an intersection LoS of F to 2031 for the current geometry. Stop rates for some movements are greater than 3 and the degree of saturation is 1.285 to 1.517. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance.

### 6.2.2 Wanneroo Road/Hastings Road intersection 2031

The analysis with no LHS indicates an intersection LoS of F to 2031 for the current geometry. Stop rates for some movements are greater than 2 for some movements and the degree of saturation is 1.024 to 1.206. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance.

### 6.2.3 Wanneroo Road/Elliot Road intersection 2031

The analysis with no LHS indicates an intersection LoS of F to 2031 for the current geometry. Stop rates for the right turn out of Elliot Road are around 7 and the degree of saturation is up to 8. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance.

### 6.2.4 Wanneroo Road/Celestine Road intersection 2031

The analysis with no LHS indicates an intersection LoS of E/ F to 2031, for the current geometry. Stop rates for the left turn out of Celestine Street Road are around 5 and the degree of saturation is up to 2.223. Queuing is significant and unacceptable in Celestine Street. The analysis indicates that upgrade is required to improve the performance.

### 6.2.5 Wanneroo Road/Ariti Ave intersection 2031

AM analysis has been undertaken only. The analysis with no LHS indicates an intersection LoS of E/ F to 2031, for the current geometry. Stop rates for the left/right turn out of Ariti Avenue are around 3 and the degree of saturation is up to 1.211. Queuing is significant and unacceptable in Ariti Ave. The analysis indicates that upgrade is required to improve the performance.

### 6.2.6 Wanneroo Road/Pinjar Road intersection 2031

The above analysis indicates an intersection LoS of E/ F to 2031 with no LHS, for the current geometry. Stop rates for some movements are in excess of 1 for a number of movements. The degree of saturation is up to 1.291. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance.

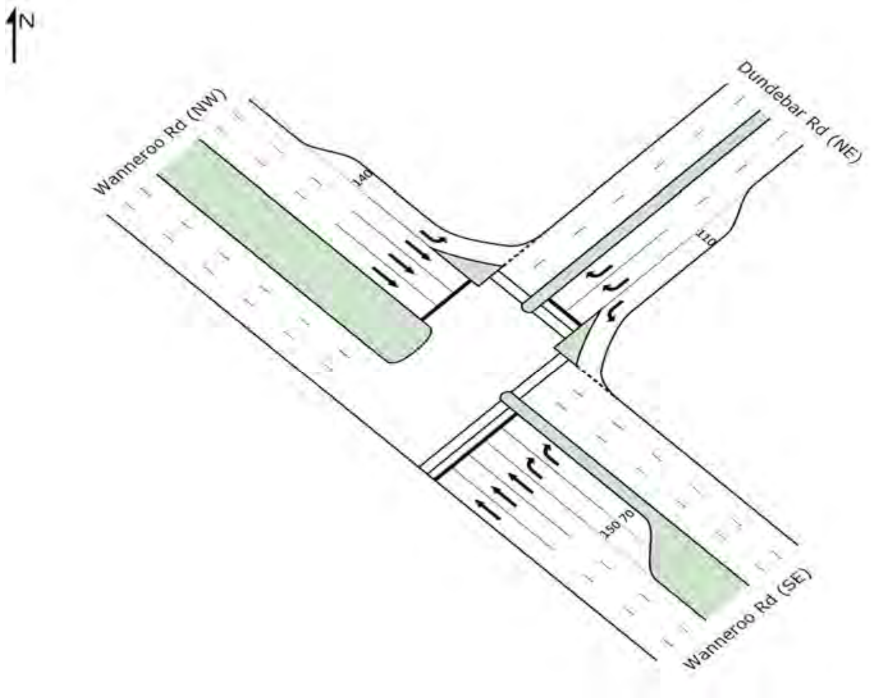
## 6.3 Intersection analysis 2031 (proposed layout with LHS)

Analysis has been undertaken of a modified intersection to determine the ultimate requirement to achieve a good level of service, however in view of the fact that some sites are constrained a compromise layout is provided to avoid land acquisition. All layouts are shown in Appendix F and are not repeated here, only the recommended layouts.

### 6.3.1 Wanneroo Road/Dundebar Road intersection 2031

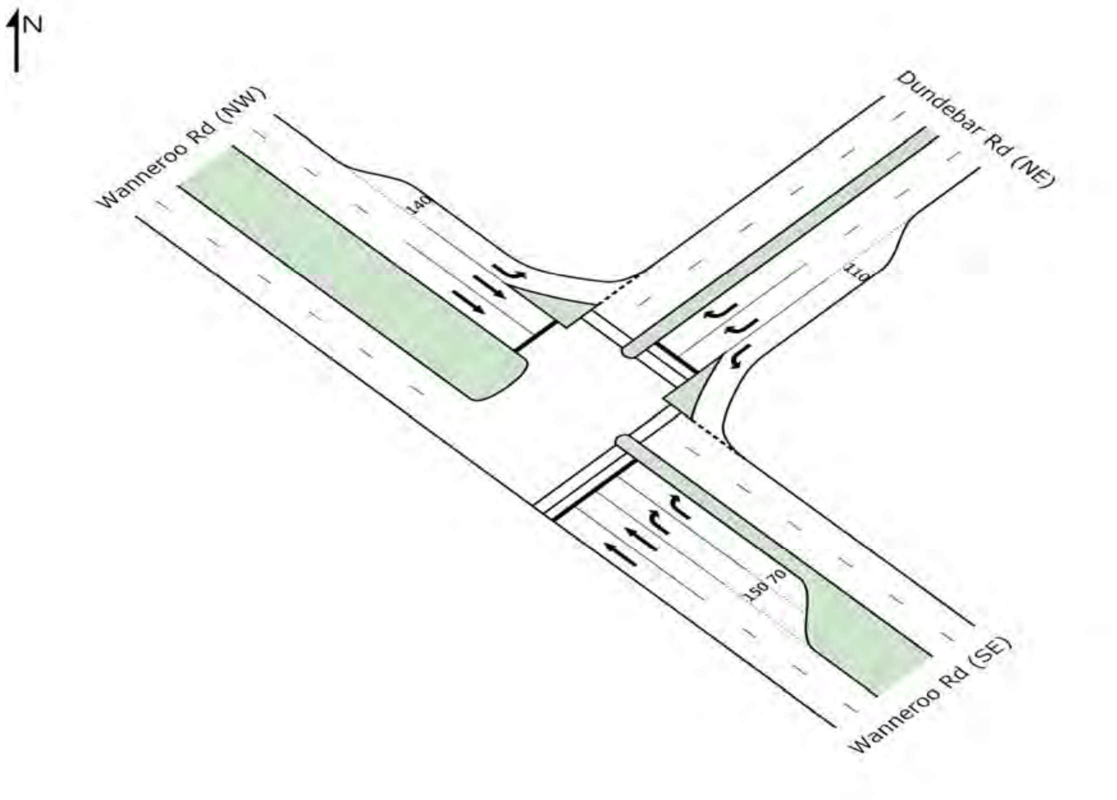
The analysis with LHS indicates that a modified signalised intersection is likely to accommodate forecast traffic volumes to 2031. Degree of Saturation is 0.887 to 0.898, LoS is C/D, the queue length on Wanneroo Road south is 357m and stop rate is 0.86 to 0.92. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required. Figure 6-1 refers.

Figure 6-1 Wanneroo Road/Dundebar Road - ultimate design




A compromise design is indicated as follows which avoids land acquisition. The performance is not as good as the optimal upgrade however the site is constrained. Degree of Saturation is 0.952 to 1.092, LoS is D/F, the queue length on Wanneroo Road south is 1.29km and stop rate is 0.89 to 1.38. It should be noted that a good operational; performance cannot be achieved with the compromise. Figure 6-2 refers.

Figure 6-2 Wanneroo Road/Dundebar Road - compromise design



Main Roads comment that a double right turn into Dundebar Road, whilst desirable for efficiency is unlikely to be possible due to land constraints. A concept plan would need to be prepared to confirm this layout can be accommodated.

### Recommendation (if no land resumption)

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded, (preferably to include additional through lanes on Wanneroo Road.)

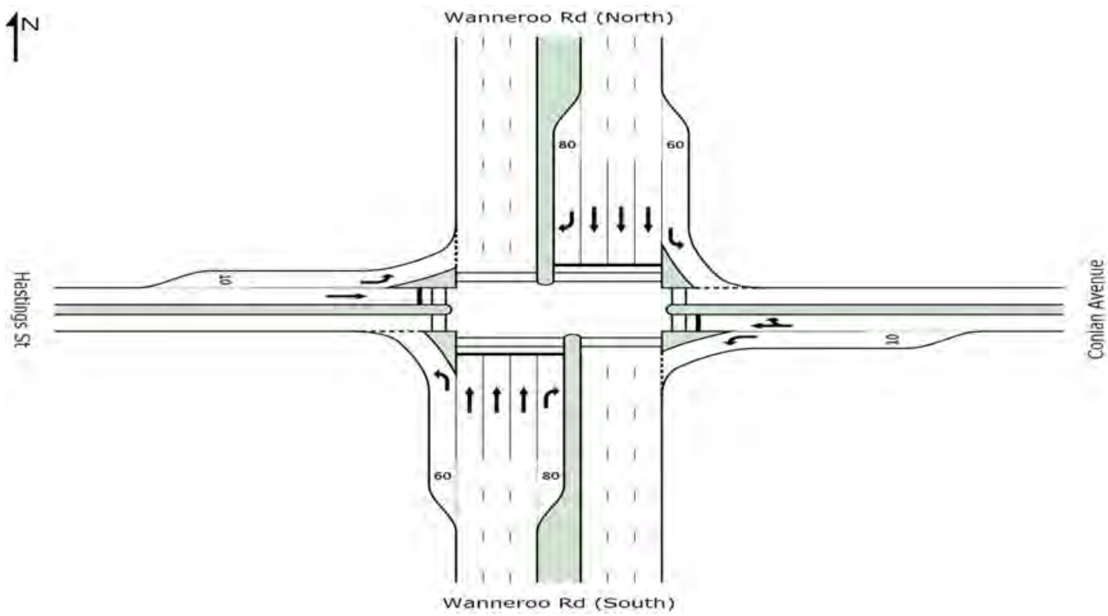
Main Roads comment is acknowledged that

> **"widening is intended to provide the opportunity of an additional lane in each direction. However, this lane is currently identified as a bus lane and therefore the existing four lane configuration should be utilised as the future configuration for Wanneroo Rd within this area".**
>
> Main Roads Western Australia

#### 6.3.2 Wanneroo Road/Hastings Road intersection 2031

The analysis with LHS indicates that a modified signalised intersection is likely to accommodate forecast traffic volumes to 2031 in the am peak hour however pm operation is poor. Degree of Saturation is 0.793 to 1.117, LoS is C/F, the queue length on Wanneroo Road south is 1.025km and stop rate is 0.77 to 1.48.  It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required. Figure 6-3 refers.

Figure 6-3 Wanneroo Road/Hastings Street – ultimate design




A compromise is to retain two lanes in each direction on Wanneroo Road to avoid land resumption however operation will be poor as indicated in the analysis, this option therefore is not recommended but is likely to be the only option in view of site constraints. Figure 6-4 refers. Degree of saturation is 1.352, LoS is F, the queue length on Wanneroo Road south is 2.62km and stop rate is 2.24.

Figure 6-4 Wanneroo Road/Hastings Street – compromise design


### Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded to include additional through lanes in Wanneroo Road however if this cannot be achieved the layout as shown above could be considered. However a very poor performance is anticipated.

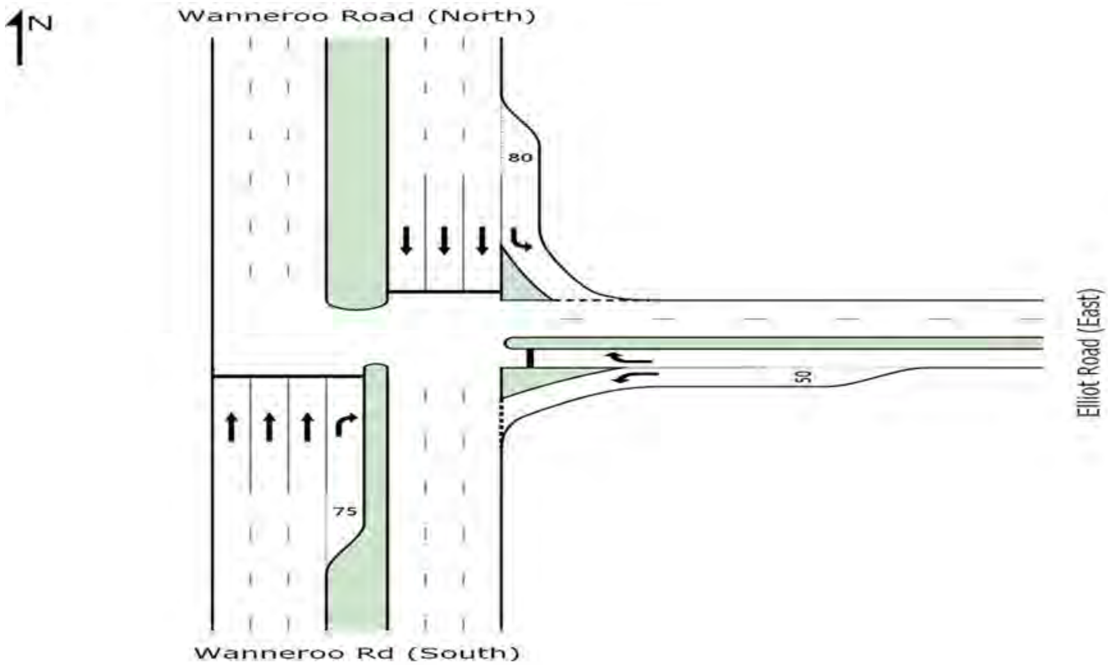
Main Roads comment is acknowledged that

> **"widening is intended to provide the opportunity of an additional lane in each direction. However, this lane is currently identified as a bus lane and therefore the existing four lane configuration should be utilised as the future configuration for Wanneroo Rd within this area"**
>
> Main Roads Western Australia

### 6.3.3 Wanneroo Road/Elliot Road intersection 2031

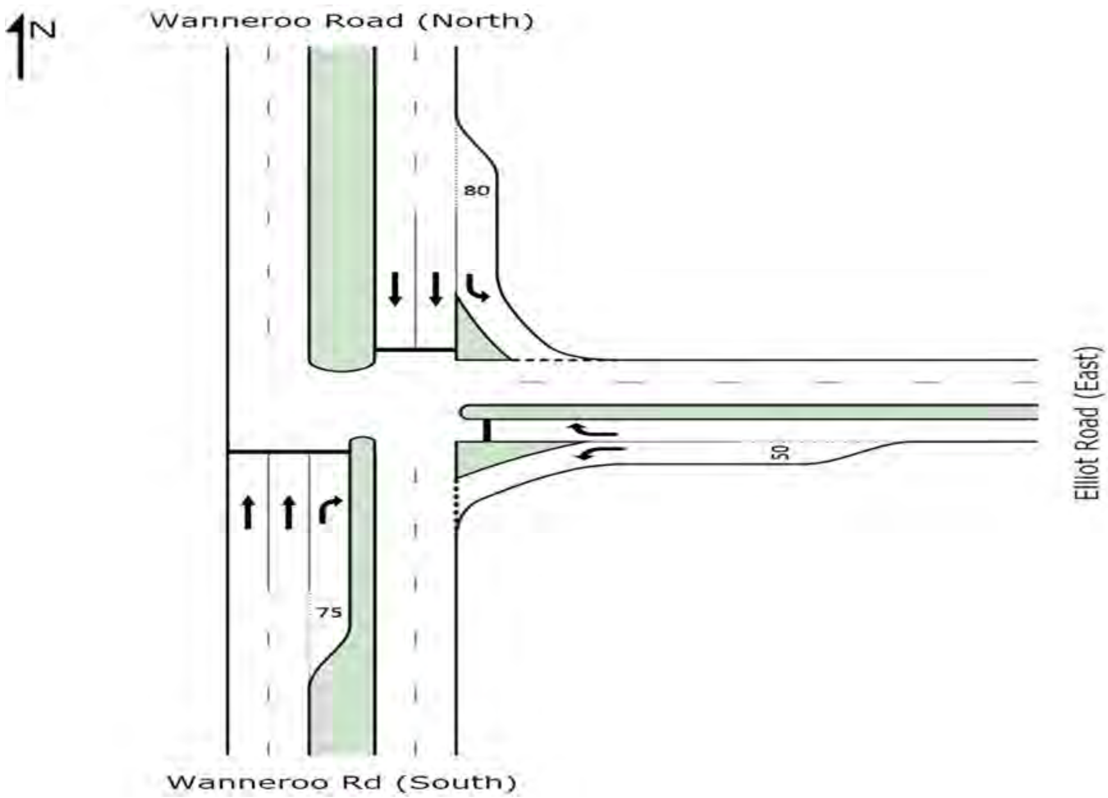
The analysis with LHS, indicates that a signalised intersection is likely to accommodate forecast traffic volumes to 2031. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required. A LoS of B and stop rates of less than one are forecast. Figure 6-5 refers.

Figure 6-5 Wanneroo Road/Elliot Road – ultimate design




A compromise design is indicated as follows which avoids land acquisition. The performance is not as good as the optimal upgrade however the site is constrained. It should be noted that a good operational; performance cannot be achieved with the compromise design particularly in the am peak hour. Degree of Saturation is 0.901 to 1, LoS is C, the queue length on Wanneroo Road south is 416m and stop rate is 0.87 to 0.88. Figure 6-6 refers.

Figure 6-6 Wanneroo Road/Elliot Road – compromise design




Main Roads have advised the following:

> **"Wanneroo Road and Elliot Road intersection analysis demonstrates that a reasonable level of service could be achieved for this intersection in 2031. However, it is important to recognise that modelling undertaken by Main Roads for the East Wanneroo North South Route and the East Wanneroo Structure Plan has indicated that ultimate volumes at this intersection could be three times, or more, than that analysed in the study undertaken for Wanneroo Housing Strategy. Accordingly, whilst the suggested intersection configuration may prove to be satisfactory at this time, it is highly probable that significant adjustments will be required in the future. This is likely to take the form of longer turning lanes and expansion of Elliot Road to four lanes."**
>
> Main Roads Western Australia

### Recommendation (if no land resumption)

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing unsignalised intersection is upgraded to include traffic signals as indicated above.

Main Roads comment is acknowledged that

**“widening is intended to provide the opportunity of an additional lane in each direction. However, this lane is currently identified as a bus lane and therefore the existing four lane configuration should be utilised as the future configuration for Wanneroo Road within this area”**

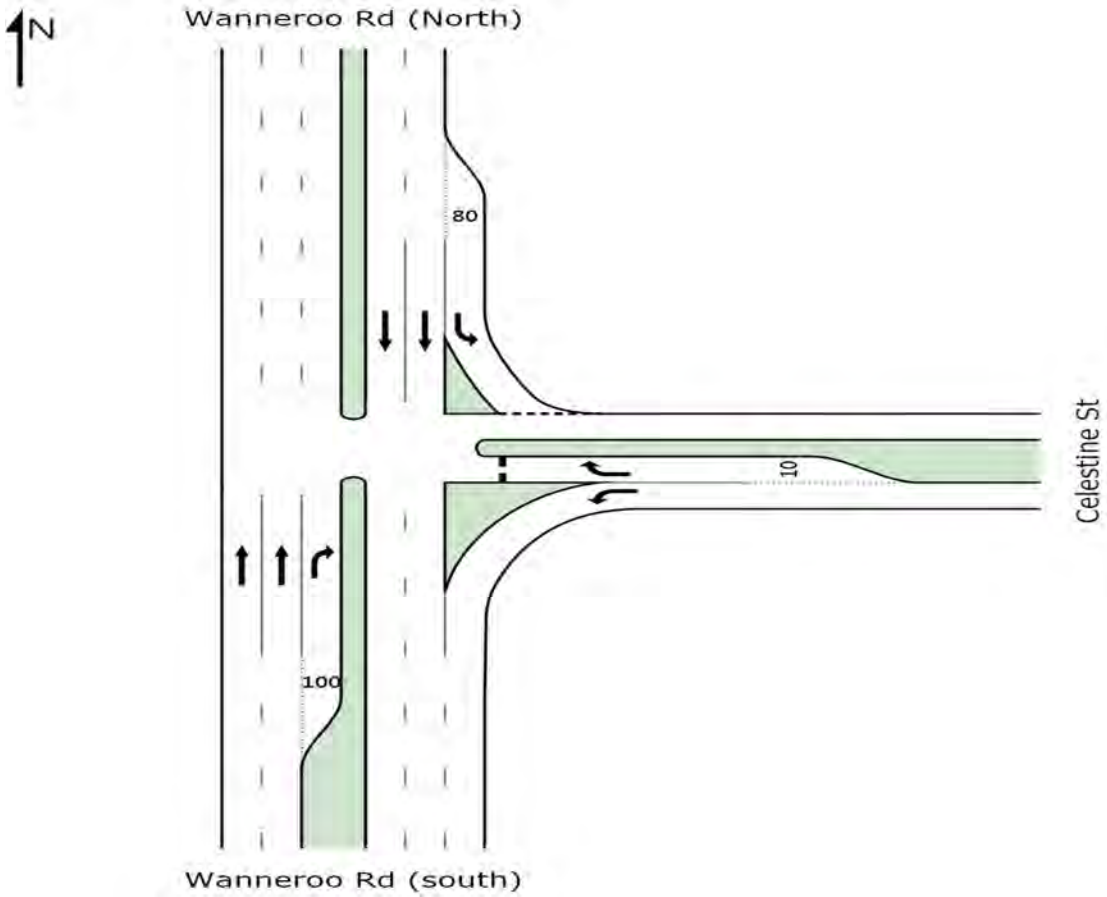
Main Roads Western Australia

Main Roads comments regarding their modelling for the East Wanneroo North-South Route are also noted and it is clear that the treatment at this intersection and of Elliot Road will need to be further considered in the future.

#### 6.3.4 Wanneroo Road/Celestine Road intersection 2031

A number of options have been tested however a good operational performance has not been achieved. The best operation for an unsignalised intersection is indicated below and includes acceleration lanes for the right and left turns from Celestine Street. Improved performance would be gained by traffic signals however it would not be practical to signalise all side road intersections. Degree of saturation is 1.079 to 1.398, LoS is E/F, the queue length on Wanneroo Road south right turn lane is 248m and stop rate is 0.14 to 0.25. Figure 6-7 refers.

Figure 6-7 Wanneroo Road/Celestine Street – ultimate design



Main Roads has commented as follows regarding the treatment of this intersection.

> **"Wanneroo Road/Celestine Road intersection 2031 is an excellent example to consider when dealing with side road connections. We agree with the statement in this section that all side road intersections cannot be signalised. Similarly, there needs to be consideration of how to deal with traffic at the Wanneroo Road and Celestine Road intersection (or any other specific location). We would promote the idea of a network review to determine how the network could be structured to make best use of locations which are chosen for the higher level of service afforded by signalisation. The suggestion of acceleration lanes is considered inappropriate in the context of adjacent intersections and vehicle crossovers to properties. The separation between intersections is insufficient, as is available land."**
>
> Main Roads Western Australia

### Recommendation

In view of Main Roads comments regarding this intersection it is recommended that the intersection is retained as existing and promote the use of the planned upgrade of Elliot Road and its planned signalised intersection with Wanneroo Road.

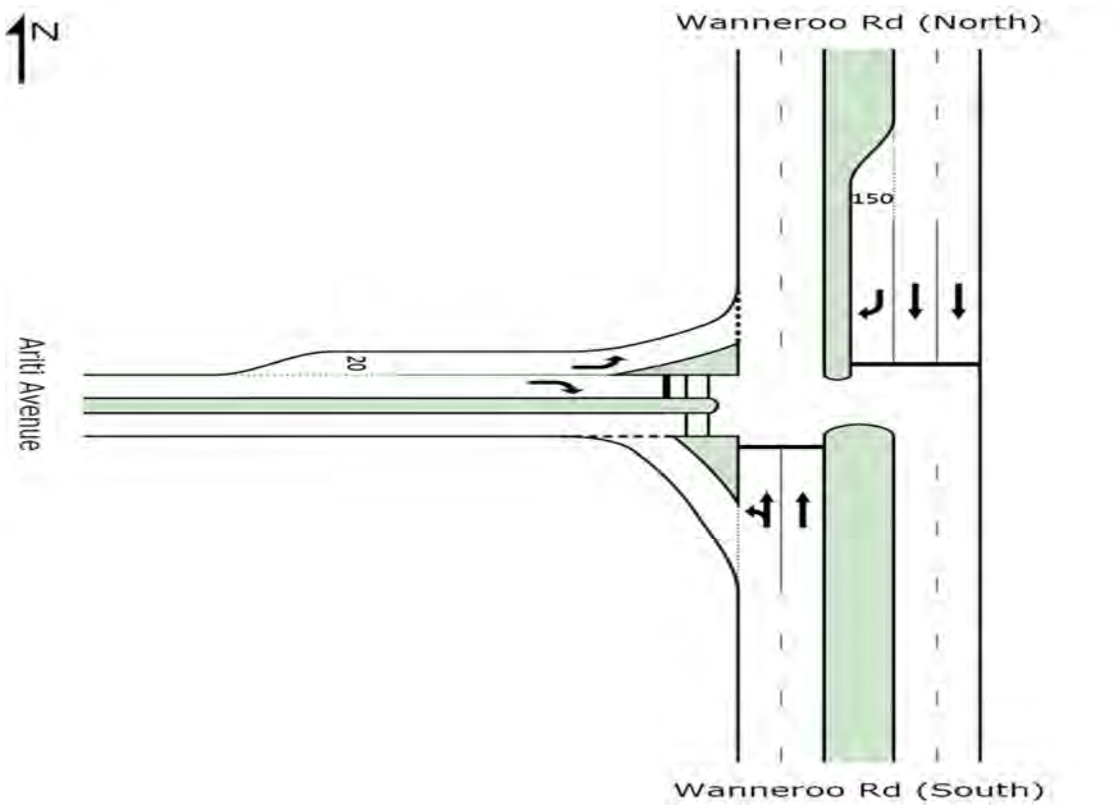
#### 6.3.5 Wanneroo Road/Ariti Ave intersection 2031

The analysis with LHS, indicates that a signalised intersection is likely to accommodate forecast traffic volumes to 2031. A LoS of A/B is forecast and stop rates of less than 1. Queues of up to 437m are forecast on Wanneroo Road south in the pm period. A signalised intersection is therefore recommended.

Land resumption is not required.

Figure 6-8 refers.

Figure 6-8 Wanneroo Road/Ariti Avenue – ultimate Design



Mains Road has commented as follows regarding the treatment at this intersection:

> **“Main Roads does not support signalising of the Wanneroo Road and Ariti Avenue intersection. Whilst queuing may be undesirable, the volume of traffic trying to access Wanneroo Rd at this location is insufficient to warrant traffic signals. This traffic can utilise other connections to Wanneroo Road which have traffic signals to assist right turning traffic”**
>
> Main Roads Western Australia

As part of the overall network improvement the signalisation of Scenic Drive/Wanneroo Road has been suggested by Main Roads and is supported by this study. The installation of traffic signals at the Scenic Drive/Wanneroo Road intersection will provide alternative access for the precinct to the west of Wanneroo Road some distance from the Town Centre.

Main Roads also comment that

> **“the current signalisation works at Wanneroo Road and Wallawa Street are an anomaly that could become an opportunity. Serious consideration should be given to how Scenic Drive could be connected to Wanneroo Road at the northern end. Wallawa Street provides an opportunity if the link between Scenic Drive and Banyandah Boulevard or Kilindi Crescent can be created”.**
>
> Main Roads Western Australia

It is agreed that the opportunity of connecting Scenic Drive to Wanneroo Road via Wallawa Street should be examined, in view of the likely benefits to accessibility and the operation of Wanneroo Road and its intersections.

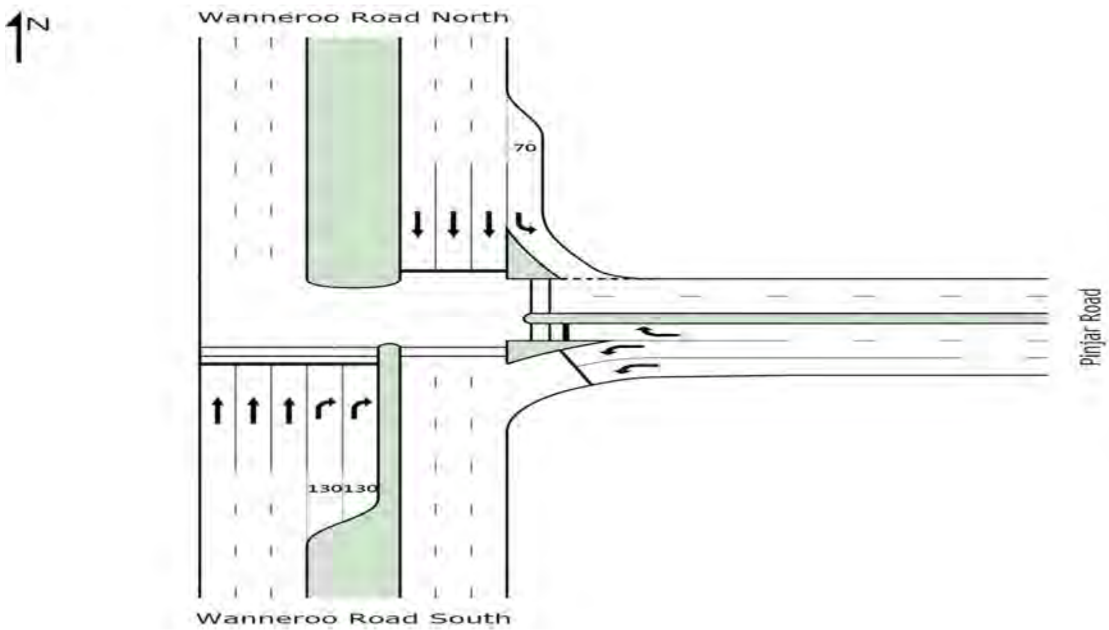
#### Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the extension of Scenic Drive north to Wanneroo Road and the signalisation of Scenic Drive/Wanneroo Road intersection are further examined.

### 6.3.6 Wanneroo Road/Pinjar Road intersection 2031

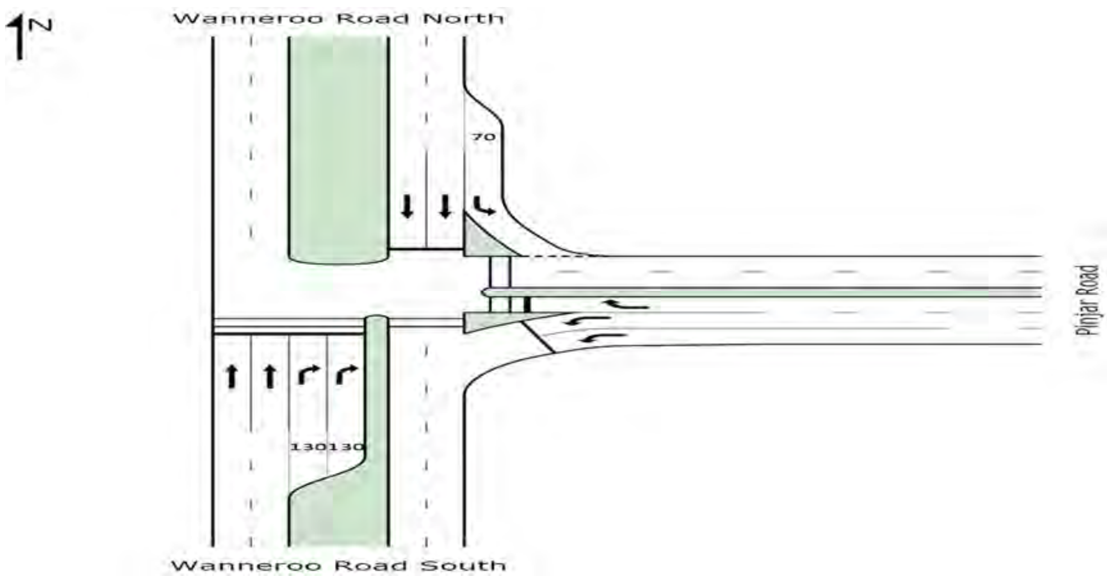
The analysis with LHS, indicates that a signalised intersection is likely to accommodate forecast traffic volumes to 2031. A LoS of C/D is forecast and stop rates of less than 1 during the am peak hour but the southbound through movement is 1.36 during the pm peak hour. Queues of 240m-250m are forecast on Wanneroo Road. Significant land resumption is required. Figure 6-9 refers.

Figure 6-9 Wanneroo Road/Pinjar Road – ultimate design




A compromise design is indicated as follows which avoids land acquisition. The performance is not as good as the optimal upgrade however the site is constrained. It should be noted that a good operational; performance cannot be achieved with the compromise design with unacceptable queues and delays and is not therefore recommended. Degree of saturation 0.975 to 1.064, LoS E/F. queue lengths 1.2km on Wanneroo Road south and a stop rate of 0.88 to 1.46. Figure 6-10 refers.

Figure 6-10 Wanneroo Road/Pinjar Road – compromise design




### Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded to include additional through lanes in Wanneroo Road, however if this cannot be achieved the layout as shown above could be considered.

Main Roads comment is acknowledged that

> **"widening is intended to provide the opportunity of an additional lane in each direction. However, this lane is currently identified as a bus lane and therefore the existing four lane configuration should be utilised as the future configuration for Wanneroo Road within this area".**
>
> Main Roads Western Australia

### 6.3.7 Wanneroo Road

It is clear from the analysis that Wanneroo Road should be upgraded to include an additional through lane in each direction adjacent to the precinct. The ROM plot (unadjusted) indicates 56,000vpd adjacent to the precinct, just south of Dundebar Road, without LHS and 59,400vpd with LHS. The capacity for a dual carriageway at a level of service C is 38,000vpd so it can be seen that by 2031 volumes will exceed this level with or without LHS.

Main Roads comment is acknowledged that


> **"widening is intended to provide the opportunity of an additional lane in each direction. However, this lane is currently identified as a bus lane and therefore the existing four lane configuration should be utilised as the future configuration for Wanneroo Road within this area".**
>
> Main Roads Western Australia


### 6.3.8 Internal roads

The above analysis considers road requirements to the key road network, i.e Local Distributor classification and above, there are however a number of Access Streets within the internal road network and commentary on these roads is provided as follows.

The WAPC document 'Liveable Neighbourhoods' indicates the anticipated traffic volumes for residential streets:

- Access Street Type C (single carriageway 7.2m to 7.5m wide): 3,000vpd
- Access Street Type D (single carriageway, 5.5m to 6m wide): 1,000vpd

The physical capacity of a single carriageway road is 8,000-12,000vpd at a good level of service C, based on the assessment of the precinct it is clear considerable capacity is available within the lower order roads in the study area and the planned increased residential density is unlikely to adversely impact these roads requiring the need to upgrade.

Current volumes on key local roads are indicated in the following table compared with the anticipated volumes based on Liveable Neighbourhoods. It should be noted that the physical capacity of the road is higher than these volumes i.e 8-12,000vpd indicating significant road capacity for higher housing density.

| Location | Existing vpd | Liveable Neighbourhoods Anticipated Volumes |
|---|---|---|
| Civic Drive | 3,180vpd | 3,000vpd |
| Kanimba Street | 3,060vpd | 3,000vpd |
| Celestine Street | 2,700vpd | 3,000vpd |
| Quarkam Street | 3,000vpd | 3,000vpd |
| Ariti Ave | 1,500vpd | 3,000vpd |

| Location | Existing vpd | Liveable Neighbourhoods Anticipated Volumes |
|---|---|---|
| San Rosa Rd | 1,700vpd | 3,000vpd |
| Scenic Dr | 2,500vpd | 3,000vpd |

The following intersection thresholds are indicated by Austroads, below which capacity analysis is unnecessary.

| Major Road Flow | Minor Road Flow |
|---|---|
| 400vph | 250vph |
| 500vph | 200vph |
| 650vph | 100vph |

Based on the above thresholds, minor road intersections within the precinct are not expected to exceed these volumes on full development and therefore not anticipated to require significant upgrade for capacity reasons.

## 6.4 Stakeholder liaison

Following completion of the technical analysis the outcomes were forwarded to the City of Wanneroo who has also consulted with Main Roads. Their coordinated response is shown in Appendix F together with GHD response. Amendments have been incorporated into this report.

# 7. Cost estimates

Apportionment of cost estimates

The following calculation has been used to estimate the proportion of each of the cost estimates which are directly attributable to the increase in traffic in the Wanneroo Housing Precinct. This takes into account the likely additional work required due to the increase in housing density.

a. Forecast traffic generation from the Wanneroo Housing Precinct to 2031 based on current planning: 78,917vpd.

b. Forecast traffic generation from the Wanneroo Housing Precinct to 2031 based on increased R Codes: 99,559vpd.

c. Forecast traffic generation from the Wanneroo Housing Precinct and Area of Influence to 2031 based on increased R Codes: 245,616vpd.

Therefore the apportionment of cost is calculated by (b-a)/b and represents 20.7**%** of road upgrade cost. Area of influence: 1km surrounding precinct.

## 7.1 Cost estimates for road network improvements

Based on the traffic assessment **internal** road upgrades are not anticipated to be required therefore no internal measures are recommended for costing for work by the City of Wanneroo.

## 7.2 Staging of Works

Based on observations of the models in operation as well as the performance results presented in Section 5 the following table outlines the anticipated staging requirements of intersection treatments.

## Table 7-1 Intersection Treatment Staging

| | Without LHS | | | | With LHS | | |
|---|---|---|---|---|---|---|---|
| | 0-5 years | 5-10 years | 10-20 years | | 0-5 years | 5-10 years | 10-20 years |
| Wanneroo Road/Dundebar Road | | x | | | | x | |
| Wanneroo Road/Pinjar Road | | | x | | | | x |
| Wanneroo Road/Church Street (Signals not supported by Main Roads) | | x | | | x | | |
| Wanneroo Road/Ariti Avenue (Signals not supported by Main Roads) | x | | | | x | | |
| Wanneroo Road/Celestine Street (Upgrade not supported by Main Roads) | | | | | | | x |
| Wanneroo Road/Elliot Road (Main Roads indicate likely higher volumes due to broader development) | | | x | | | x | |

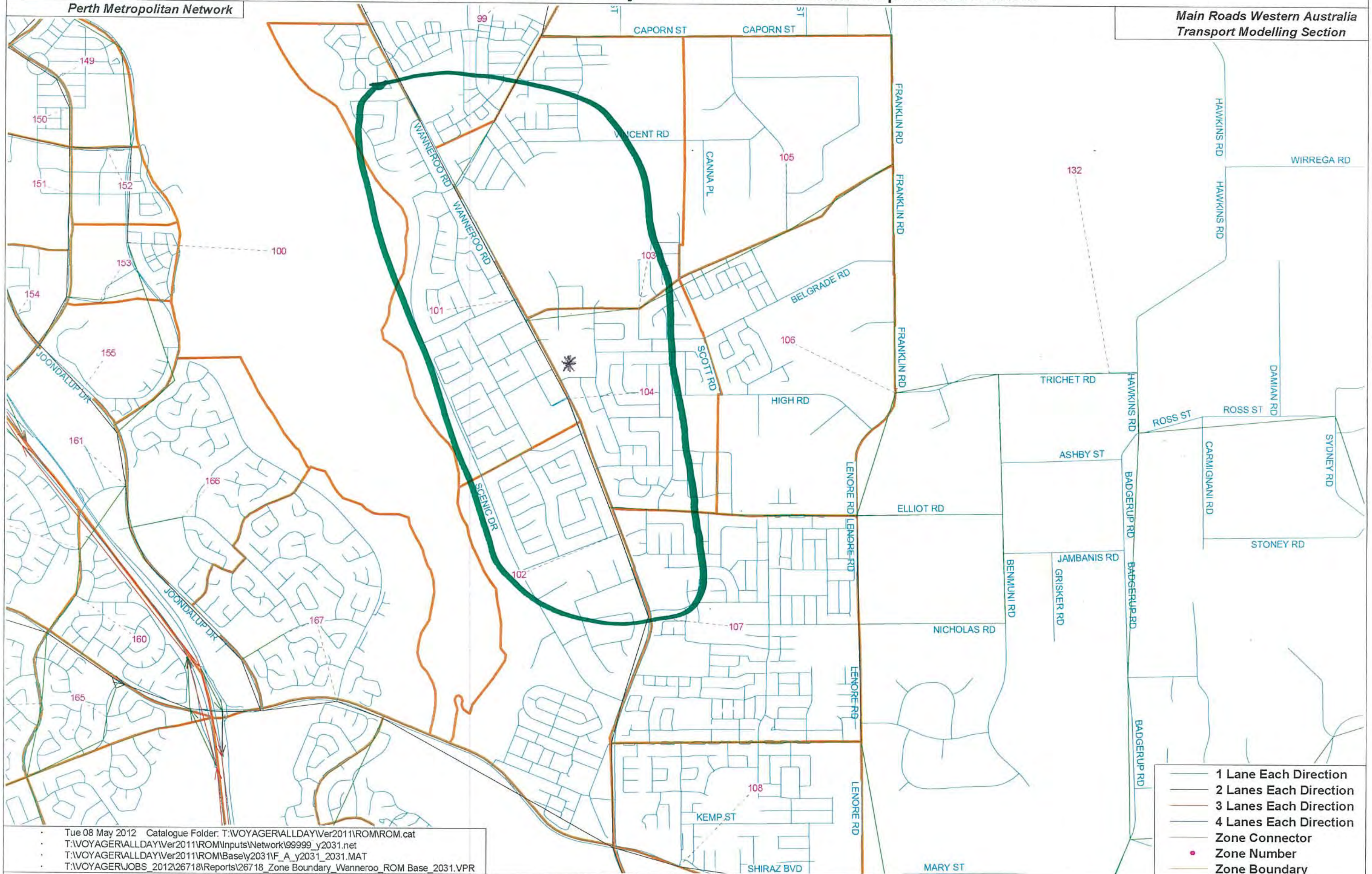
# Appendices

# Appendix A - Landuse input

# 2031 Base Model - Zone Boundary Plot for Wanneroo Traffic Impact Assessment

Perth Metropolitan Network

Main Roads Western Australia
Transport Modelling Section

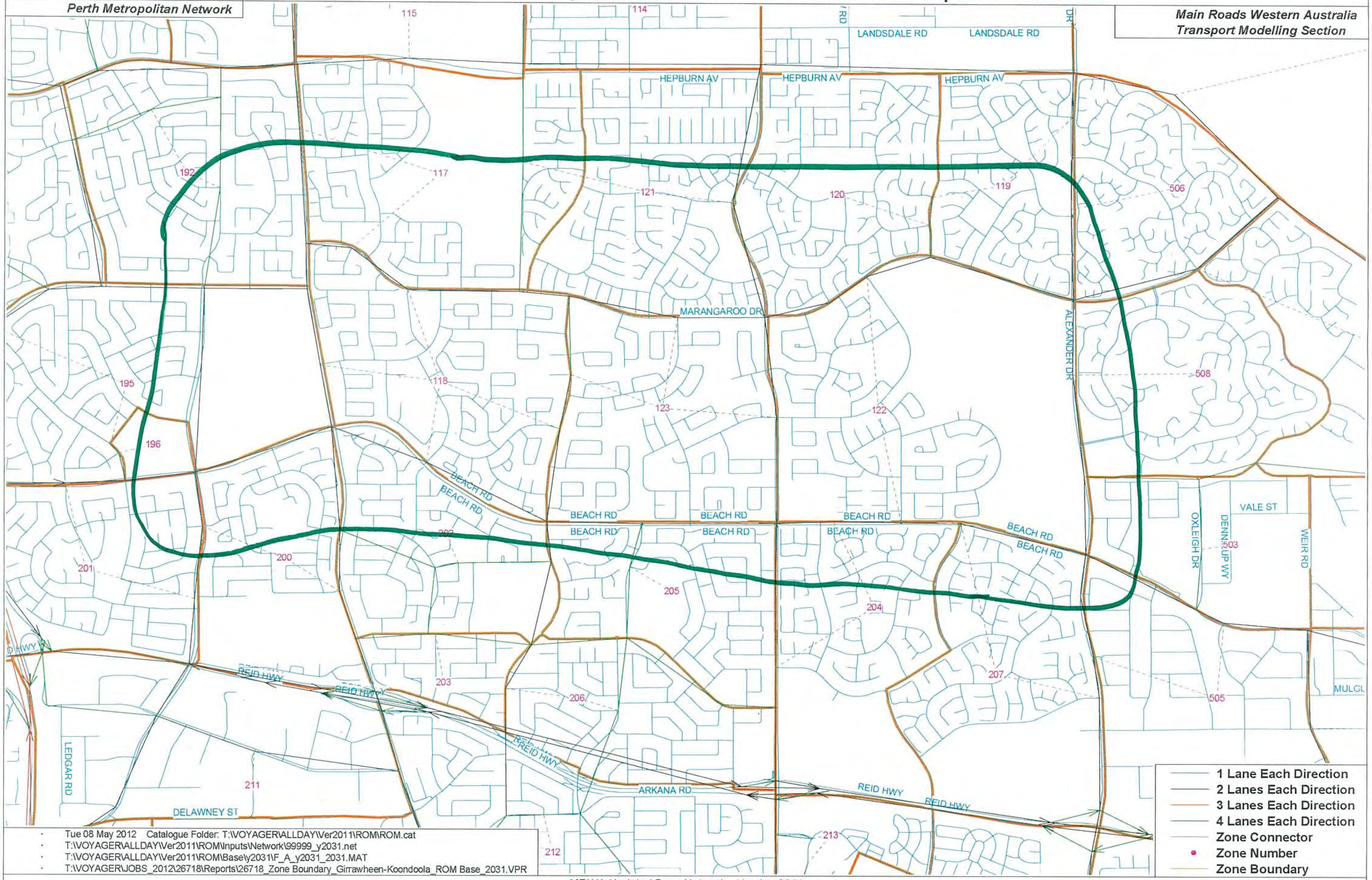



Tue 08 May 2012 Catalogue Folder: T:\VOYAGER\ALLDAY\Ver2011\ROM\ROM.cat
T:\VOYAGER\ALLDAY\Ver2011\ROM\Inputs\Network\99999_y2031.net
T:\VOYAGER\ALLDAY\Ver2011\ROM\Base\y2031\F_A_y2031_2031.MAT
T:\VOYAGER\JOBS_2012\26718\Reports\26718_Zone Boundary_Wanneroo_ROM Base_2031.VPR

*MRWA Updated Base Network - Version 2011*
*MRWA Transport Modelling Data as supplied to approved clients is confidential and is not to be made available to unauthorised persons or organisations*

cube

# 2031 Base Model - Zone Boundary Plot for Girrawheen-Koondoola Traffic Impact Assessment




- Tue 08 May 2012 Catalogue Folder: T:\VOYAGER\ALLDAY\Ver2011\ROM\ROM.cat
- T:\VOYAGER\ALLDAY\Ver2011\ROM\Inputs\Network\99999_y2031.net
- T:\VOYAGER\ALLDAY\Ver2011\ROM\Base\y2031\F_A_y2031_2031.MAT
- T:\VOYAGER\JOBS_2012\26718\Reports\26718_Zone Boundary_Girrawheen-Koondoola_ROM Base_2031.VPR

*MRWA Updated Base Network - Version 2011*

*MRWA Transport Modelling Data as supplied to approved clients is confidential and is not to be made available to unauthorised persons or organisations*

cube

# Appendix B - Paramics base model validation report

# City of Wanneroo

## Wanneroo Microsimulation Traffic Model
## Base Model Validation Report

29 January 2013

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

# Table of contents



# Table index

# Figure index



# Appendices

# 1. Introduction

City of Wanneroo has engaged GHD to undertake a Traffic Impact Assessment (TIA) to evaluate the potential effect of the proposed increases to R Coding within the Wanneroo Housing Precinct. As part of this study, GHD is undertaking local area microsimulation traffic modelling to assist in the traffic assessment. This report discusses the development of the initial 'Base' models which provide a representation of the current on-site conditions on the Wanneroo road network, and outlines the calibration and validation methodologies that have been employed.

The purpose of this report is to demonstrate and provide confidence that the Wanneroo Base models are a robust representation of the on-street conditions and as such provide a suitable foundation for the subsequent testing of future year scenario. The report therefore provides information relating to the following topics:

- Data sources used for the modelling;
- Model network development;
- Trip matrix development;
- Model calibration; and
- Model validation.

Figure 1 outlines the adopted study area for the traffic modelling assessment.

Figure 1 Extents of Model Study Area

# 2. Data Collection

## 2.1 Introduction

Microsimulation models typically require large volumes of data in order to accurately represent traffic networks at a microscopic level and to ensure the model is a good representation of current on-site conditions. This section of the report details each dataset that has been collected for the study. It provides information relating to the type of data, the source of the data and the date and time periods that the data was collected for.

## 2.2 Traffic Volume Data

Traffic volume count data was obtained from a number of sources including the following:

- SCATS loop counts;
- Manual turning movement surveys; and
- Historical tube count data.

### 2.2.1 SCATS Loop Counts

Signalised intersection detector counts were requested from Main Roads for the sites within the Wanneroo study area. These signalised intersections consisted of the following:

- Wanneroo Road / Pinjar Road (TCS 985);
- Wanneroo Road / Dundebar Road (TCS 736); and
- Wanneroo Road / Hastings Street / Conlan Avenue (TCS 487).

Detector counts were provided in hourly intervals for each intersection loop for the week beginning 19 March 2012.

These types of traffic counts have a number of limitations which need to be considered when assessing the suitability of such data to use an input traffic models. These constraints include:

- Some intersection movements are not captured due to some lanes not being covered by an in-pavement detector, e.g. often left turn slip lanes are not detected:
- Some lanes have multiple designations e.g. a shared left turn and through movement lane. In these instances it is unclear from the detector count what proportion of vehicles conduct each movement;
- Detectors are not always reliable e.g. detectors can be faulty and hence not record all vehicles accurately; and
- Detector counts do not differentiate between vehicle classifications.

### 2.2.2 Manual Turning Movement Count Surveys

To supplement the SCATS detector count data (and to overcome some of the shortcomings of that data set) a number of manual turning movement surveys were collected. These were undertaken by Excel Traffic Data during the week beginning 28 May 2012 at the following sites:

- Wanneroo Road / Ariti Drive;
- Wanneroo Road / Celestine Drive;
- Wanneroo Road / Hastings Street / Conlan Street; and
- Wanneroo Road / Elliot Road.

Surveys were undertaken for the following time periods:

- AM Peak: 7.30 – 9.30; and
- PM Peak: 15.30 – 17.30.

Traffic count data was provided in the form of turning counts in 15 minute intervals and was disaggregated into car and truck vehicle types. These traffic surveys provided a high level of data resolution for input into the model.

### 2.2.3 Historical Tube Count Data

City of Wanneroo provided a number of tube count surveys which had previously been undertaken throughout the study area. These surveys were used by GHD to inform the project of indicative volumes on lower order roads and to assess the validity of recently collected data. These data sets typically provided only mid-block two-way traffic volumes, and as such they were not used to determine directional or turning movement data inputs. The provided tube counts ranged in currency from 2009 and 2012.

## 2.3 Signal Data

In additional to the SCATS detector counts (discussed in Section 2.2.1), traffic signal operation data was sourced from Main Roads for each signalised intersection in the study area to ensure signal operations could be represented accurately. The signalised sites included:

- Wanneroo Road / Pinjar Road (TCS 985);
- Wanneroo Road / Dundebar Road (TCS 736); and
- Wanneroo Road / Hastings Street / Conlan Avenue (TCS 487).

The specific signal data which was requested and subsequently provided by Main Roads consisted of the following:

- SCATS TCS graphics;
- IDM (intersection diagnostic monitor) data files (for two consecutive days, June 2012); and
- Intersection timing charts.

## 2.4 Travel Time Data

Vehicular journey times through the study area were recorded on-site for the key movements. This information would provide the key source of model validation data (discussed in detail in Section 5). GHD collected travel time survey data, as well as in-car video footage for the AM and PM peak periods on Tuesday 5 June 2012. GHD staff undertook these travel time surveys which allowed observations of queuing and congestion levels on-site to be considered during the calibration and validation stages of the modelling process.

The primary route through the Wanneroo road network was identified as Wanneroo Road between Pinjar Road and the southern extent of the model study area i.e. Ocean Reef Road. This route was surveyed in both directions and journey times disaggregated into the following intervals:

- Pinjar Road to Dundebar Road;
- Dundebar Road to Conlan Road ; and
- Conlan Road to Elliot Road.

## 2.5 ROM Strategic Model Outputs

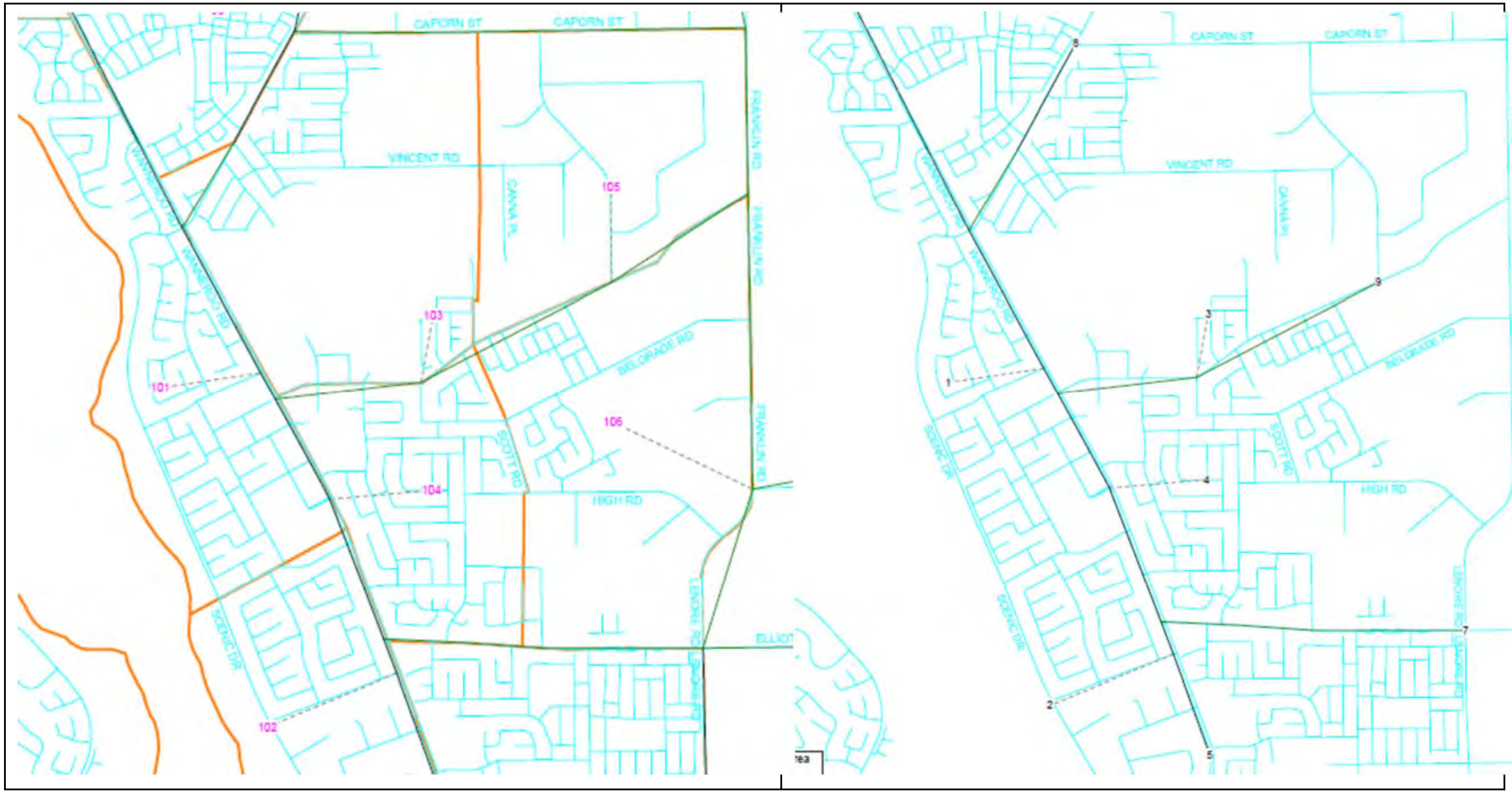
Main Roads provided outputs from the Regional Operations Model (ROM) to assist with the study. The outputs requested by GHD and provided by Main Roads consisted of the following:

- ROM network layout and zoning structure around the Wanneroo study area; and
- Sub-area cordon trip matrices from ROM for the 2011 Base scenario (as well as the 2031 scenario matrices) for the Wanneroo microsimulation model study area.

The ROM network and the requested sub-area network is shown in Figure 2.

Figure 2 ROM Network and Sub-area

***ROM Network*** ***Wanneroo sub-area***



# 3. Model Development

## 3.1 Introduction

The microsimulation modelling for this study has been developed using Quadstone Paramics software (version 6). Paramics is a traffic simulation software package that can be used to analyse a connected network of road links and signal controlled intersections, roundabouts, priority junctions in a single model network and to a high level of detail. The simulated driver behaviour is based on lane changing and vehicle following models and can provide an accurate reflection of on-site driver and vehicle behaviour.

## 3.2 Model Definition

The model runs for two discreet one-hour time periods as per the following:

- AM Peak Model: 8.00-9.00 with preceding warm-up period between 7.00 and 8.00; and
- PM Peak Model: 16.00-17.00 with preceding warm-up period between 15.00 and 16.00.

The time periods above were found to be the critical peak periods with regards to the highest traffic volumes following a review of the available traffic data for the study area. The warm-up periods are in place to ensure vehicles are upon the network at the commencement of the evaluation period.

The Base model is simulated using five variable ‘seed values’ with the resultant outputs analysed for discrepancies and ultimately averaged for output purposes. The seed value affects the generation of the random numbers that influence the model operation and variability. Therefore each time the model is run with a different seed value a slightly different set of outputs is generated. It would generally be expected that these outputs would be very similar (but not identical), and can loosely be thought of as day-to-day on-site fluctuations. The use of multiple seed values therefore provides confidence that the model results are not based upon a single outlying model run, but the result of a larger sample of model runs.

## 3.3 Model Network

The core model network was coded through the assistance of aerial photography and on-site observations to ensure the following attributes were included into the network:

- Intersection configurations;
- Number of lanes and lane allocations;
- Roadway widths, kerb locations and stopline positions;
- Road speed limits;
- Unsignalised intersection priority controls; and
- Turning lane storage lengths.

The model network is shown in Figure 3.

Figure 3 Wanneroo Model Network


***Shared Model Space: Wanneroo and Girrawheen***

It should be noted that this Wanneroo model network has been developed at the same time as a Girrawheen study area model has been developed also for City of Wanneroo. Given the close proximity of these two area, the two models have been developed within the same Paramics model space. The models can be run together (although the two networks do not interact with each other) or separately (by specifying demands for an individual network).

## 3.4 Signalised Intersections

Signalised junctions have been coded into the model to function under fixed time operation consisted with the phasing structure and times recorded in the IDM files. A review of the signal information provided by Main Roads revealed that phase and cycle times remained broadly consistent between consecutive days, as such these timing were coded into the model for the AM and PM peak periods.

## 3.5 Trip Matrices

Microsimulation models require accurate trip matrices in order to produce an indicative simulation of existing traffic movements. To develop a detailed set of trip matrices the following data sources were used:

- Turning movement volumes from recent surveys (outlined in Section 2.2); and
- An understanding of routing patterns and trip distributions through the study area network (outlined in Section 2.5).

The information above was combined to generate the trip matrices from the traffic assessment as per the following methodology:

A sub-area cordon was cut in ROM by Main Roads to represent only traffic movements within the study area. This produced a daily trips matrix for the study area network, albeit at a coarse zone and network level. A number of the ROM zones were split in order to match the more detailed definition of the zones within the microsimulation network. Following this, the proportional distribution matrix was determined from the ROM daily trip volume matrix. This distribution pattern was then utilised as the initial estimate of trip distributions for the peak period models.

An iterative process of furnessing was undertaken to factor the row and column totals of the microsimulation demand matrices to match the turning count data for entry and exit points to the Paramics model. This factored the overall matrix size to the observed traffic levels whilst retaining the broad original-destination pattern of the original matrices. This process was undertaken separately from both the AM and PM periods. The resulting matrices then underwent a manual matrix-estimation refinement process based on comparisons against known turning movement volumes. These refined trip sets were then applied as the input demand matrices for the Base models.

## 3.6 Vehicle Release Profiling

Demand release profiles were developed for each of the key model entry locations (where the necessary data was available). These profiles are used to specify the staged release of vehicles into the models across the hourly periods i.e. vehicles do not necessarily arrive at a constant rate across a one hour peak period. Profiles were developed for 15-minute intervals from observed turning movement counts. Individual profiles were applied to external zones which connect directly to an intersection where a turning movement survey was undertaken (and hence 15-minute data was available). For entry zones where data was not available in 15-minute intervals, the ‘average’ profile was applied to these releases.

## 3.7 Model Assignment

The modelled network has no route choice since it is a corridor model. As such, the Paramics assignment method is inconsequential in this instance. Notwithstanding, an all-or-nothing plus perturbation (AON+P) assignment is in use within this model.

## 3.8 Vehicle Classification

Traffic survey data was interrogated to determine the average recorded proportion of light and heavy vehicles on the network during the AM and PM peak periods. The resulting truck proportions are shown in Table 1 and have been incorporated in the respective model periods.

Table 1 Heavy Vehicle Proportions

| Peak Period | Heavy Vehicle Proportion |
|---|---|
| AM Peak | 4.2 % |
| PM Peak | 2.3 % |

## 3.9 Model Plugins

Azalient Ceejazz model plugins have been utilised within the model. These third party plugins operate in conjunction with the core Paramics software and enhance its functionality. The specific plugin modules which have been used on the Wanneroo model network consist of the following:

- Validator: Used to extract results relating to modelled traffic volumes and travel times; and
- Lane Choice: Used to ensure sensible and accurate lane discipline of vehicles on approach to junctions.

# 4. Model Calibration

## 4.1 Introduction

Model calibration is the process whereby data that has been used in the model building process is checked against the model output to ensure that the model has been accurately coded and is representing the measured on-site conditions.  Turning movement traffic volumes have been used as the calibration measure in this instance.  A such, the calibration process involved ensuring traffic volumes output by the model were sufficiently accurate when compared against traffic volumes observed on site.

## 4.2 Turning Count Calibration

A turning count calibration was undertaken for each of the major intersections within the model study area.  The purpose of this calibration was to check that traffic volumes collected from the model were representative of traffic volumes measured on site for each traffic movement at each intersection. The GEH statistic was used to compare observed and modelled traffic volumes.

The GEH statistic is a self scaling indicator developed to sensibly compare observed and modelled flows. Rather than directly comparing flows by measure of either absolute or relative differences, the GEH statistic considers both of these measures within thresholds that are appropriate for traffic flow. For instance, the GEH statistic reflects that while an absolute difference of 100 vehicles/hr can be important in the context of a flow of 200 vehicles/hr, it is much less relevant in a flow of several thousand vehicles/hr.

GEH compares the differences between hourly observed flows and hourly modelled flows by using the following formula:

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

Where:

$V_O$ = Observed traffic flow (vehicles/hour)

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

The following criteria were used during the turning count calibration process:

- 85% of GEH statistics for individual junction turning-movement total volumes should be less than 5;
- $R^2$ statistic between 0.9 and 1.0 and slope factors between 0.9 and 1.1, of modelled vs. observed flow plots.

Table 2 provides a summary of the turning movement GEH criteria results.  It can be seen that a total of 40 individual movements were assessed within each time period.  The turning movements included as part of the calibration assessment include only movements which were directly known from recent survey information i.e. manual counts and selected SCATS detector recordings.

Table 2 demonstrates that during both peak periods, the model provides a close match of modelled and observed traffic flows.

Table 2 Summary of GEH Criteria Results

| Time Period | Number of Observations | Observations with GEH < 5 | Average GEH | $R^2$ and Slope | Exceeds Criteria? |
|---|---|---|---|---|---|
| AM Peak | 40 | 40 (*100%*) | 1.53 | 0.99, 1.039 | Yes |
| PM Peak | 40 | 40 (*100%*) | 1.19 | 0.99, 0.969 | Yes |

Figure 4 and Figure 5 show plots of modelled traffic volumes compared with observed traffic volumes for each turning movement. It can be seen from theses charts that there is close fit between observed and modelled traffic volumes across each of the time periods surveyed.

It should be noted that the raw surveyed traffic volumes have been adopted directly for this assessment. That is, there has not been any manual smoothing or manipulation of the surveyed data, as such there exist some minor discrepancies between adjacent sites due to inherent survey errors. Consequently, under this approach it is not possible to match each and every count precisely.

Appendix A provides fully tabulated results of the turning count calibration assessment for each individual turning movement.

Figure 4 AM Peak Traffic Volume Comparison

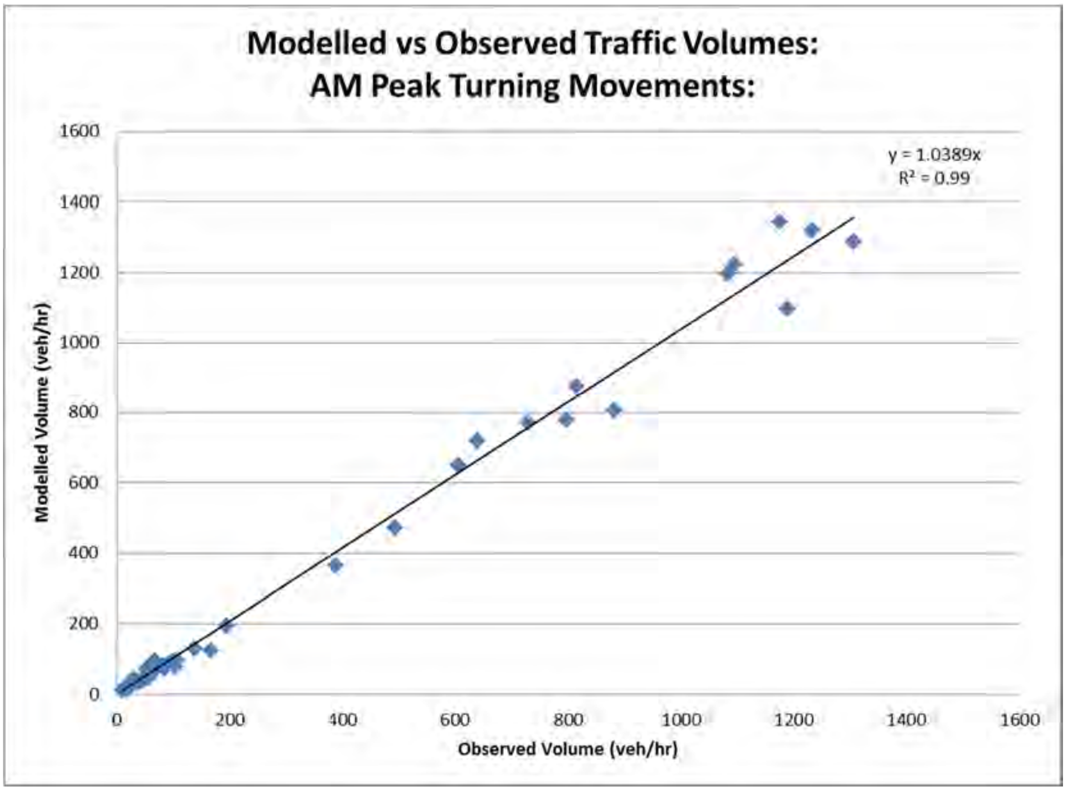
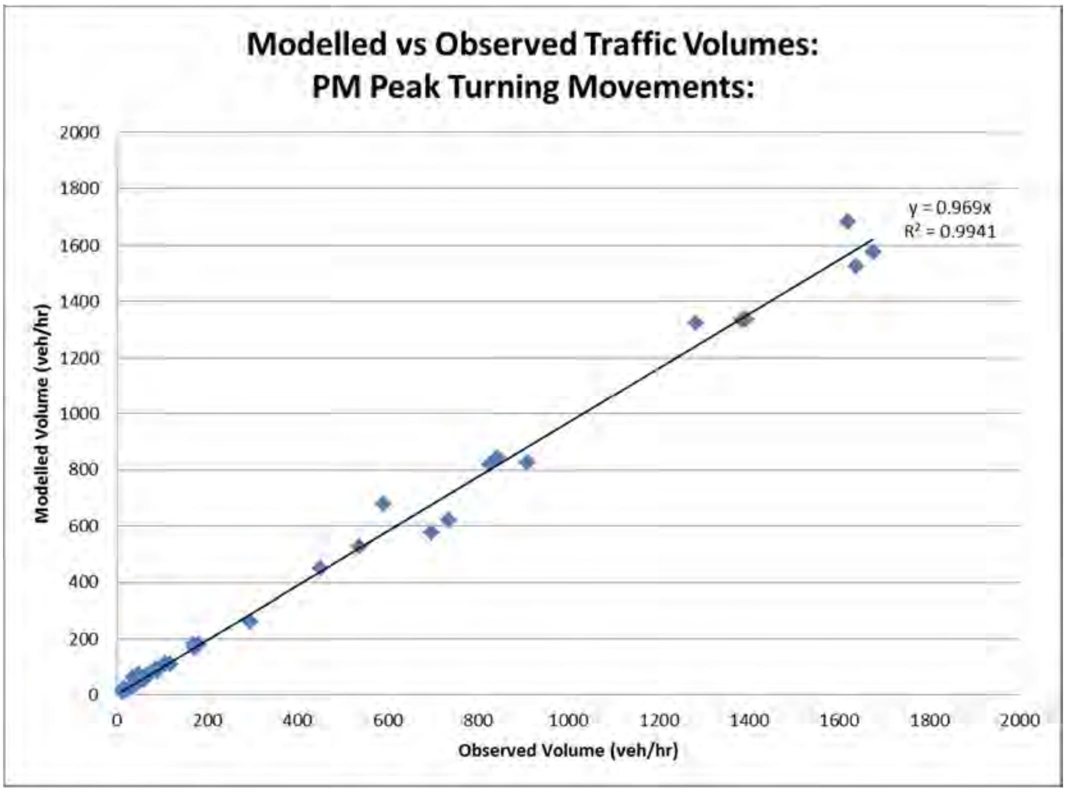


Figure 5 PM Peak Traffic Volume Comparison



# 5. Model Validation

## 5.1 Introduction

This section details the results from the validation of the base model. The purpose of model validation is to ensure that statistical results in the model accurately reflect data collected during the survey period, but have not been explicitly used as model inputs during the development stages. The validation measure used in this instance was travel time data.

In addition to the travel time validation, an assessment of model stability has also been presented which shows model output variations across multiple seed value runs.

## 5.2 Travel Time Validation

As part of the validation process GHD undertook an analysis of journey times for vehicles in the model along Wanneroo Road and compared these against journey time observations recorded on site. Average journey times across five seed runs were collected from the model outputs and analysed. The following criteria was used to assess whether the modelled journey times were representative of conditions on site:

- Percentage difference between total observed and total modelled journey times for each route should be less than 15% or 1-minute (whichever is greater).

Table 3 and Table 4 shows a summary of the travel time validation results for Wanneroo Road for the AM and PM periods respectively. It is clear that the model closely replicates the recorded travel times along this critical corridor for both the AM and PM periods.

Table 3 AM Peak Travel Time Comparison

| Location | Observed (seconds) | Modelled (seconds) | Difference (seconds) | Meets Criteria? |
|---|---|---|---|---|
| **Southbound** | | | | |
| Pinjar Road to Dundebar Road | 104 | 100 | -4 | *Yes* |
| Dundebar Road to Conlan Road | 40 | 16 | -23 | *Yes* |
| Conlan Road to Elliot Road | 79 | 73 | -6 | *Yes* |
| **Northbound** | | | | |
| Elliot Road to Hastings Street | 79 | 84 | 6 | *Yes* |
| Hastings Street to Dundebar Road | 11 | 28 | 18 | *Yes* |
| Dundebar Road to Pinjar Road | 83 | 79 | -5 | *Yes* |

It is noted that the observed travel time between Dundebar Road and Conlan Road is 40 seconds (compared to an average modelled time of 16 seconds). A closer inspection of the individual times representing the 40 second average revealed a range between 10 and 71 seconds, and was dependent upon whether the survey vehicle was required to stop at the Conlan Road traffic signals.

Table 4 PM Peak Travel Time Comparison

| Location | Observed (seconds) | Modelled (seconds) | Difference (seconds) | Meets Criteria? |
|---|---|---|---|---|
| **Southbound** | | | | |
| Pinjar Road to Dundebar Road | 97 | 98 | 1 | *Yes* |
| Dundebar Road to Conlan Road | 13 | 17 | 3 | *Yes* |
| Conlan Road to Elliot Road | 77 | 72 | -4 | *Yes* |
| **Northbound** | | | | |
| Elliot Road to Hastings Street | 111 | 96 | -15 | *Yes* |
| Hastings Street to Dundebar Road | 16 | 20 | 4 | *Yes* |
| Dundebar Road to Pinjar Road | 111 | 85 | -27 | *Yes* |

It can be seen from Table 3 and Table 4 that the difference between the observed and modelled journey times is significantly less than the 1-minute threshold for all comparisons (in fact, all are less than 30 seconds).

## 5.3 Model Stability

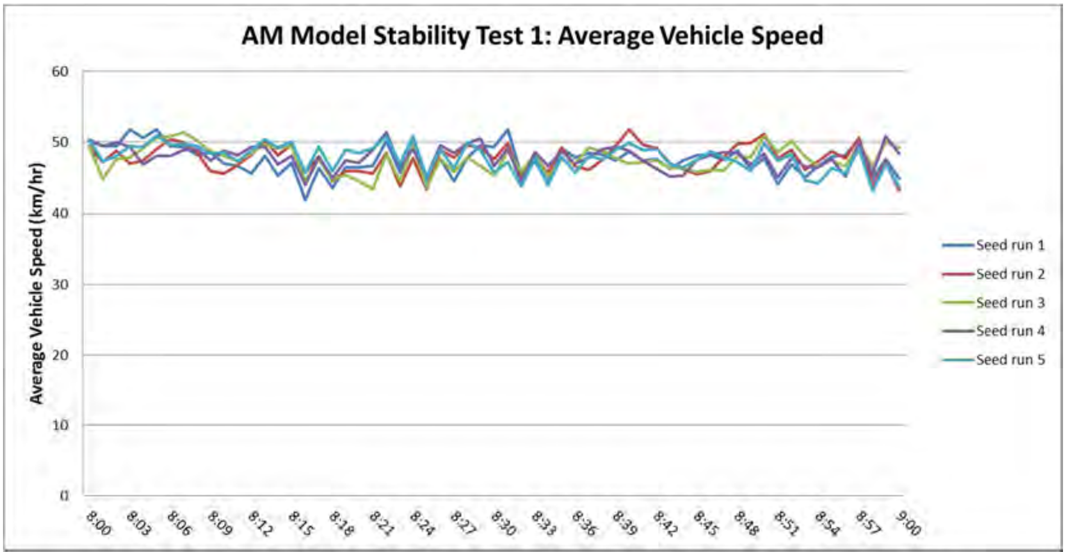
The base model has been run with five 'seed' values (as discussed in Section 3.2 of this report) and the results of these model runs have been averaged for the calibration and validation outputs. However, it is important to ensure that the model runs are providing a stable and consistent model platform to take forward to the option testing stage. This requires the assessment of output statistics from each seed run to ensure that the variability of the outputs appears to be within reasonable limits.

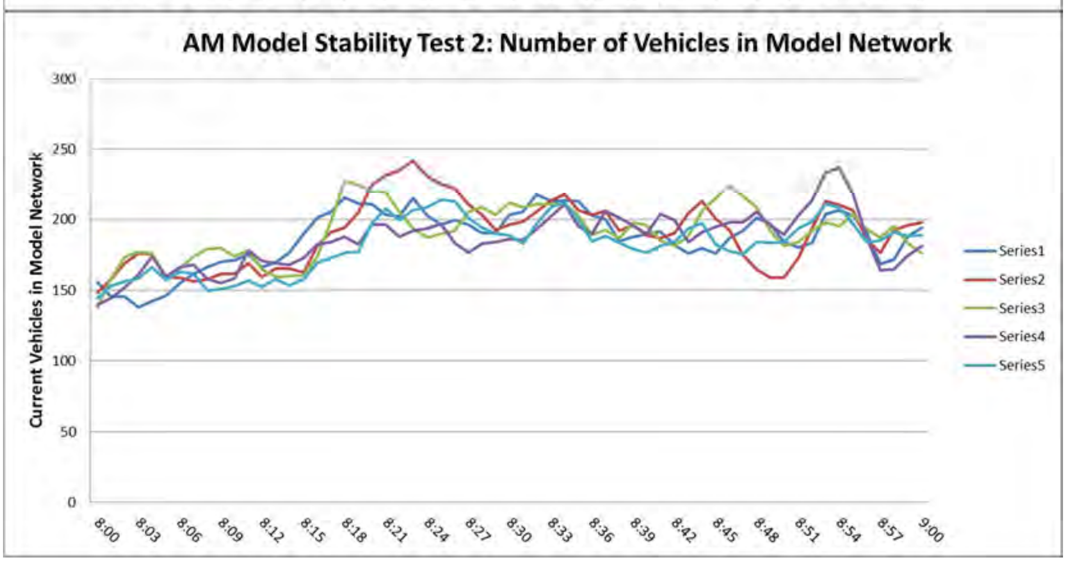
In order to assess model stability for this study, two network wide statistics have been extracted and presented comparing each of the five individual seed value runs. The two assessment statistics are as follows:

- Average vehicle speed (veh/hr) of all vehicles currently in the model network; and
- Current number of vehicles being serviced by the network.

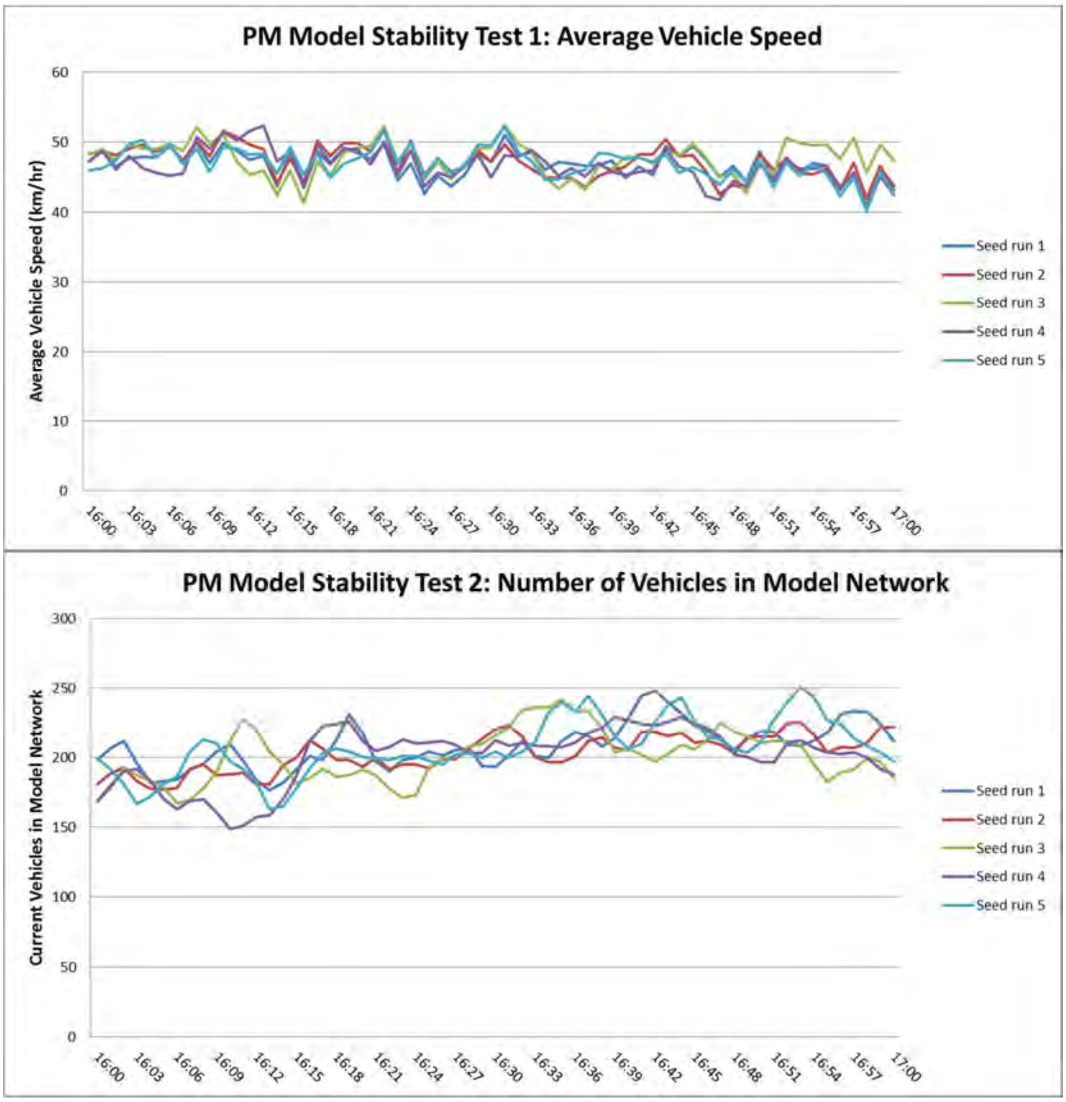
Figure 6 and Figure 7 show the stability test outputs for the AM and PM models respectively. These figures display variations between seed vales (as expected), but do not highlight any substantial outlying or rogue results.

Figure 6 AM Peak Model Stability Test Results



## Figure 7 PM Peak Model Stability Test Results



# 6. Conclusion

## 6.1 Summary

This document has outlined the development of the microsimulation Base model for the central area of Wanneroo. Paramics (version 6) in conjunction with Azalient plugins has been used to simulate the movement vehicles for the critical AM and PM peak periods of an average weekday.

The report has detailed the calibration process used to ensure that the model is representative of observed on-site turning movement traffic volumes. These have been shown to meet and significantly exceed industry standard guidelines.

In addition, the validation process for travel times has been outlined. All modelled travel time data has been shown to meet the target criteria. Furthermore, both the AM and PM models have been found to exhibit stable results across different seed value runs.

Given the results of the calibration and validation process, the model is now considered a robust representation of the study area during the AM and PM peak time periods. As such, these models are considered suitable to be used as the foundation for future year scenario testing.

## 6.2 Next Steps

The next step with regards to the traffic modelling assessment consists of using the AM and PM models as detailed in this report to assess the Wanneroo network performance with increased traffic volumes aligning with the following scenarios:

- 2031 horizon with no change to R-coding; and
- 2031 horizon with increased R-coding designations.

The volumes and trip distributions corresponding to the above scenarios will be determined through analysis of the provided ROM trip matrices for the two scenarios. The relative change in volumes between the two scenarios, and the base volumes, will be considered when interpreting these forecast volumes.

.

# Appendices

# Appendix A Turning Count Calibration Statistics

**AM Peak Turning Movement Comparison**

| Intersection | Movement | Observed | Modelled | GEH |
|---|---|---|---|---|
| Wanneroo Road / Elliot Road | S to N | 729 | 772 | 1.56 |
| Wanneroo Road / Elliot Road | S to E | 99 | 92 | 0.74 |
| Wanneroo Road / Elliot Road | E to S | 137 | 130 | 0.64 |
| Wanneroo Road / Elliot Road | E to N | 68 | 96 | 3.09 |
| Wanneroo Road / Elliot Road | N to E | 56 | 75 | 2.39 |
| Wanneroo Road / Elliot Road | N to S | 1176 | 1343 | 4.72 |
| Wanneroo Road / Celestine Road | S to N | 797 | 779 | 0.63 |
| Wanneroo Road / Celestine Road | S to E | 92 | 87 | 0.57 |
| Wanneroo Road / Celestine Road | E to S | 106 | 98 | 0.83 |
| Wanneroo Road / Celestine Road | E to N | 28 | 40 | 2.06 |
| Wanneroo Road / Celestine Road | N to E | 25 | 30 | 0.92 |
| Wanneroo Road / Celestine Road | N to S | 1232 | 1320 | 2.45 |
| Wanneroo Road / Ariti Avenue | S to W | 11 | 12 | 0.29 |
| Wanneroo Road / Ariti Avenue | S to N | 882 | 805 | 2.65 |
| Wanneroo Road / Ariti Avenue | N to S | 1306 | 1287 | 0.52 |
| Wanneroo Road / Ariti Avenue | N to W | 21 | 21 | 0.09 |
| Wanneroo Road / Ariti Avenue | W to N | 21 | 28 | 1.34 |
| Wanneroo Road / Ariti Avenue | W to S | 50 | 43 | 1.09 |
| Wanneroo Road / Hastings Street / Conlan Street | S to W | 37 | 33 | 0.68 |
| Wanneroo Road / Hastings Street / Conlan Street | S to N | 639 | 720 | 3.09 |
| Wanneroo Road / Hastings Street / Conlan Street | S to E | 103 | 78 | 2.63 |
| Wanneroo Road / Hastings Street / Conlan Street | E to S | 42 | 35 | 1.09 |
| Wanneroo Road / Hastings Street / Conlan Street | E to W | 18 | 14 | 1.00 |
| Wanneroo Road / Hastings Street / Conlan Street | W to N | 10 | 13 | 0.88 |
| Wanneroo Road / Hastings Street / Conlan Street | N to E | 59 | 58 | 0.10 |
| Wanneroo Road / Hastings Street / Conlan Street | N to S | 1096 | 1224 | 3.75 |
| Wanneroo Road / Hastings Street / Conlan Street | N to W | 53 | 70 | 2.19 |
| Wanneroo Road / Hastings Street / Conlan Street | W to N | 32 | 41 | 1.52 |
| Wanneroo Road / Hastings Street / Conlan Street | W to E | 65 | 65 | 0.00 |
| Wanneroo Road / Hastings Street / Conlan Street | W to S | 84 | 75 | 1.01 |
| Wanneroo Road / Dundebar Road | S to N | 605 | 650 | 1.81 |
| Wanneroo Road / Dundebar Road | S to E | 167 | 125 | 3.49 |
| Wanneroo Road / Dundebar Road | E to N | 388 | 366 | 1.15 |
| Wanneroo Road / Dundebar Road | N to S | 1083 | 1196 | 3.36 |
| Wanneroo Road / Pinjar Road | S to N | 816 | 876 | 2.06 |
| Wanneroo Road / Pinjar Road | S to E | 194 | 196 | 0.11 |
| Wanneroo Road / Pinjar Road | E to S | 494 | 473 | 0.94 |
| Wanneroo Road / Pinjar Road | E to N | 83 | 83 | 0.02 |
| Wanneroo Road / Pinjar Road | N to E | 57 | 50 | 0.99 |
| Wanneroo Road / Pinjar Road | N to S | 1189 | 1095 | 2.77 |

### PM Peak Turning Movement Comparison

| Intersection | Movement | Observed | Modelled | GEH |
|---|---|---|---|---|
| Wanneroo Road / Elliot Road | S to N | 1619 | 1682 | 1.56 |
| Wanneroo Road / Elliot Road | S to E | 181 | 180 | 0.04 |
| Wanneroo Road / Elliot Road | E to S | 117 | 109 | 0.75 |
| Wanneroo Road / Elliot Road | E to N | 55 | 61 | 0.74 |
| Wanneroo Road / Elliot Road | N to E | 66 | 67 | 0.17 |
| Wanneroo Road / Elliot Road | N to S | 843 | 843 | 0.01 |
| Wanneroo Road / Celestine Road | S to N | 1674 | 1575 | 2.46 |
| Wanneroo Road / Celestine Road | S to E | 172 | 166 | 0.43 |
| Wanneroo Road / Celestine Road | E to S | 88 | 84 | 0.41 |
| Wanneroo Road / Celestine Road | E to N | 12 | 11 | 0.29 |
| Wanneroo Road / Celestine Road | N to E | 17 | 15 | 0.50 |
| Wanneroo Road / Celestine Road | N to S | 909 | 826 | 2.81 |
| Wanneroo Road / Ariti Avenue | S to W | 36 | 61 | 3.54 |
| Wanneroo Road / Ariti Avenue | S to N | 1637 | 1525 | 2.82 |
| Wanneroo Road / Ariti Avenue | N to S | 826 | 817 | 0.30 |
| Wanneroo Road / Ariti Avenue | N to W | 35 | 30 | 0.91 |
| Wanneroo Road / Ariti Avenue | W to N | 16 | 23 | 1.63 |
| Wanneroo Road / Ariti Avenue | W to S | 23 | 19 | 0.78 |
| Wanneroo Road / Hastings Street / Conlan Street | S to W | 36 | 37 | 0.17 |
| Wanneroo Road / Hastings Street / Conlan Street | S to N | 1283 | 1325 | 1.17 |
| Wanneroo Road / Hastings Street / Conlan Street | S to E | 170 | 181 | 0.85 |
| Wanneroo Road / Hastings Street / Conlan Street | E to S | 105 | 111 | 0.54 |
| Wanneroo Road / Hastings Street / Conlan Street | E to W | 62 | 66 | 0.45 |
| Wanneroo Road / Hastings Street / Conlan Street | W to N | 87 | 92 | 0.49 |
| Wanneroo Road / Hastings Street / Conlan Street | N to E | 54 | 55 | 0.08 |
| Wanneroo Road / Hastings Street / Conlan Street | N to S | 591 | 677 | 3.42 |
| Wanneroo Road / Hastings Street / Conlan Street | N to W | 49 | 73 | 3.03 |
| Wanneroo Road / Hastings Street / Conlan Street | W to N | 42 | 37 | 0.73 |
| Wanneroo Road / Hastings Street / Conlan Street | W to E | 62 | 61 | 0.13 |
| Wanneroo Road / Hastings Street / Conlan Street | W to S | 61 | 55 | 0.79 |
| Wanneroo Road / Dundebar Road | S to N | 1386 | 1334 | 1.40 |
| Wanneroo Road / Dundebar Road | S to E | 107 | 112 | 0.52 |
| Wanneroo Road / Dundebar Road | E to N | 536 | 527 | 0.39 |
| Wanneroo Road / Dundebar Road | N to S | 696 | 577 | 4.73 |
| Wanneroo Road / Pinjar Road | S to N | 1394 | 1336 | 1.56 |
| Wanneroo Road / Pinjar Road | S to E | 452 | 448 | 0.20 |
| Wanneroo Road / Pinjar Road | E to S | 296 | 261 | 2.08 |
| Wanneroo Road / Pinjar Road | E to N | 74 | 76 | 0.28 |
| Wanneroo Road / Pinjar Road | N to E | 56 | 58 | 0.21 |
| Wanneroo Road / Pinjar Road | N to S | 733 | 620 | 4.34 |

GHD

180 Lonsdale Street
Melbourne,  Victoria  3000
T: (03) 8687 8000   F: (03) 8687 8111   E: melmail@ghd.com.au



G:\31\29005\WP\213748.docx

Document Status

| Rev No. | Author | Reviewer | | Approved for Issue | | |
|---|---|---|---|---|---|---|
| | | Name | Signature | Name | Signature | Date |
| 0 | S. Bennett | S. Smedley | | S. Smedley | | |
| | | | | | | |
| | | | | | | |

www.ghd.com

# Appendix C - 2031 forecast traffic volumes

| Intersection | Movement | 2031 AM without LHS | 2031 AM with LHS | 2031 PM without LHS | 2031 PM with LHS |
|---|---|---|---|---|---|
| Wanneroo Road / Elliot Road | S to N | 1050 | 1185 | 2296 | 2589 |
| Wanneroo Road / Elliot Road | S to E | 122 | 139 | 292 | 325 |
| Wanneroo Road / Elliot Road | E to S | 347 | 330 | 230 | 232 |
| Wanneroo Road / Elliot Road | E to N | 262 | 246 | 196 | 192 |
| Wanneroo Road / Elliot Road | N to E | 185 | 217 | 134 | 186 |
| Wanneroo Road / Elliot Road | N to S | 1830 | 2049 | 1217 | 1328 |
| Wanneroo Road / Celestine Road | S to N | 1188 | 1248 | 2280 | 2447 |
| Wanneroo Road / Celestine Road | S to E | 121 | 180 | 210 | 335 |
| Wanneroo Road / Celestine Road | E to S | 126 | 168 | 119 | 163 |
| Wanneroo Road / Celestine Road | E to N | 74 | 122 | 24 | 40 |
| Wanneroo Road / Celestine Road | N to E | 54 | 106 | 38 | 50 |
| Wanneroo Road / Celestine Road | N to S | 1889 | 2098 | 1232 | 1351 |
| Wanneroo Road / Ariti Avenue | S to W | 11 | 18 | 59 | 95 |
| Wanneroo Road / Ariti Avenue | S to N | 1252 | 1360 | 2243 | 2412 |
| Wanneroo Road / Ariti Avenue | N to S | 1876 | 2123 | 1248 | 1366 |
| Wanneroo Road / Ariti Avenue | N to W | 30 | 52 | 54 | 87 |
| Wanneroo Road / Ariti Avenue | W to N | 49 | 76 | 36 | 56 |
| Wanneroo Road / Ariti Avenue | W to S | 49 | 77 | 26 | 35 |
| Wanneroo Road / Hastings Street / Conlan Street | S to W | 31 | 54 | 38 | 44 |
| Wanneroo Road / Hastings Street / Conlan Street | S to N | 1168 | 1241 | 2015 | 2102 |
| Wanneroo Road / Hastings Street / Conlan Street | S to E | 104 | 137 | 224 | 332 |
| Wanneroo Road / Hastings Street / Conlan Street | E to S | 42 | 62 | 127 | 185 |
| Wanneroo Road / Hastings Street / Conlan Street | E to W | 26 | 46 | 66 | 139 |
| Wanneroo Road / Hastings Street / Conlan Street | E to N | 16 | 28 | 189 | 260 |
| Wanneroo Road / Hastings Street / Conlan Street | N to E | 100 | 137 | 104 | 159 |
| Wanneroo Road / Hastings Street / Conlan Street | N to S | 1829 | 2045 | 1132 | 1206 |
| Wanneroo Road / Hastings Street / Conlan Street | N to W | 100 | 143 | 108 | 165 |
| Wanneroo Road / Hastings Street / Conlan Street | W to N | 64 | 76 | 68 | 100 |
| Wanneroo Road / Hastings Street / Conlan Street | W to E | 90 | 166 | 78 | 143 |
| Wanneroo Road / Hastings Street / Conlan Street | W to S | 81 | 103 | 55 | 67 |
| Wanneroo Road / Dundebar Road | S to N | 986 | 1053 | 2018 | 2167 |
| Wanneroo Road / Dundebar Road | S to E | 266 | 294 | 255 | 289 |
| Wanneroo Road / Dundebar Road | E to S | 361 | 423 | 374 | 443 |
| Wanneroo Road / Dundebar Road | E to N | 914 | 894 | 1448 | 1562 |
| Wanneroo Road / Dundebar Road | N to E | 1028 | 1061 | 528 | 523 |
| Wanneroo Road / Dundebar Road | N to S | 1679 | 1910 | 972 | 1084 |
| Wanneroo Road / Pinjar Road | S to N | 1365 | 1432 | 2128 | 2246 |
| Wanneroo Road / Pinjar Road | S to E | 754 | 751 | 1510 | 1603 |
| Wanneroo Road / Pinjar Road | E to S | 1219 | 1342 | 685 | 764 |
| Wanneroo Road / Pinjar Road | E to N | 304 | 304 | 384 | 410 |
| Wanneroo Road / Pinjar Road | N to E | 332 | 297 | 233 | 237 |
| Wanneroo Road / Pinjar Road | N to S | 1665 | 1801 | 944 | 1024 |

# Appendix D - Modelled intersection configurations – Paramics

<table>
<tr><td colspan="2">Wanneroo Road – Pinjar Road</td></tr>
<tr><td>Existing layout</td><td>‘without LHS’ and ‘with LHS’</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Wanneroo Road – New Intersection</td></tr>
<tr><td>Existing layout</td><td>‘without LHS’ and ‘with LHS’</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Wanneroo Road – Church Street</td></tr>
<tr><td>Existing layout</td><td>‘without LHS’ and ‘with LHS’</td></tr>
<tr><td></td><td></td></tr>
</table>

<table>
<tr><td colspan="2">Wanneroo Road – Dundebar Road</td></tr>
<tr><td>Existing layout</td><td>‘without LHS’ and ‘with LHS’</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Wanneroo Road – Hastings Street</td></tr>
<tr><td>Existing layout</td><td>‘without LHS’ and ‘with LHS’</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Wanneroo Road – Ariti Avenue</td></tr>
<tr><td>Existing layout</td><td>‘without LHS’ and ‘with LHS’</td></tr>
<tr><td></td><td></td></tr>
</table>

<table>
<tr><td colspan="3">Wanneroo Road – Celestine Street</td></tr>
<tr><td>Existing layout</td><td>‘without LHS’ (no change from existing)</td><td>‘with LHS’</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

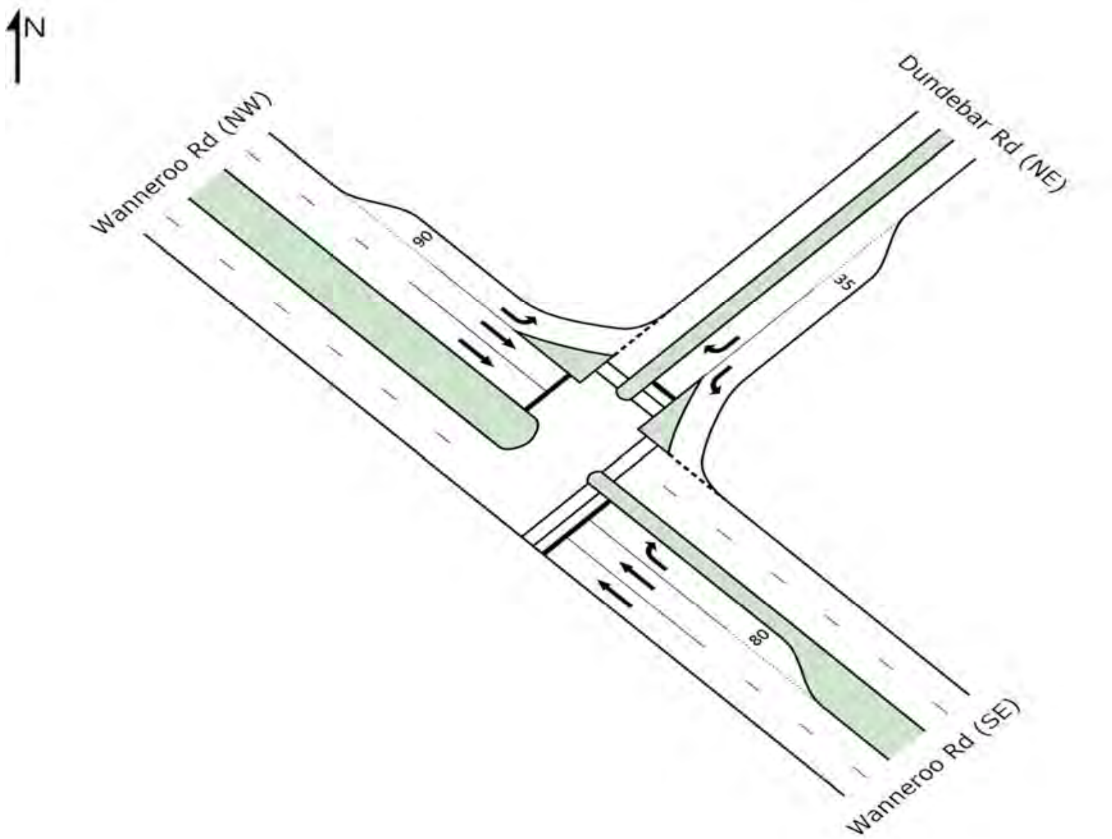
<table>
<tr><td colspan="2">Wanneroo Road – Elliot Road</td></tr>
<tr><td>Existing layout</td><td>‘without LHS’ and ‘with LHS’</td></tr>
<tr><td></td><td></td></tr>
</table>

# Appendix E - Summary of Sidra analysis, 2031 no LHS existing geometry

# Sidra Analysis with NO LHS 2031

This technical note provides the Sidra analysis and output for the Existing Intersection Geometry for full development (2031) with No LHS.

### Wanneroo Road/Dundebar Road Intersection 2031




Dundebar Rd / Wanneroo Rd 2031 NO LHS am Existing Geometry
Signals - Fixed Time    Cycle Time = 149 seconds (Optimum Cycle Time - Minimum Delay)

| Movement Performance - Vehicles | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South East: Wanneroo Rd (SE) | | | | | | | | | | | |
| 22 | T | 1103 | 5.0 | 0.625 | 31.4 | LOS C | 29.8 | 217.4 | 0.81 | 0.73 | 30.7 |
| 23 | R | 149 | 5.0 | 1.029 | 177.3 | LOS F | 17.8 | 130.3 | 1.00 | 1.30 | 10.2 |
| Approach | | 1252 | 5.0 | 1.029 | 48.7 | LOS D | 29.8 | 217.4 | 0.83 | 0.80 | 24.8 |
| North East: Dundebar Rd (NE) | | | | | | | | | | | |
| 24 | L | 239 | 5.0 | 1.000 [3] | 22.5 | LOS C | 7.9 | 57.5 | 0.53 | 0.72 | 37.3 |
| 26 | R | 1036 | 5.0 | 1.285 | 595.8 | LOS F | 280.5 | 2047.6 | 1.00 | 2.20 | 3.5 |
| Approach | | 1275 | 5.0 | 1.285 | 488.3 | LOS F | 280.5 | 2047.6 | 0.91 | 1.92 | 4.2 |
| North West: Wanneroo Rd (NW) | | | | | | | | | | | |
| 27 | L | 1028 | 5.0 | 1.000 [3] | 12.7 | LOS B | 20.1 | 147.1 | 0.69 | 0.81 | 44.4 |
| 28 | T | 1679 | 5.0 | 1.274 | 572.0 | LOS F | 220.9 | 1612.5 | 1.00 | 3.12 | 3.6 |
| Approach | | 2707 | 5.0 | 1.274 | 359.6 | LOS F | 220.9 | 1612.5 | 0.88 | 2.24 | 5.5 |
| All Vehicles | | 5234 | 5.0 | 1.285 | 316.6 | LOS F | 280.5 | 2047.6 | 0.88 | 1.82 | 6.2 |

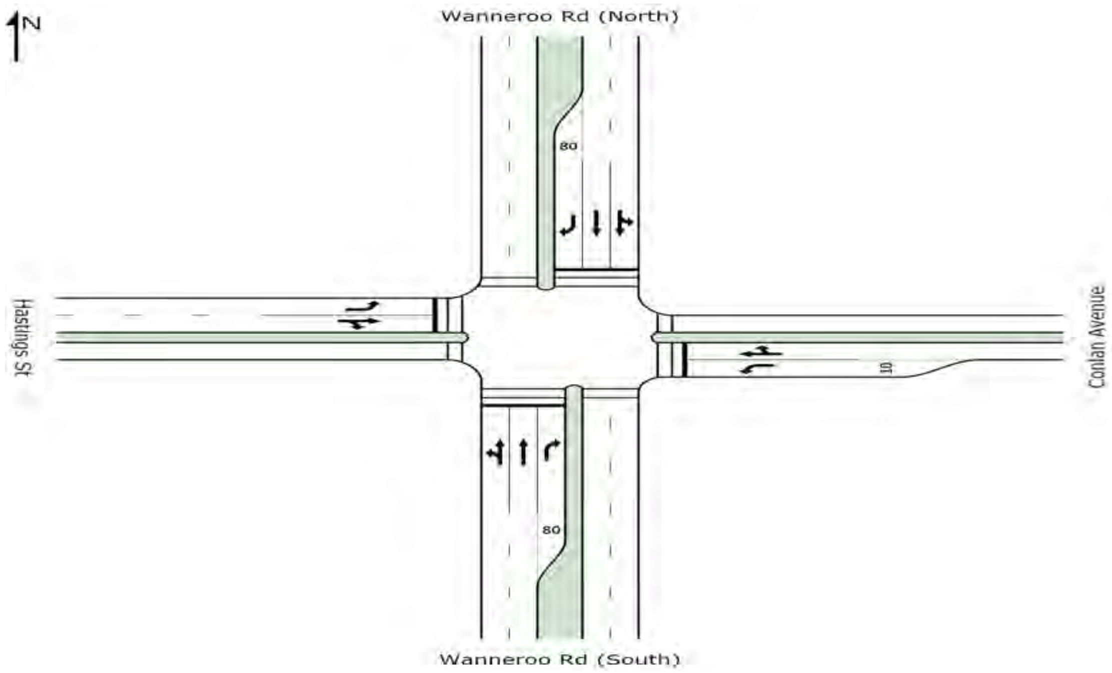
Dundebar Rd / Wanneroo Rd 2031 NO LHS pm Existing Geometry
Signals - Fixed Time    Cycle Time = 124 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South East: Wanneroo Rd (SE) | | | | | | | | | | | |
| 22 | T | 2096 | 5.0 | 1.499 | 965.2 | LOS F | 361.3 | 2637.2 | 1.00 | 4.82 | 2.2 |
| 23 | R | 177 | 5.0 | 1.017 | 147.6 | LOS F | 17.8 | 130.2 | 1.00 | 1.33 | 11.9 |
| Approach | | 2273 | 5.0 | 1.499 | 901.7 | LOS F | 361.3 | 2637.2 | 1.00 | 4.54 | 2.3 |
| North East: Dundebar Rd (NE) | | | | | | | | | | | |
| 24 | L | 374 | 5.0 | 0.997 | 16.5 | LOS B | 7.9 | 57.4 | 0.57 | 0.74 | 41.4 |
| 26 | R | 1448 | 5.0 | 1.517 | 1000.7 | LOS F | 511.5 | 3733.7 | 1.00 | 3.17 | 2.1 |
| Approach | | 1822 | 5.0 | 1.517 | 798.7 | LOS F | 511.5 | 3733.7 | 0.91 | 2.67 | 2.6 |
| North West: Wanneroo Rd (NW) | | | | | | | | | | | |
| 27 | L | 528 | 5.0 | 0.513 | 9.9 | LOS A | 6.4 | 46.6 | 0.29 | 0.68 | 47.3 |
| 28 | T | 972 | 5.0 | 1.140 | 330.0 | LOS F | 85.7 | 625.6 | 1.00 | 2.43 | 5.9 |
| Approach | | 1500 | 5.0 | 1.140 | 217.3 | LOS F | 85.7 | 625.6 | 0.75 | 1.82 | 8.6 |
| All Vehicles | | 5595 | 5.0 | 1.517 | 684.7 | LOS F | 511.5 | 3733.7 | 0.90 | 3.20 | 3.0 |

The above analysis indicates an intersection LoS of F to 2031 with no LHS for the current geometry. Stop rates for some movements are greater than 3 and the degree of saturation is 1.285 to 1.517. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance

## Wanneroo Road/Hastings Road Intersection 2031




Wannerroo Hastings 2031 NO LHS Existing Geometry am
Signals - Fixed Time    Cycle Time = 150 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 1 | L | 31 | 5.0 | 0.636 | 37.4 | LOS D | 31.5 | 230.2 | 0.79 | 0.94 | 31.0 |
| 2 | T | 1168 | 5.0 | 0.636 | 29.1 | LOS C | 31.6 | 230.8 | 0.79 | 0.72 | 31.9 |
| 3 | R | 104 | 5.0 | 0.967 | 117.1 | LOS F | 9.7 | 70.8 | 1.00 | 1.14 | 14.2 |
| Approach | | 1303 | 5.0 | 0.967 | 36.3 | LOS D | 31.6 | 230.8 | 0.81 | 0.75 | 29.0 |
| East: Conlan Avenue | | | | | | | | | | | |
| 4 | L | 35 | 5.0 | 1.000[3] | 72.9 | LOS E | 2.2 | 16.3 | 0.96 | 0.71 | 20.0 |
| 5 | T | 33 | 5.0 | 0.192 | 61.8 | LOS E | 3.2 | 23.5 | 0.92 | 0.70 | 21.1 |
| 6 | R | 16 | 5.0 | 0.192 | 70.0 | LOS E | 3.2 | 23.5 | 0.92 | 0.76 | 20.9 |
| Approach | | 84 | 5.0 | 1.000 | 67.9 | LOS E | 3.2 | 23.5 | 0.94 | 0.72 | 20.6 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 100 | 5.0 | 1.024 | 149.2 | LOS F | 122.3 | 893.0 | 1.00 | 1.44 | 12.0 |
| 8 | T | 1829 | 5.0 | 1.024 | 140.7 | LOS F | 122.9 | 897.0 | 1.00 | 1.45 | 12.1 |
| 9 | R | 100 | 5.0 | 0.929 | 103.9 | LOS F | 8.7 | 63.2 | 1.00 | 1.06 | 15.6 |
| Approach | | 2029 | 5.0 | 1.024 | 139.3 | LOS F | 122.9 | 897.0 | 1.00 | 1.43 | 12.2 |
| West: Hastings St | | | | | | | | | | | |
| 10 | L | 64 | 5.0 | 0.255 | 71.0 | LOS E | 4.2 | 30.8 | 0.93 | 0.77 | 20.3 |
| 11 | T | 90 | 5.0 | 0.663 | 67.3 | LOS E | 12.1 | 88.5 | 1.00 | 0.83 | 20.0 |
| 12 | R | 81 | 5.0 | 0.663 | 75.5 | LOS E | 12.1 | 88.5 | 1.00 | 0.83 | 19.9 |
| Approach | | 235 | 5.0 | 0.663 | 71.1 | LOS E | 12.1 | 88.5 | 0.98 | 0.81 | 20.0 |
| All Vehicles | | 3651 | 5.0 | 1.024 | 96.5 | LOS F | 122.9 | 897.0 | 0.93 | 1.14 | 16.1 |

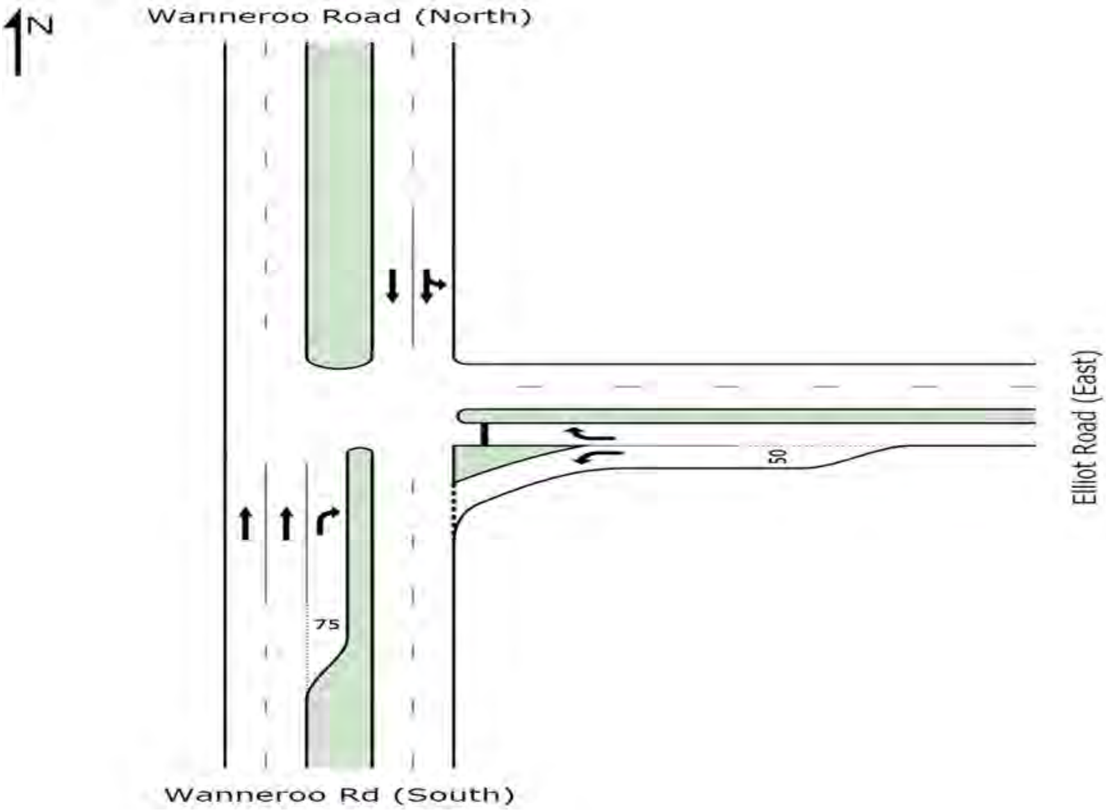
Wannerroo Hastings 2031 NO LHS Existing Geometry pm
Signals - Fixed Time    Cycle Time = 150 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 1 | L | 38 | 5.0 | 1.206 | 454.2 | LOS F | 249.4 | 1820.5 | 1.00 | 2.68 | 4.5 |
| 2 | T | 2112 | 5.0 | 1.206 | 445.8 | LOS F | 249.4 | 1820.5 | 1.00 | 2.66 | 4.5 |
| 3 | R | 127 | 5.0 | 1.065 | 230.5 | LOS F | 17.9 | 130.6 | 1.00 | 1.41 | 8.2 |
| Approach | | 2277 | 5.0 | 1.206 | 433.9 | LOS F | 249.4 | 1820.5 | 1.00 | 2.59 | 4.6 |
| East: Conlan Avenue | | | | | | | | | | | |
| 4 | L | 36 | 5.0 | 1.000 [3] | 71.4 | LOS E | 2.2 | 16.3 | 0.97 | 0.72 | 20.2 |
| 5 | T | 157 | 5.0 | 1.196 | 443.4 | LOS F | 76.2 | 556.1 | 1.00 | 2.00 | 4.5 |
| 6 | R | 189 | 5.0 | 1.196 | 451.6 | LOS F | 76.2 | 556.1 | 1.00 | 2.00 | 4.5 |
| Approach | | 382 | 5.0 | 1.196 | 412.8 | LOS F | 76.2 | 556.1 | 1.00 | 1.88 | 4.8 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 104 | 5.0 | 0.694 | 41.2 | LOS D | 34.8 | 253.7 | 0.85 | 0.92 | 29.3 |
| 8 | T | 1132 | 5.0 | 0.694 | 32.8 | LOS C | 35.1 | 255.9 | 0.85 | 0.77 | 30.1 |
| 9 | R | 108 | 5.0 | 0.903 | 98.5 | LOS F | 9.1 | 66.1 | 1.00 | 1.01 | 16.2 |
| Approach | | 1344 | 5.0 | 0.903 | 38.7 | LOS D | 35.1 | 255.9 | 0.86 | 0.80 | 28.1 |
| West: Hastings St | | | | | | | | | | | |
| 10 | L | 68 | 5.0 | 0.271 | 71.2 | LOS E | 4.5 | 32.9 | 0.94 | 0.77 | 20.3 |
| 11 | T | 78 | 5.0 | 0.514 | 65.4 | LOS E | 9.2 | 66.9 | 0.98 | 0.79 | 20.4 |
| 12 | R | 55 | 5.0 | 0.514 | 73.6 | LOS E | 9.2 | 66.9 | 0.98 | 0.81 | 20.3 |
| Approach | | 201 | 5.0 | 0.514 | 69.6 | LOS E | 9.2 | 66.9 | 0.96 | 0.79 | 20.3 |
| All Vehicles | | 4204 | 5.0 | 1.206 | 288.3 | LOS F | 249.4 | 1820.5 | 0.95 | 1.87 | 6.7 |

The above analysis indicates an intersection LoS of F to 2031 with no LHS for the current geometry. Stop rates for some movements are greater than 2 for some movements and the degree of saturation is 1.024 to 1.206. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance.

## Wanneroo Road/Elliot Road Intersection 2031




Wanneroo Rd / Elliot Rd 2031 NO LHS 2031 am
Stop (Two-Way)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 2 | T | 1095 | 5.0 | 0.291 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| 3 | R | 77 | 5.0 | 1.283 | 661.2 | LOS F | 25.5 | 186.4 | 1.00 | 2.73 | 3.1 |
| Approach | | 1172 | 5.0 | 1.283 | 43.4 | NA | 25.5 | 186.4 | 0.07 | 0.18 | 27.4 |
| East: Elliot Road (East) | | | | | | | | | | | |
| 4 | L | 70 | 5.0 | 1.170 | 466.8 | LOS F | 17.0 | 123.9 | 1.00 | 2.28 | 4.4 |
| 6 | R | 539 | 5.0 | 8.045 | 12757.5 | LOS F | 609.8 | 4451.6 | 1.00 | 7.97 | 0.2 |
| Approach | | 609 | 5.0 | 8.045 | 11340.8 | LOS F | 609.8 | 4451.6 | 1.00 | 7.32 | 0.2 |
| North: Wanneroo Road (North) | | | | | | | | | | | |
| 7 | L | 185 | 5.0 | 0.536 | 8.4 | LOS A | 0.0 | 0.0 | 0.00 | 0.98 | 49.0 |
| 8 | T | 1830 | 5.0 | 0.536 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| Approach | | 2015 | 5.0 | 0.536 | 0.8 | NA | 0.0 | 0.0 | 0.00 | 0.09 | 58.8 |
| All Vehicles | | 3796 | 5.0 | 8.045 | 1833.2 | NA | 609.8 | 4451.6 | 0.18 | 1.28 | 1.2 |

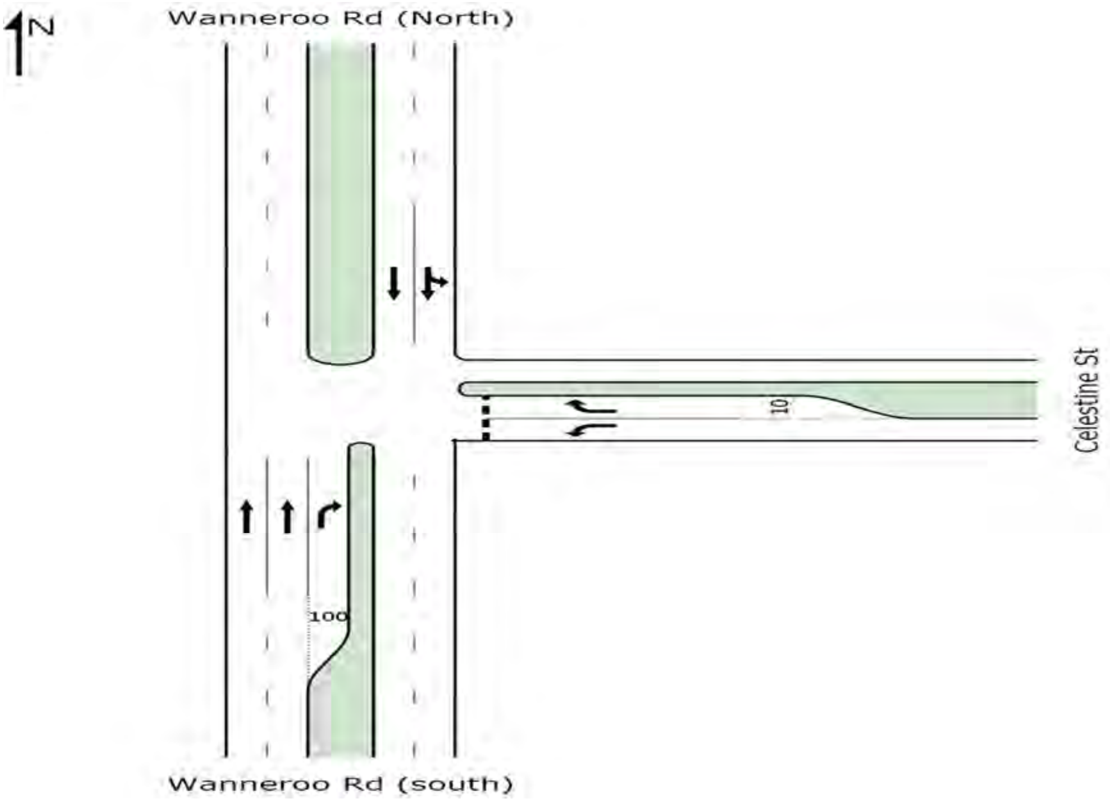
Wanneroo Rd / Elliot Rd 2031 NO LHS 2031 pm
Stop (Two-Way)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 2 | T | 2336 | 5.0 | 0.619 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| 3 | R | 252 | 5.0 | 1.044 | 170.3 | LOS F | 25.5 | 186.1 | 1.00 | 3.01 | 10.6 |
| Approach | | 2588 | 5.0 | 1.044 | 16.6 | NA | 25.5 | 186.1 | 0.10 | 0.29 | 41.2 |
| East: Elliot Road (East) | | | | | | | | | | | |
| 4 | L | 195 | 5.0 | 1.018 | 148.7 | LOS F | 16.8 | 122.5 | 1.00 | 2.42 | 11.9 |
| 6 | R | 231 | 5.0 | 1.458 | 881.9 | LOS F | 96.5 | 704.4 | 1.00 | 6.53 | 2.4 |
| Approach | | 426 | 5.0 | 1.458 | 545.5 | LOS F | 96.5 | 704.4 | 1.00 | 4.64 | 3.8 |
| North: Wanneroo Road (North) | | | | | | | | | | | |
| 7 | L | 134 | 5.0 | 0.360 | 8.4 | LOS A | 0.0 | 0.0 | 0.00 | 0.97 | 49.0 |
| 8 | T | 1217 | 5.0 | 0.360 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| Approach | | 1351 | 5.0 | 0.360 | 0.8 | NA | 0.0 | 0.0 | 0.00 | 0.10 | 58.7 |
| All Vehicles | | 4365 | 5.0 | 1.458 | 63.3 | NA | 96.5 | 704.4 | 0.16 | 0.66 | 21.9 |

The above analysis indicates an intersection LoS of F to 2031 with no LHS for the current geometry. Stop rates for the right turn out of Elliot Road are around 7 and the degree of saturation is up to 8.0451. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance.

## Wanneroo Road/Celestine Road Intersection 2031




Wannerro Rd / Celestine St 2031 NO LHS Existing Geometry AM
Giveway / Yield (Two-Way) To Median

**Movement Performance - Vehicles**

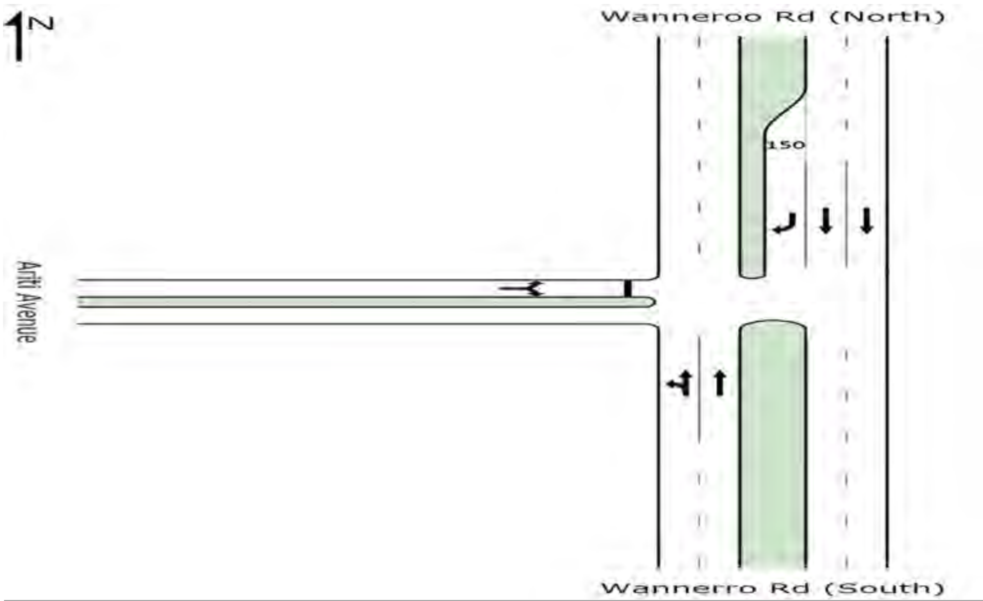
| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (south) | | | | | | | | | | | |
| 2 | T | 1223 | 5.0 | 0.324 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| 3 | R | 86 | 5.0 | 1.376 | 814.3 | LOS F | 34.0 | 248.5 | 1.00 | 3.16 | 2.6 |
| Approach | | 1309 | 5.0 | 1.376 | 53.7 | NA | 34.0 | 248.5 | 0.07 | 0.21 | 24.2 |
| East: Celestine St | | | | | | | | | | | |
| 4 | L | 133 | 5.0 | 2.223 | 2294.8 | LOS F | 97.5 | 712.0 | 1.00 | 5.14 | 0.9 |
| 6 | R | 67 | 5.0 | 1.000 [3] | 88.8 | LOS F | 3.4 | 24.9 | 1.00 | 1.07 | 17.4 |
| Approach | | 200 | 5.0 | 2.223 | 1560.2 | LOS F | 97.5 | 712.0 | 1.00 | 3.79 | 1.4 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 54 | 5.0 | 0.515 | 8.4 | LOS A | 0.0 | 0.0 | 0.00 | 1.06 | 49.0 |
| 8 | T | 1889 | 5.0 | 0.515 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| Approach | | 1943 | 5.0 | 0.515 | 0.2 | NA | 0.0 | 0.0 | 0.00 | 0.03 | 59.6 |
| All Vehicles | | 3452 | 5.0 | 2.223 | 110.9 | NA | 97.5 | 712.0 | 0.08 | 0.31 | 14.8 |

Wannerro Rd / Celestine St 2031 NO LHS Existing Geometry PM
Giveway / Yield (Two-Way) To Median

| Movement Performance - Vehicles | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue | | Prop. Queued | Effective Stop Rate | Average Speed |
| | | | | | | | Vehicles | Distance | | | |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (south) | | | | | | | | | | | |
| 2 | T | 2280 | 5.0 | 0.604 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| 3 | R | 210 | 5.0 | 0.750 | 36.4 | LOS E | 4.4 | 31.8 | 0.94 | 1.26 | 30.1 |
| Approach | | 2490 | 5.0 | 0.750 | 3.1 | NA | 4.4 | 31.8 | 0.08 | 0.11 | 55.4 |
| East: Celestine St | | | | | | | | | | | |
| 4 | L | 119 | 5.0 | 0.580 | 35.0 | LOS E | 2.4 | 17.6 | 0.92 | 1.10 | 30.6 |
| 6 | R | 24 | 5.0 | 0.134 | 27.6 | LOS D | 0.4 | 3.0 | 0.87 | 0.96 | 34.2 |
| Approach | | 143 | 5.0 | 0.580 | 33.8 | LOS D | 2.4 | 17.6 | 0.91 | 1.07 | 31.2 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 38 | 5.0 | 0.337 | 8.4 | LOS A | 0.0 | 0.0 | 0.00 | 1.06 | 49.0 |
| 8 | T | 1232 | 5.0 | 0.337 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| Approach | | 1270 | 5.0 | 0.337 | 0.3 | NA | 0.0 | 0.0 | 0.00 | 0.03 | 59.6 |
| All Vehicles | | 3903 | 5.0 | 0.750 | 3.3 | NA | 4.4 | 31.8 | 0.08 | 0.12 | 55.1 |

The above analysis indicates an intersection LoS of E/ F to 2031 with no LHS, for the current geometry. Stop rates for the left turn out of Celestine Street Road are around 5 and the degree of saturation is up to 2.223. Queuing is significant and unacceptable in Celestine Street. The analysis indicates that upgrade is required to improve the performance.

## Wanneroo Road/Ariti Ave 2031




Wanneroo Road / Ariti Ave 2031 NO LHS Existing Geometry am
Stop (Two-Way)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wannerro Rd (South) | | | | | | | | | | | |
| 1 | L | 12 | 7.4 | 0.357 | 8.5 | LOS A | 0.0 | 0.0 | 0.00 | 1.10 | 49.0 |
| 2 | T | 1318 | 7.4 | 0.357 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| Approach | | 1329 | 7.4 | 0.357 | 0.1 | NA | 0.0 | 0.0 | 0.00 | 0.01 | 59.9 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 8 | T | 1975 | 7.4 | 0.531 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| 9 | R | 32 | 7.4 | 0.141 | 24.4 | LOS C | 0.5 | 3.4 | 0.86 | 0.95 | 36.1 |
| Approach | | 2006 | 7.4 | 0.531 | 0.4 | NA | 0.5 | 3.4 | 0.01 | 0.02 | 59.4 |
| West: Ariti Avenue | | | | | | | | | | | |
| 10 | L | 52 | 7.4 | 0.599 | 43.9 | LOS E | 2.4 | 18.0 | 0.93 | 1.12 | 28.0 |
| 12 | R | 52 | 7.4 | 0.599 | 43.9 | LOS E | 2.4 | 18.0 | 0.93 | 1.13 | 28.0 |
| Approach | | 103 | 7.4 | 0.599 | 43.9 | LOS E | 2.4 | 18.0 | 0.93 | 1.12 | 28.0 |
| All Vehicles | | 3439 | 7.4 | 0.599 | 1.6 | NA | 2.4 | 18.0 | 0.04 | 0.05 | 57.6 |

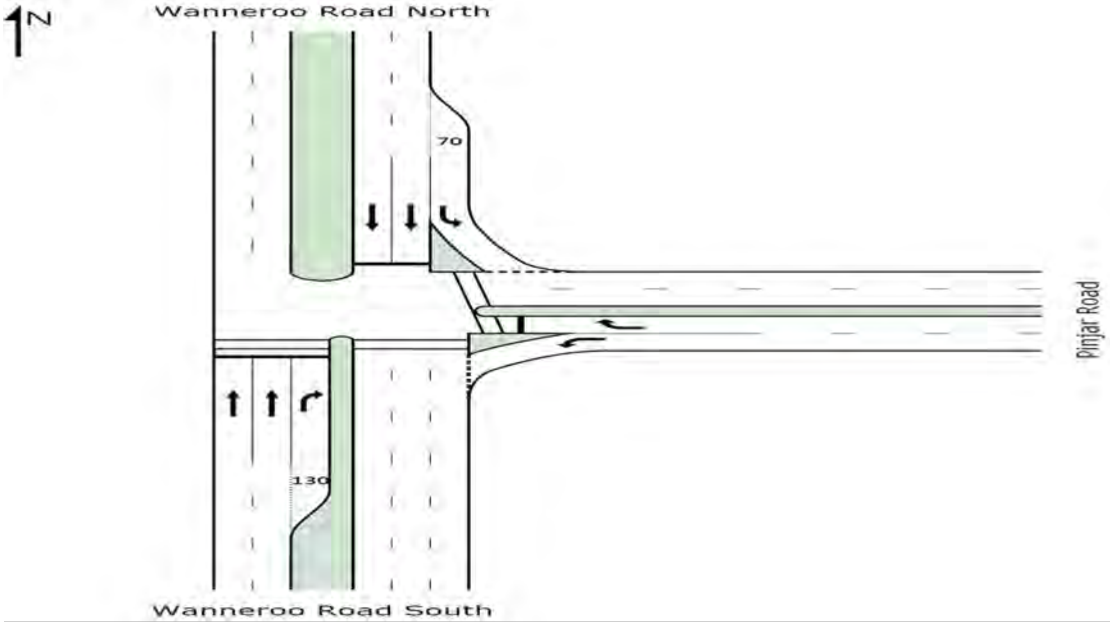
Wanneroo Road / Ariti Ave 2031 NO LHS Existing Geometry am From Median
Stop (Two-Way)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wannerro Rd (South) | | | | | | | | | | | |
| 1 | L | 12 | 7.4 | 0.357 | 8.5 | LOS A | 0.0 | 0.0 | 0.00 | 1.10 | 49.0 |
| 2 | T | 1318 | 7.4 | 0.357 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| Approach | | 1329 | 7.4 | 0.357 | 0.1 | NA | 0.0 | 0.0 | 0.00 | 0.01 | 59.9 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 8 | T | 1975 | 7.4 | 0.531 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| 9 | R | 32 | 7.4 | 0.141 | 24.4 | LOS C | 0.5 | 3.4 | 0.86 | 0.95 | 36.1 |
| Approach | | 2006 | 7.4 | 0.531 | 0.4 | NA | 0.5 | 3.4 | 0.01 | 0.02 | 59.4 |
| West: Ariti Avenue | | | | | | | | | | | |
| 10 | L | 52 | 7.4 | 1.211 | 506.3 | LOS F | 27.6 | 205.3 | 1.00 | 3.09 | 4.0 |
| 12 | R | 52 | 7.4 | 1.211 | 506.3 | LOS F | 27.6 | 205.3 | 1.00 | 2.93 | 4.0 |
| Approach | | 103 | 7.4 | 1.211 | 506.3 | LOS F | 27.6 | 205.3 | 1.00 | 3.01 | 4.0 |
| All Vehicles | | 3439 | 7.4 | 1.211 | 15.4 | NA | 27.6 | 205.3 | 0.04 | 0.10 | 42.2 |

AM analysis has been undertaken only. The above analysis indicates an intersection LoS of E/ F to 2031 with no LHS, for the current geometry. Stop rates for the left/right turn out of Ariti Ave are around 3 and the degree of saturation is up to 1.211. Queuing is significant and unacceptable in Ariti Ave. The analysis indicates that upgrade is required to improve the performance.

## Wanneroo Road/Pinjar Road Intersection 2031




Wanneroo Road/Pinjar Road 2031 NO LHS Existing Geometry am
Signals - Fixed Time    Cycle Time = 150 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Road South | | | | | | | | | | | |
| 2 | T | 1713 | 5.0 | 0.681 | 15.5 | LOS B | 37.3 | 272.3 | 0.66 | 0.61 | 39.8 |
| 3 | R | 406 | 5.0 | 1.000 [3] | 70.9 | LOS E | 30.0 | 218.7 | 1.00 | 0.87 | 20.4 |
| Approach | | 2119 | 5.0 | 1.000 | 26.2 | LOS C | 37.3 | 272.3 | 0.72 | 0.66 | 33.7 |
| East: Pinjar Road | | | | | | | | | | | |
| 4 | L | 1219 | 5.0 | 1.291 | 584.1 | LOS F | 310.8 | 2269.1 | 1.00 | 2.38 | 3.6 |
| 6 | R | 304 | 5.0 | 0.687 | 63.3 | LOS E | 20.2 | 147.6 | 0.97 | 0.85 | 22.0 |
| Approach | | 1523 | 5.0 | 1.291 | 480.1 | LOS F | 310.8 | 2269.1 | 0.99 | 2.08 | 4.3 |
| North: Wanneroo Road North | | | | | | | | | | | |
| 7 | L | 332 | 5.0 | 0.589 | 14.8 | LOS B | 7.8 | 57.2 | 0.40 | 0.70 | 42.8 |
| 8 | T | 1665 | 5.0 | 1.084 | 239.2 | LOS F | 134.4 | 980.9 | 1.00 | 1.89 | 7.8 |
| Approach | | 1997 | 5.0 | 1.084 | 201.9 | LOS F | 134.4 | 980.9 | 0.90 | 1.70 | 9.1 |
| All Vehicles | | 5639 | 5.0 | 1.291 | 211.0 | LOS F | 310.8 | 2269.1 | 0.86 | 1.41 | 8.8 |

Wanneroo Road/Pinjar Road 2031 NO LHS Existing Geometry pm
Signals - Fixed Time    Cycle Time = 125 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Road South | | | | | | | | | | | |
| 2 | T | 3086 | 5.0 | 1.153 | 331.3 | LOS F | 301.1 | 2198.0 | 1.00 | 2.41 | 5.9 |
| 3 | R | 552 | 5.0 | 1.000 [3] | 45.6 | LOS D | 29.1 | 212.2 | 1.00 | 0.89 | 26.7 |
| Approach | | 3638 | 5.0 | 1.153 | 287.9 | LOS F | 301.1 | 2198.0 | 1.00 | 2.18 | 6.7 |
| East: Pinjar Road | | | | | | | | | | | |
| 4 | L | 685 | 5.0 | 0.579 | 16.9 | LOS B | 19.4 | 141.8 | 0.59 | 0.78 | 41.1 |
| 6 | R | 384 | 5.0 | 1.164 | 382.3 | LOS F | 72.9 | 532.2 | 1.00 | 1.95 | 5.2 |
| Approach | | 1069 | 5.0 | 1.164 | 148.2 | LOS F | 72.9 | 532.2 | 0.74 | 1.20 | 11.9 |
| North: Wanneroo Road North | | | | | | | | | | | |
| 7 | L | 233 | 5.0 | 0.436 | 15.6 | LOS B | 5.2 | 38.2 | 0.45 | 0.71 | 42.2 |
| 8 | T | 944 | 5.0 | 0.919 | 66.7 | LOS E | 34.5 | 252.1 | 1.00 | 1.13 | 20.5 |
| Approach | | 1177 | 5.0 | 0.919 | 56.6 | LOS E | 34.5 | 252.1 | 0.89 | 1.04 | 22.8 |
| All Vehicles | | 5884 | 5.0 | 1.164 | 216.3 | LOS F | 301.1 | 2198.0 | 0.93 | 1.78 | 8.6 |

The above analysis indicates an intersection LoS of E/ F to 2031 with no LHS, for the current geometry. Stop rates for some movements are in excess of 1 for a number of movements. The degree of saturation is up to 1.291. Queuing is significant and unacceptable. The analysis indicates that upgrade is required to improve the performance.

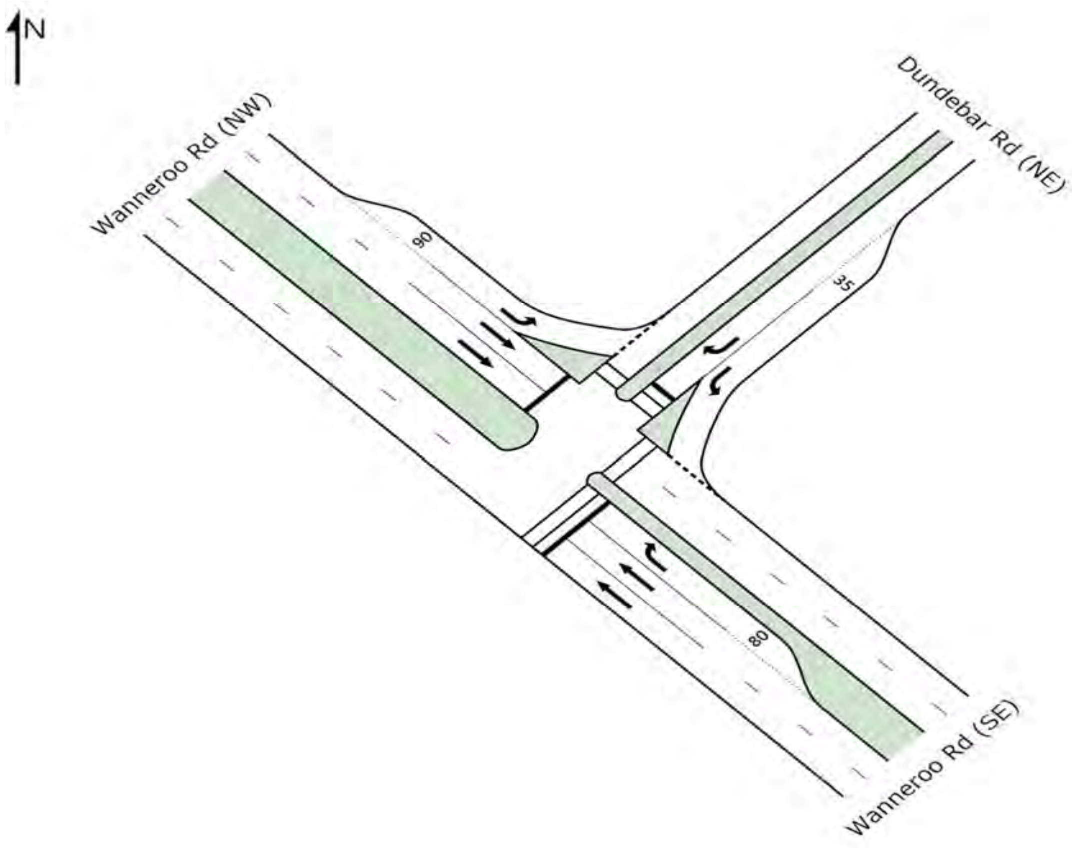
# Appendix F - Summary of Sidra analysis, 2031 with LHS proposed geometry

# Sidra Analysis with LHS 2031

This technical note provides the Sidra analysis and output for the Proposed Ultimate Intersection Geometry for full development (2031) WITH LHS and a compromise Geometry where the site is constrained to avoid land acquisition.

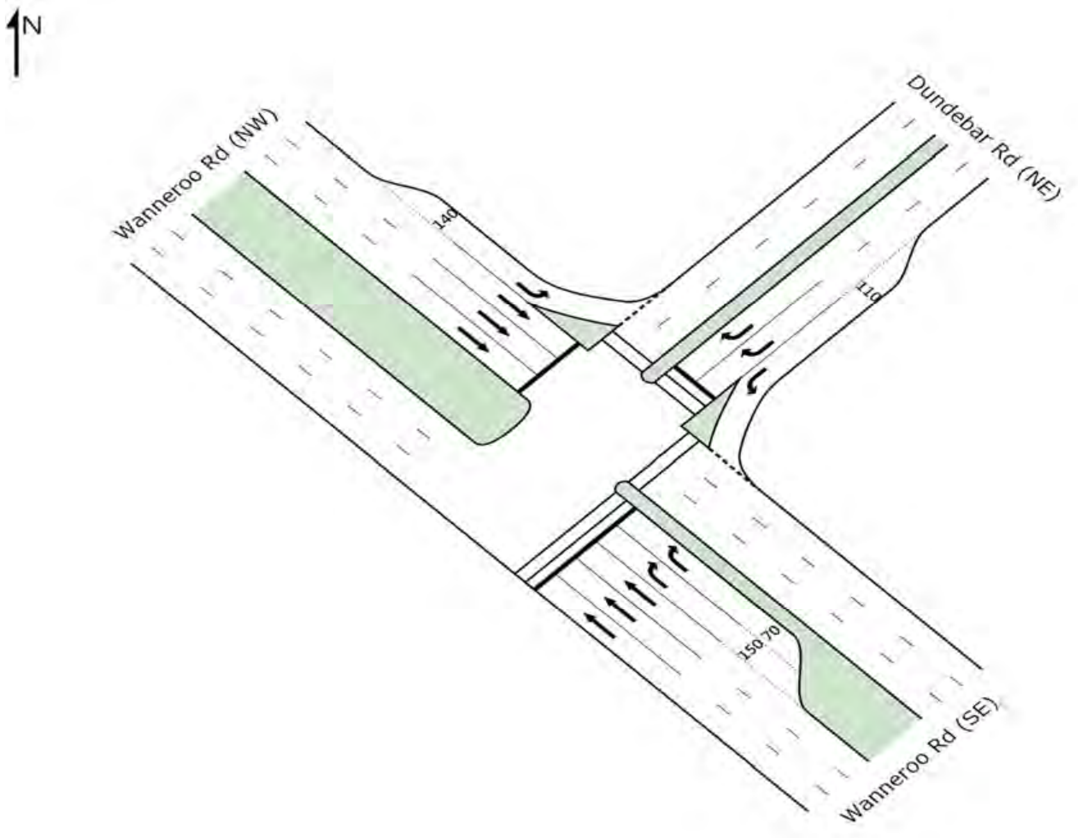
**Wanneroo Road/Dundebar Road Intersection 2031**

Existing Geometry




Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry




Dundebar Rd / Wanneroo Rd 2031 WITH LHS am
Signals - Fixed Time    Cycle Time = 90 seconds (Practical Cycle Time)

| Movement Performance - Vehicles | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South East: Wanneroo Rd (SE) | | | | | | | | | | | |
| 22 | T | 1053 | 4.0 | 0.339 | 12.2 | LOS B | 8.5 | 61.8 | 0.60 | 0.52 | 43.0 |
| 23 | R | 294 | 4.0 | 0.814 | 57.5 | LOS E | 7.1 | 51.8 | 1.00 | 0.95 | 23.4 |
| Approach | | 1347 | 4.0 | 0.814 | 22.1 | LOS C | 8.5 | 61.8 | 0.69 | 0.61 | 36.3 |
| North East: Dundebar Rd (NE) | | | | | | | | | | | |
| 24 | L | 423 | 4.0 | 0.514 | 19.7 | LOS B | 9.3 | 67.0 | 0.62 | 0.83 | 39.2 |
| 26 | R | 894 | 4.0 | 0.768 | 40.2 | LOS D | 18.8 | 136.3 | 0.96 | 0.90 | 28.6 |
| Approach | | 1317 | 4.0 | 0.768 | 33.6 | LOS C | 18.8 | 136.3 | 0.85 | 0.88 | 31.4 |
| North West: Wanneroo Rd (NW) | | | | | | | | | | | |
| 27 | L | 1061 | 4.0 | 0.816 | 12.0 | LOS B | 16.5 | 119.8 | 0.47 | 0.78 | 45.3 |
| 28 | T | 1910 | 4.0 | 0.887 | 40.1 | LOS D | 32.1 | 232.3 | 1.00 | 1.08 | 27.3 |
| Approach | | 2971 | 4.0 | 0.887 | 30.1 | LOS C | 32.1 | 232.3 | 0.81 | 0.97 | 31.8 |
| All Vehicles | | 5635 | 4.0 | 0.887 | 29.0 | LOS C | 32.1 | 232.3 | 0.79 | 0.86 | 32.7 |

Dundebar Rd / Wanneroo Rd 2031 with LHS PM
Signals - Fixed Time    Cycle Time = 130 seconds (Practical Cycle Time)

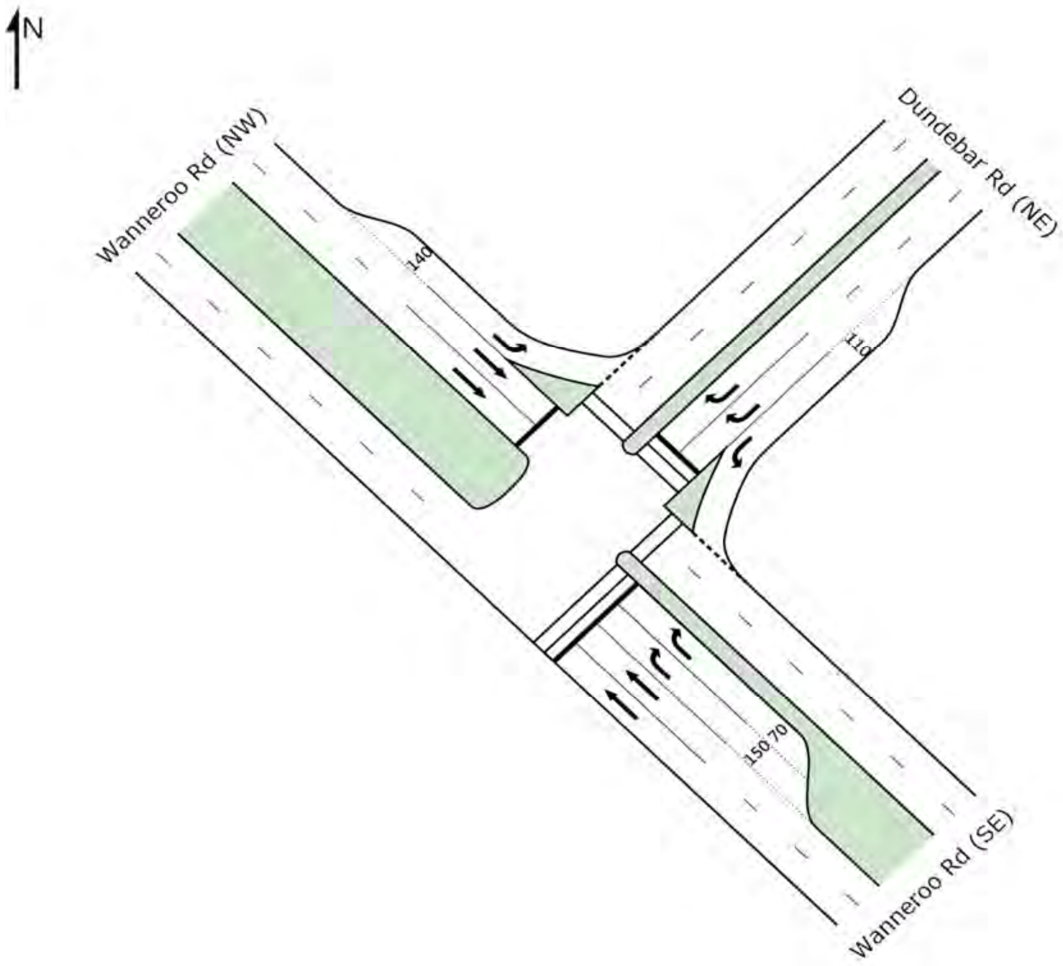
**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South East: Wanneroo Rd (SE) | | | | | | | | | | | |
| 22 | T | 2167 | 4.0 | 0.898 | 49.5 | LOS D | 49.4 | 357.9 | 1.00 | 1.02 | 24.4 |
| 23 | R | 289 | 4.0 | 0.694 | 70.6 | LOS E | 9.3 | 67.0 | 1.00 | 0.84 | 20.5 |
| Approach | | 2456 | 4.0 | 0.898 | 52.0 | LOS D | 49.4 | 357.9 | 1.00 | 1.00 | 23.9 |
| North East: Dundebar Rd (NE) | | | | | | | | | | | |
| 24 | L | 442 | 4.0 | 0.505 | 14.2 | LOS B | 9.5 | 68.9 | 0.42 | 0.75 | 43.4 |
| 26 | R | 1561 | 4.0 | 0.892 | 51.1 | LOS D | 51.4 | 372.3 | 0.98 | 0.97 | 25.1 |
| Approach | | 2003 | 4.0 | 0.892 | 43.0 | LOS D | 51.4 | 372.3 | 0.86 | 0.92 | 27.7 |
| North West: Wanneroo Rd (NW) | | | | | | | | | | | |
| 27 | L | 522 | 4.0 | 0.428 | 9.4 | LOS A | 5.9 | 42.5 | 0.24 | 0.66 | 47.8 |
| 28 | T | 1083 | 4.0 | 0.726 | 47.6 | LOS D | 21.1 | 152.5 | 0.97 | 0.85 | 25.0 |
| Approach | | 1605 | 4.0 | 0.726 | 35.2 | LOS D | 21.1 | 152.5 | 0.73 | 0.79 | 29.6 |
| All Vehicles | | 6064 | 4.0 | 0.898 | 44.6 | LOS D | 51.4 | 372.3 | 0.88 | 0.92 | 26.4 |

The above analysis with LHS indicates that a modified signalised intersection is likely to accommodate forecast traffic volumes to 2031. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required.

A compromise design is indicated as follows which avoids land acquisition. The performance is not as good as the optimal upgrade however the site is constrained. It should be noted that a good operational; performance cannot be achieved with the compromise and the operation is forecast to be unacceptable. Additional through lanes on Wanneroo Road are required.

## Recommended Geometry (if no land resumption)




Dundebar Rd / Wanneroo Rd 2031 WITH LHS am
Signals - Fixed Time Cycle Time = 150 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South East: Wanneroo Rd (SE) | | | | | | | | | | | |
| 22 | T | 1053 | 4.0 | 0.420 | 12.6 | LOS B | 17.7 | 127.8 | 0.51 | 0.46 | 43.0 |
| 23 | R | 294 | 4.0 | 0.939 | 105.3 | LOS F | 13.0 | 94.3 | 1.00 | 1.08 | 15.5 |
| Approach | | 1347 | 4.0 | 0.939 | 32.8 | LOS C | 17.7 | 127.8 | 0.62 | 0.59 | 30.9 |
| North East: Dundebar Rd (NE) | | | | | | | | | | | |
| 24 | L | 423 | 4.0 | 0.808 | 48.1 | LOS D | 21.6 | 156.4 | 0.80 | 1.00 | 26.1 |
| 26 | R | 894 | 4.0 | 0.952 | 100.2 | LOS F | 42.2 | 305.4 | 1.00 | 1.06 | 16.0 |
| Approach | | 1317 | 4.0 | 0.952 | 83.5 | LOS F | 42.2 | 305.4 | 0.94 | 1.04 | 18.3 |
| North West: Wanneroo Rd (NW) | | | | | | | | | | | |
| 27 | L | 1061 | 4.0 | 0.869 | 11.5 | LOS B | 20.2 | 146.2 | 0.40 | 0.76 | 45.9 |
| 28 | T | 1910 | 4.0 | 0.942 | 57.0 | LOS E | 80.7 | 584.3 | 1.00 | 1.06 | 22.5 |
| Approach | | 2971 | 4.0 | 0.942 | 40.8 | LOS D | 80.7 | 584.3 | 0.79 | 0.96 | 27.6 |
| All Vehicles | | 5635 | 4.0 | 0.952 | 48.9 | LOS D | 80.7 | 584.3 | 0.78 | 0.89 | 25.2 |

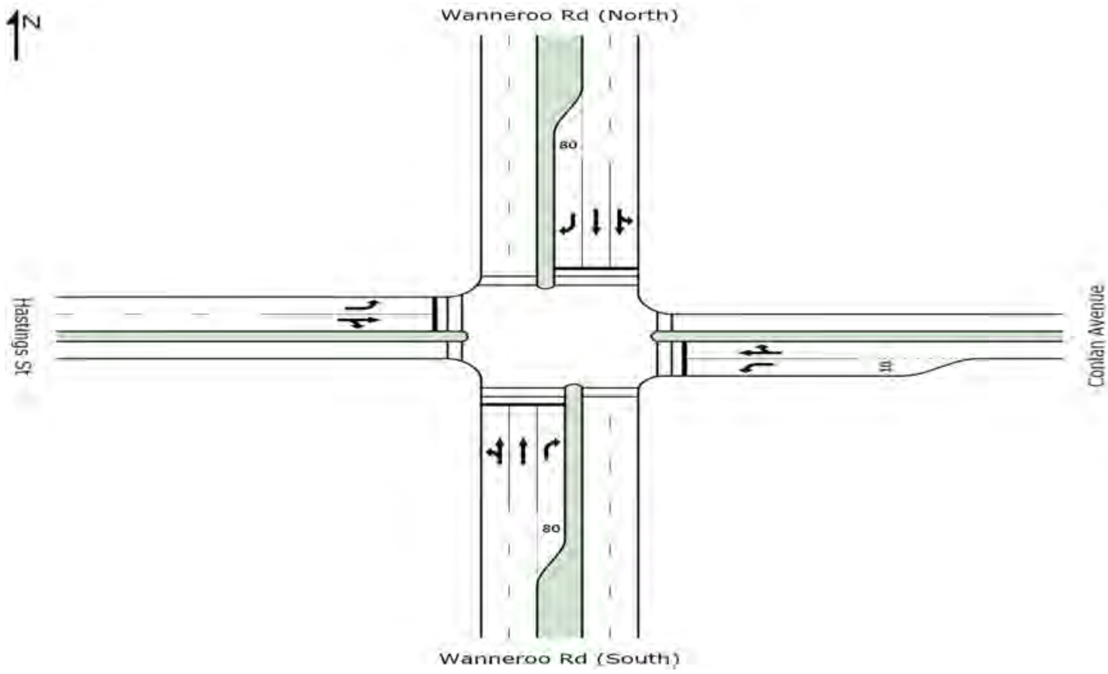
Dundebar Rd / Wanneroo Rd 2031 WITH LHS pm
Signals - Fixed Time    Cycle Time = 149 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South East: Wanneroo Rd (SE) | | | | | | | | | | | |
| 22 | T | 2167 | 4.0 | 1.089 | 238.7 | LOS F | 178.6 | 1293.1 | 1.00 | 1.92 | 7.8 |
| 23 | R | 289 | 4.0 | 0.745 | 81.8 | LOS F | 10.8 | 77.9 | 1.00 | 0.86 | 18.5 |
| Approach | | 2456 | 4.0 | 1.089 | 220.2 | LOS F | 178.6 | 1293.1 | 1.00 | 1.79 | 8.4 |
| North East: Dundebar Rd (NE) | | | | | | | | | | | |
| 24 | L | 443 | 4.0 | 0.625 | 22.2 | LOS C | 14.6 | 105.8 | 0.56 | 0.83 | 37.5 |
| 26 | R | 1562 | 4.0 | 1.092 | 262.7 | LOS F | 129.9 | 940.8 | 1.00 | 1.51 | 7.3 |
| Approach | | 2005 | 4.0 | 1.092 | 209.6 | LOS F | 129.9 | 940.8 | 0.90 | 1.36 | 8.9 |
| North West: Wanneroo Rd (NW) | | | | | | | | | | | |
| 27 | L | 523 | 4.0 | 0.439 | 9.5 | LOS A | 6.3 | 45.4 | 0.22 | 0.66 | 47.7 |
| 28 | T | 1084 | 4.0 | 0.759 | 43.2 | LOS D | 34.0 | 246.5 | 0.94 | 0.84 | 26.3 |
| Approach | | 1607 | 4.0 | 0.759 | 32.3 | LOS C | 34.0 | 246.5 | 0.71 | 0.78 | 30.9 |
| All Vehicles | | 6068 | 4.0 | 1.092 | 166.9 | LOS F | 178.6 | 1293.1 | 0.89 | 1.38 | 10.7 |

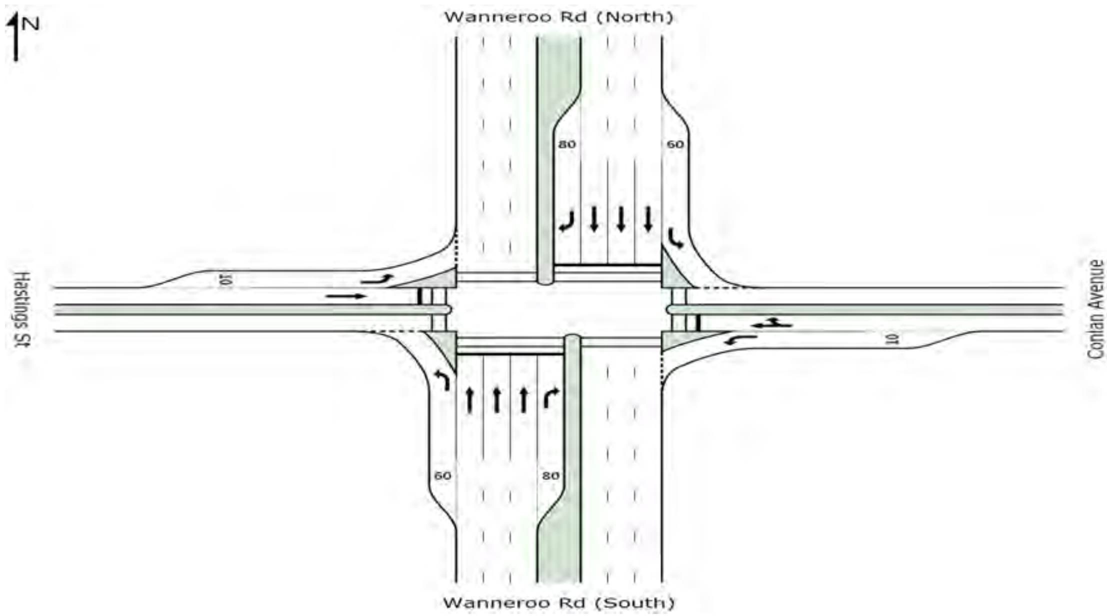
**Wanneroo Road/Hastings Road Intersection 2031**

Existing Geometry




Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry



Wannerroo Hastings 2031 With LHS Ultimate Geometry am
Signals - Fixed Time    Cycle Time = 134 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 1 | L | 54 | 5.0 | 0.067 | 9.3 | LOS A | 0.5 | 3.7 | 0.20 | 0.64 | 47.9 |
| 2 | T | 1241 | 5.0 | 0.481 | 27.0 | LOS C | 18.6 | 135.7 | 0.75 | 0.66 | 33.1 |
| 3 | R | 137 | 5.0 | 0.731 | 74.9 | LOS E | 9.2 | 67.3 | 1.00 | 0.85 | 19.7 |
| Approach | | 1432 | 5.0 | 0.731 | 30.9 | LOS C | 18.6 | 135.7 | 0.75 | 0.68 | 31.4 |
| East: Conlan Avenue | | | | | | | | | | | |
| 4 | L | 62 | 5.0 | 0.668 | 27.0 | LOS C | 2.0 | 14.3 | 0.43 | 0.74 | 34.7 |
| 5 | T | 46 | 5.0 | 0.765 | 74.5 | LOS E | 5.2 | 38.2 | 1.00 | 0.86 | 18.8 |
| 6 | R | 28 | 5.0 | 0.765 | 82.4 | LOS F | 5.2 | 38.2 | 1.00 | 0.86 | 18.9 |
| Approach | | 136 | 5.0 | 0.765 | 54.5 | LOS D | 5.2 | 38.2 | 0.74 | 0.81 | 23.8 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 137 | 5.0 | 0.214 | 10.8 | LOS B | 1.9 | 13.8 | 0.28 | 0.66 | 46.4 |
| 8 | T | 2045 | 5.0 | 0.793 | 33.1 | LOS C | 37.6 | 274.1 | 0.92 | 0.84 | 30.0 |
| 9 | R | 143 | 5.0 | 0.763 | 76.0 | LOS E | 9.7 | 71.1 | 1.00 | 0.87 | 19.5 |
| Approach | | 2325 | 5.0 | 0.793 | 34.4 | LOS C | 37.6 | 274.1 | 0.89 | 0.83 | 29.6 |
| West: Hastings St | | | | | | | | | | | |
| 10 | L | 76 | 5.0 | 0.533 | 11.3 | LOS B | 1.1 | 8.1 | 0.30 | 0.66 | 45.9 |
| 11 | T | 166 | 5.0 | 0.421 | 49.7 | LOS D | 9.5 | 69.1 | 0.92 | 0.75 | 24.4 |
| Approach | | 242 | 5.0 | 0.533 | 37.7 | LOS D | 9.5 | 69.1 | 0.72 | 0.72 | 28.7 |
| All Vehicles | | 4135 | 5.0 | 0.793 | 34.1 | LOS C | 37.6 | 274.1 | 0.83 | 0.77 | 29.9 |

Wannerroo Hastings 2031 With LHS Existing Geometry pm
Signals - Fixed Time    Cycle Time = 158 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 1 | L | 44 | 5.0 | 0.073 | 10.9 | LOS B | 0.6 | 4.7 | 0.25 | 0.64 | 46.4 |
| 2 | T | 2275 | 5.0 | 1.117 | 301.1 | LOS F | 140.5 | 1025.4 | 1.00 | 2.04 | 6.4 |
| 3 | R | 159 | 5.0 | 1.002 | 150.0 | LOS F | 17.8 | 130.3 | 1.00 | 1.22 | 11.8 |
| Approach | | 2478 | 5.0 | 1.117 | 286.2 | LOS F | 140.5 | 1025.4 | 0.99 | 1.96 | 6.7 |
| East: Conlan Avenue | | | | | | | | | | | |
| 4 | L | 111 | 5.0 | 1.000 [3] | 17.5 | LOS B | 2.2 | 16.3 | 0.58 | 0.71 | 40.7 |
| 5 | T | 213 | 5.0 | 1.109 | 294.8 | LOS F | 83.8 | 612.0 | 1.00 | 1.73 | 6.5 |
| 6 | R | 260 | 5.0 | 1.109 | 302.7 | LOS F | 83.8 | 612.0 | 1.00 | 1.73 | 6.5 |
| Approach | | 584 | 5.0 | 1.109 | 245.5 | LOS F | 83.8 | 612.0 | 0.92 | 1.54 | 7.7 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 159 | 5.0 | 0.271 | 11.4 | LOS B | 2.6 | 19.1 | 0.27 | 0.66 | 45.9 |
| 8 | T | 1212 | 5.0 | 0.593 | 43.6 | LOS D | 25.0 | 182.6 | 0.87 | 0.77 | 26.3 |
| 9 | R | 159 | 5.0 | 1.001 | 149.2 | LOS F | 17.8 | 129.8 | 1.00 | 1.21 | 11.8 |
| Approach | | 1530 | 5.0 | 1.001 | 51.3 | LOS D | 25.0 | 182.6 | 0.82 | 0.80 | 24.3 |
| West: Hastings St | | | | | | | | | | | |
| 10 | L | 54 | 5.0 | 1.000 [3] | 31.8 | LOS C | 2.2 | 16.3 | 0.61 | 0.69 | 32.2 |
| 11 | T | 189 | 5.0 | 0.843 | 76.5 | LOS E | 20.7 | 151.4 | 1.00 | 0.96 | 18.5 |
| 12 | R | 67 | 5.0 | 0.843 | 84.4 | LOS F | 20.7 | 151.4 | 1.00 | 0.96 | 18.5 |
| Approach | | 310 | 5.0 | 1.000 | 70.4 | LOS E | 20.7 | 151.4 | 0.93 | 0.91 | 20.0 |
| All Vehicles | | 4902 | 5.0 | 1.117 | 194.4 | LOS F | 140.5 | 1025.4 | 0.92 | 1.48 | 9.4 |

The above analysis with LHS indicates that a modified signalised intersection is likely to accommodate forecast traffic volumes to 2031 in the am peak hour however pm operation is poor. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required.

A compromise is to retain two lanes in each direction on Wanneroo Road to avoid land resumption however operation will be poor as indicated in the analysis below, this option therefore is not recommended.

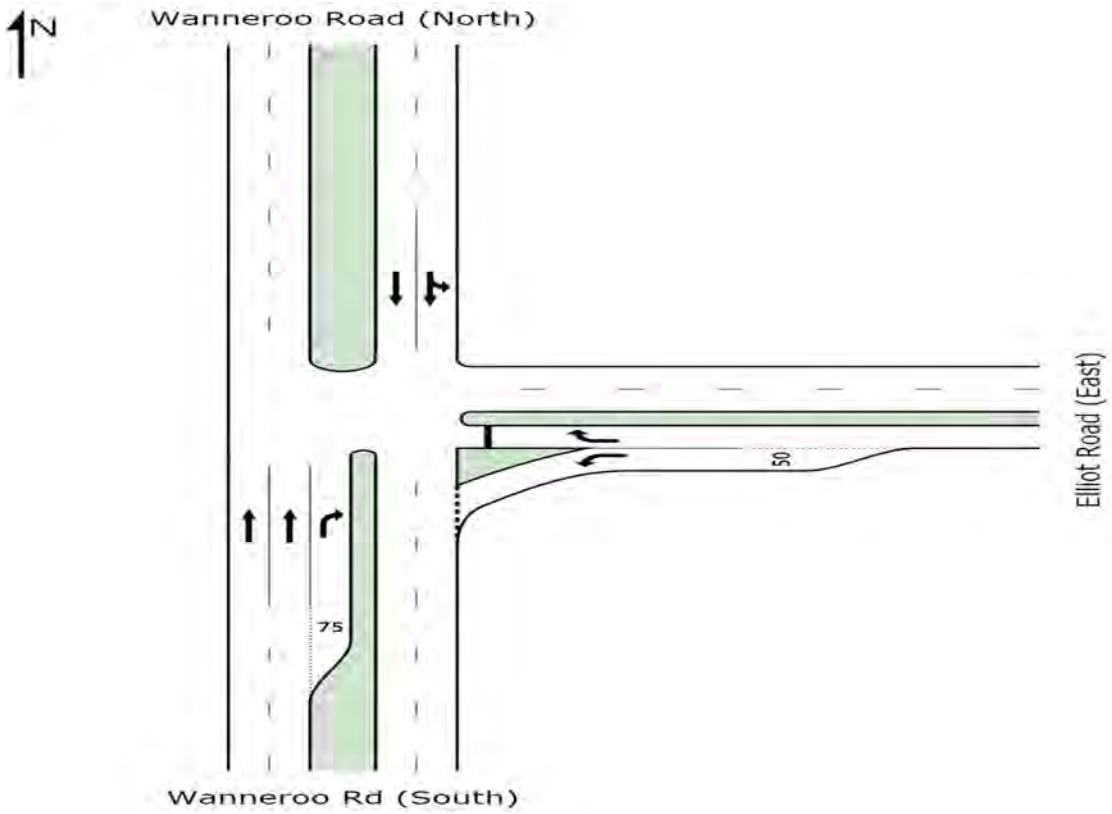

Wannerroo Hastings 2031 With Compromise Geometry pm
Signals - Fixed Time    Cycle Time = 159 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 1 | L | 44 | 5.0 | 0.061 | 9.5 | LOS A | 0.5 | 3.5 | 0.19 | 0.63 | 47.8 |
| 2 | T | 2333 | 5.0 | 1.352 | 710.9 | LOS F | 359.3 | 2622.8 | 1.00 | 3.29 | 2.9 |
| 3 | R | 101 | 5.0 | 1.119 | 324.5 | LOS F | 17.9 | 130.6 | 1.00 | 1.53 | 6.1 |
| Approach | | 2478 | 5.0 | 1.352 | 682.7 | LOS F | 359.3 | 2622.8 | 0.99 | 3.17 | 3.0 |
| East: Conlan Avenue | | | | | | | | | | | |
| 4 | L | 80 | 5.0 | 1.000 [3] | 21.4 | LOS C | 2.2 | 16.3 | 0.55 | 0.70 | 38.0 |
| 5 | T | 244 | 5.0 | 1.336 | 695.5 | LOS F | 148.6 | 1084.6 | 1.00 | 2.61 | 3.0 |
| 6 | R | 260 | 5.0 | 1.336 | 703.5 | LOS F | 148.6 | 1084.6 | 1.00 | 2.61 | 3.0 |
| Approach | | 584 | 5.0 | 1.336 | 607.1 | LOS F | 148.6 | 1084.6 | 0.94 | 2.35 | 3.4 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 159 | 5.0 | 0.235 | 10.1 | LOS B | 2.1 | 15.4 | 0.23 | 0.65 | 47.1 |
| 8 | T | 1270 | 5.0 | 0.734 | 37.1 | LOS D | 39.6 | 289.2 | 0.88 | 0.80 | 28.4 |
| 9 | R | 101 | 5.0 | 1.120 | 324.4 | LOS F | 17.9 | 130.6 | 1.00 | 1.53 | 6.1 |
| Approach | | 1530 | 5.0 | 1.120 | 53.3 | LOS D | 39.6 | 289.2 | 0.82 | 0.83 | 23.6 |
| West: Hastings St | | | | | | | | | | | |
| 10 | L | 47 | 5.0 | 1.000 [3] | 39.8 | LOS D | 2.2 | 16.3 | 0.69 | 0.69 | 28.9 |
| 11 | T | 196 | 5.0 | 1.081 | 252.8 | LOS F | 41.6 | 303.5 | 1.00 | 1.70 | 7.4 |
| 12 | R | 67 | 5.0 | 1.081 | 260.9 | LOS F | 41.6 | 303.5 | 1.00 | 1.70 | 7.4 |
| Approach | | 310 | 5.0 | 1.081 | 222.5 | LOS F | 41.6 | 303.5 | 0.95 | 1.55 | 8.4 |
| All Vehicles | | 4902 | 5.0 | 1.352 | 448.2 | LOS F | 359.3 | 2622.8 | 0.93 | 2.24 | 4.5 |

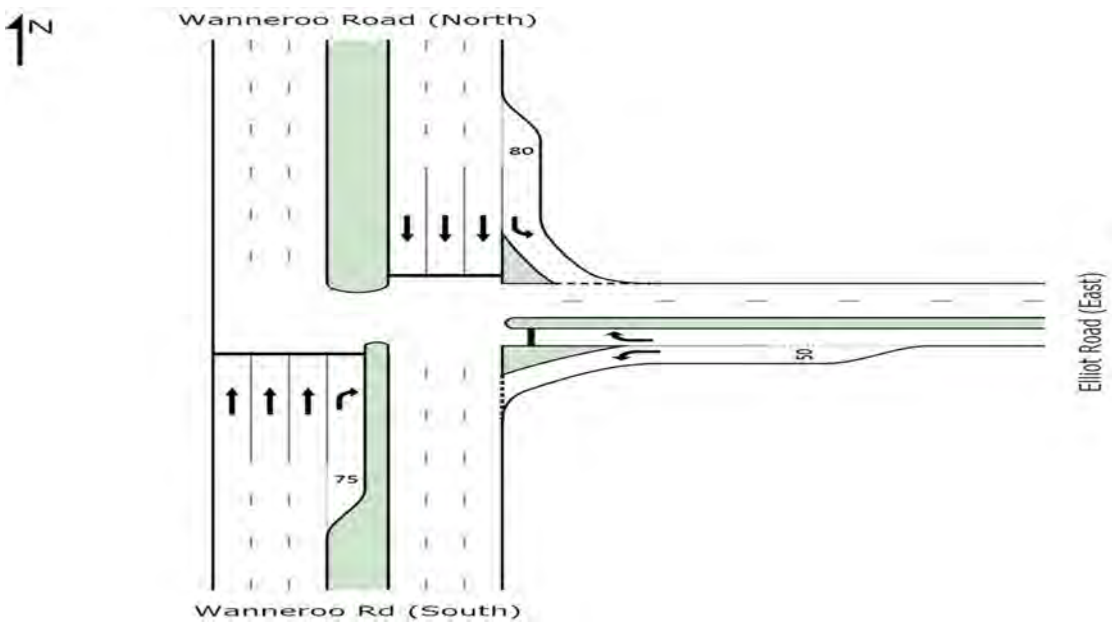
**Wanneroo Road/Elliot Road Intersection 2031**

Existing Geometry




Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry- Signalised



Wanneroo Rd / Elliot Rd 2031 With LHS 2031 am Ultimate Geometry Signals
Signals - Fixed Time    Cycle Time = 101 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 2 | T | 1185 | 5.0 | 0.306 | 6.8 | LOS A | 7.7 | 55.9 | 0.43 | 0.38 | 48.9 |
| 3 | R | 139 | 5.0 | 0.712 | 58.8 | LOS E | 7.1 | 52.0 | 1.00 | 0.86 | 23.0 |
| Approach | | 1324 | 5.0 | 0.712 | 12.2 | LOS B | 7.7 | 55.9 | 0.49 | 0.43 | 43.7 |
| East: Elliot Road (East) | | | | | | | | | | | |
| 4 | L | 330 | 5.0 | 0.817 | 28.6 | LOS C | 11.2 | 81.6 | 0.60 | 0.85 | 33.9 |
| 6 | R | 246 | 5.0 | 0.693 | 50.4 | LOS D | 11.7 | 85.7 | 0.98 | 0.85 | 25.3 |
| Approach | | 576 | 5.0 | 0.817 | 37.9 | LOS D | 11.7 | 85.7 | 0.76 | 0.85 | 29.6 |
| North: Wanneroo Road (North) | | | | | | | | | | | |
| 7 | L | 217 | 5.0 | 0.196 | 9.0 | LOS A | 1.6 | 11.5 | 0.23 | 0.65 | 48.3 |
| 8 | T | 2049 | 5.0 | 0.702 | 19.9 | LOS B | 25.4 | 185.5 | 0.82 | 0.74 | 36.9 |
| Approach | | 2266 | 5.0 | 0.702 | 18.9 | LOS B | 25.4 | 185.5 | 0.76 | 0.73 | 37.7 |
| All Vehicles | | 4166 | 5.0 | 0.817 | 19.4 | LOS B | 25.4 | 185.5 | 0.68 | 0.65 | 37.9 |

Wanneroo Rd / Elliot Rd 2031 With LHS 2031 pm Ultimate Geometry Signals
Signals - Fixed Time    Cycle Time = 100 seconds (Optimum Cycle Time - Minimum Delay)

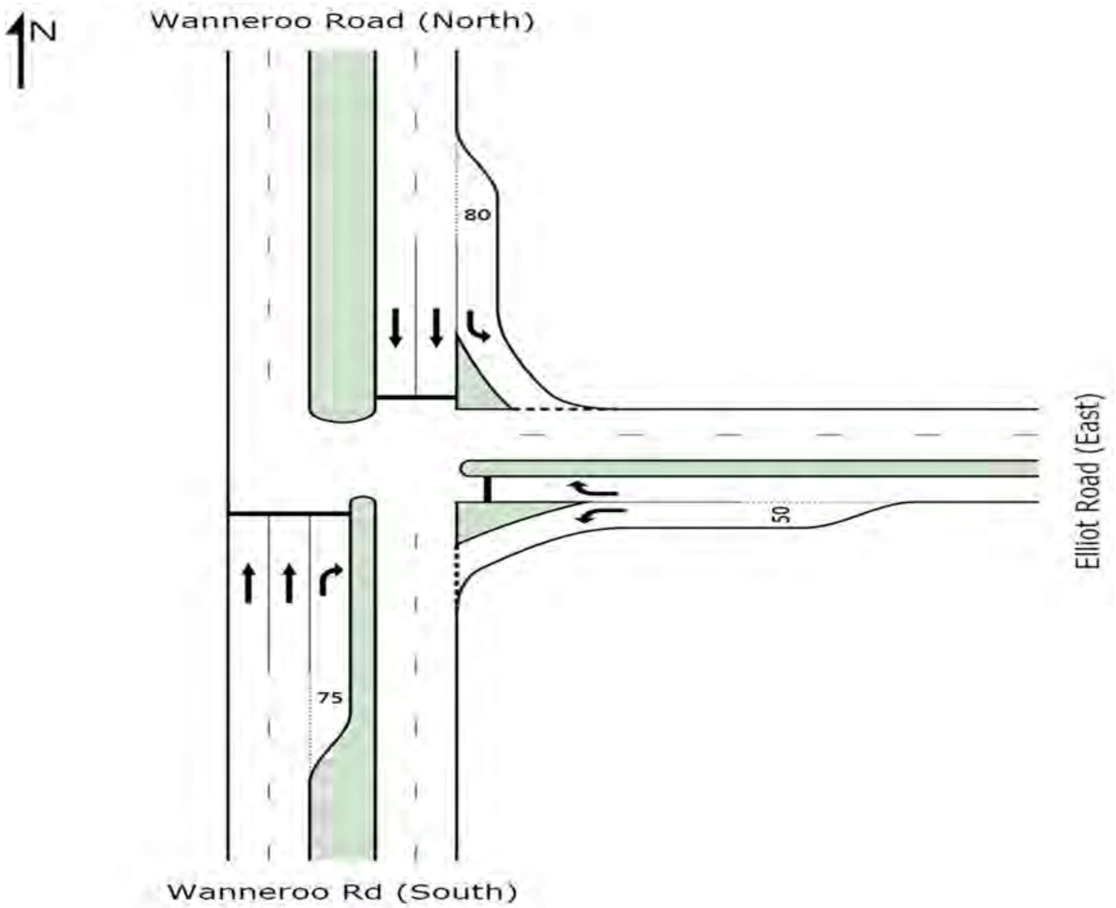
**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 2 | T | 2589 | 5.0 | 0.617 | 6.6 | LOS A | 19.8 | 144.8 | 0.52 | 0.48 | 48.7 |
| 3 | R | 325 | 5.0 | 0.778 | 39.0 | LOS D | 13.5 | 98.8 | 0.82 | 0.87 | 29.1 |
| Approach | | 2914 | 5.0 | 0.778 | 10.2 | LOS B | 19.8 | 144.8 | 0.55 | 0.52 | 45.3 |
| East: Elliot Road (East) | | | | | | | | | | | |
| 4 | L | 232 | 5.0 | 0.417 | 12.5 | LOS B | 3.5 | 25.9 | 0.41 | 0.70 | 44.8 |
| 6 | R | 192 | 5.0 | 0.765 | 57.1 | LOS E | 9.8 | 71.6 | 1.00 | 0.90 | 23.5 |
| Approach | | 424 | 5.0 | 0.765 | 32.7 | LOS C | 9.8 | 71.6 | 0.68 | 0.79 | 31.8 |
| North: Wanneroo Road (North) | | | | | | | | | | | |
| 7 | L | 186 | 5.0 | 0.222 | 10.2 | LOS B | 2.0 | 14.4 | 0.30 | 0.67 | 47.1 |
| 8 | T | 1328 | 5.0 | 0.756 | 35.3 | LOS D | 20.2 | 147.8 | 0.96 | 0.87 | 29.1 |
| Approach | | 1514 | 5.0 | 0.756 | 32.2 | LOS C | 20.2 | 147.8 | 0.88 | 0.85 | 30.5 |
| All Vehicles | | 4852 | 5.0 | 0.778 | 19.0 | LOS B | 20.2 | 147.8 | 0.67 | 0.65 | 38.1 |

The above analysis with LHS, indicates that a signalised intersection is likely to accommodate forecast traffic volumes to 2031. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required. A LoS of B is forecast and stop rates of less than 1.

A compromise design is indicated as follows which avoids land acquisition. The performance is not as good as the optimal upgrade however the site is constrained. It should be noted that a good operational; performance cannot be achieved with the compromise design particularly in the am peak hour.

## Recommended Geometry (if no land resumption)




Wanneroo Rd / Elliot Rd 2031 With LHS 2031 am Ultimate Geometry Signals
Signals - Fixed Time    Cycle Time = 102 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 2 | T | 1185 | 5.0 | 0.438 | 6.4 | LOS A | 12.0 | 87.6 | 0.45 | 0.40 | 49.3 |
| 3 | R | 139 | 5.0 | 0.988 | 103.6 | LOS F | 10.4 | 75.8 | 1.00 | 1.30 | 15.6 |
| Approach | | 1324 | 5.0 | 0.988 | 16.6 | LOS B | 12.0 | 87.6 | 0.51 | 0.50 | 40.2 |
| East: Elliot Road (East) | | | | | | | | | | | |
| 4 | L | 306 | 5.0 | 1.000 [3] | 30.1 | LOS C | 11.2 | 81.8 | 0.83 | 0.81 | 33.0 |
| 6 | R | 270 | 5.0 | 0.904 | 68.4 | LOS E | 16.2 | 118.0 | 1.00 | 1.05 | 20.9 |
| Approach | | 576 | 5.0 | 1.000 | 48.1 | LOS D | 16.2 | 118.0 | 0.91 | 0.92 | 26.0 |
| North: Wanneroo Road (North) | | | | | | | | | | | |
| 7 | L | 217 | 5.0 | 0.194 | 8.9 | LOS A | 1.6 | 11.5 | 0.22 | 0.65 | 48.3 |
| 8 | T | 2049 | 5.0 | 0.938 | 45.5 | LOS D | 65.1 | 474.9 | 1.00 | 1.14 | 25.5 |
| Approach | | 2266 | 5.0 | 0.938 | 42.0 | LOS D | 65.1 | 474.9 | 0.93 | 1.10 | 26.8 |
| All Vehicles | | 4166 | 5.0 | 1.000 | 34.8 | LOS C | 65.1 | 474.9 | 0.79 | 0.88 | 29.8 |

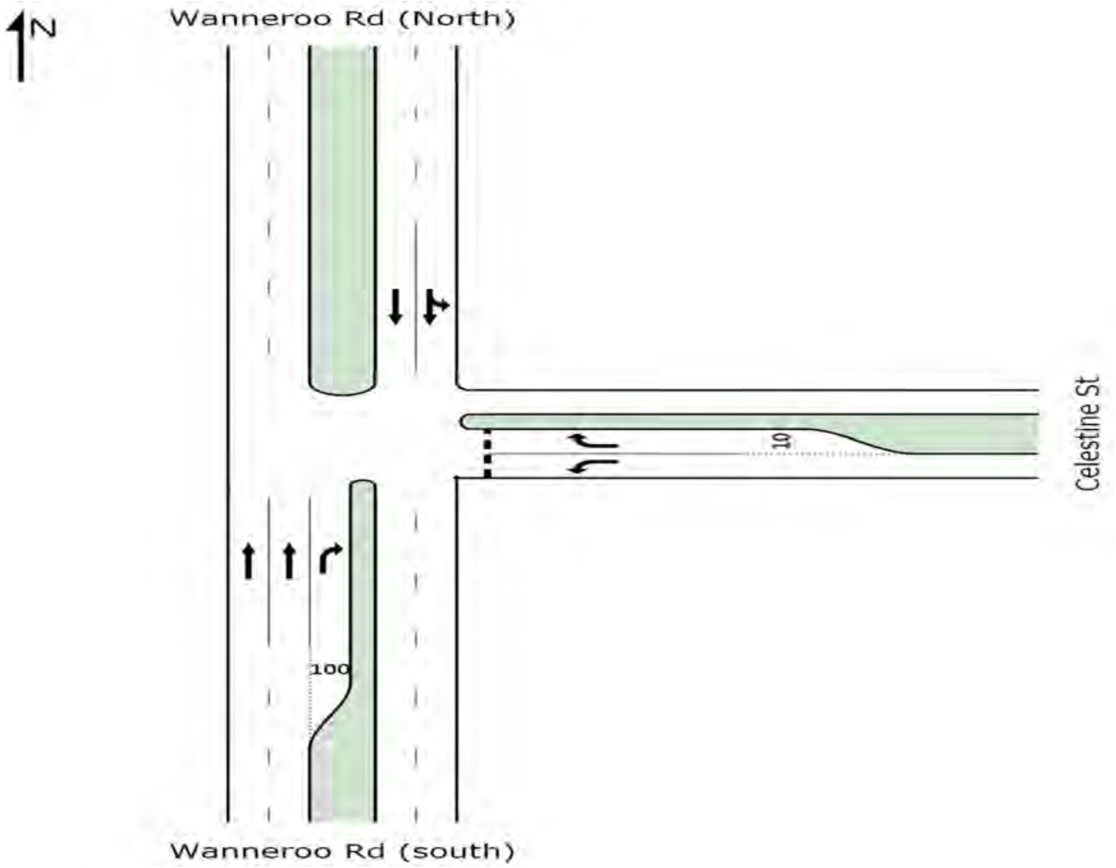
Wanneroo Rd / Elliot Rd 2031 With LHS 2031 pm Ultimate Geometry Signals
Signals - Fixed Time    Cycle Time = 101 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (South) | | | | | | | | | | | |
| 2 | T | 2589 | 5.0 | 0.899 | 18.3 | LOS B | 57.1 | 416.6 | 0.83 | 0.85 | 37.9 |
| 3 | R | 325 | 5.0 | 0.881 | 53.9 | LOS D | 16.8 | 122.4 | 0.94 | 0.95 | 24.2 |
| Approach | | 2914 | 5.0 | 0.899 | 22.3 | LOS C | 57.1 | 416.6 | 0.84 | 0.86 | 35.6 |
| East: Elliot Road (East) | | | | | | | | | | | |
| 4 | L | 232 | 5.0 | 0.531 | 16.6 | LOS B | 5.0 | 36.2 | 0.53 | 0.73 | 41.4 |
| 6 | R | 192 | 5.0 | 0.901 | 69.7 | LOS E | 11.3 | 82.4 | 1.00 | 1.06 | 20.7 |
| Approach | | 424 | 5.0 | 0.901 | 40.6 | LOS D | 11.3 | 82.4 | 0.75 | 0.88 | 28.5 |
| North: Wanneroo Road (North) | | | | | | | | | | | |
| 7 | L | 186 | 5.0 | 0.226 | 10.9 | LOS B | 2.3 | 16.6 | 0.33 | 0.68 | 46.4 |
| 8 | T | 1328 | 5.0 | 0.826 | 31.7 | LOS C | 31.3 | 228.5 | 0.95 | 0.92 | 30.6 |
| Approach | | 1514 | 5.0 | 0.826 | 29.1 | LOS C | 31.3 | 228.5 | 0.88 | 0.89 | 31.9 |
| All Vehicles | | 4852 | 5.0 | 0.901 | 26.0 | LOS C | 57.1 | 416.6 | 0.84 | 0.87 | 33.7 |

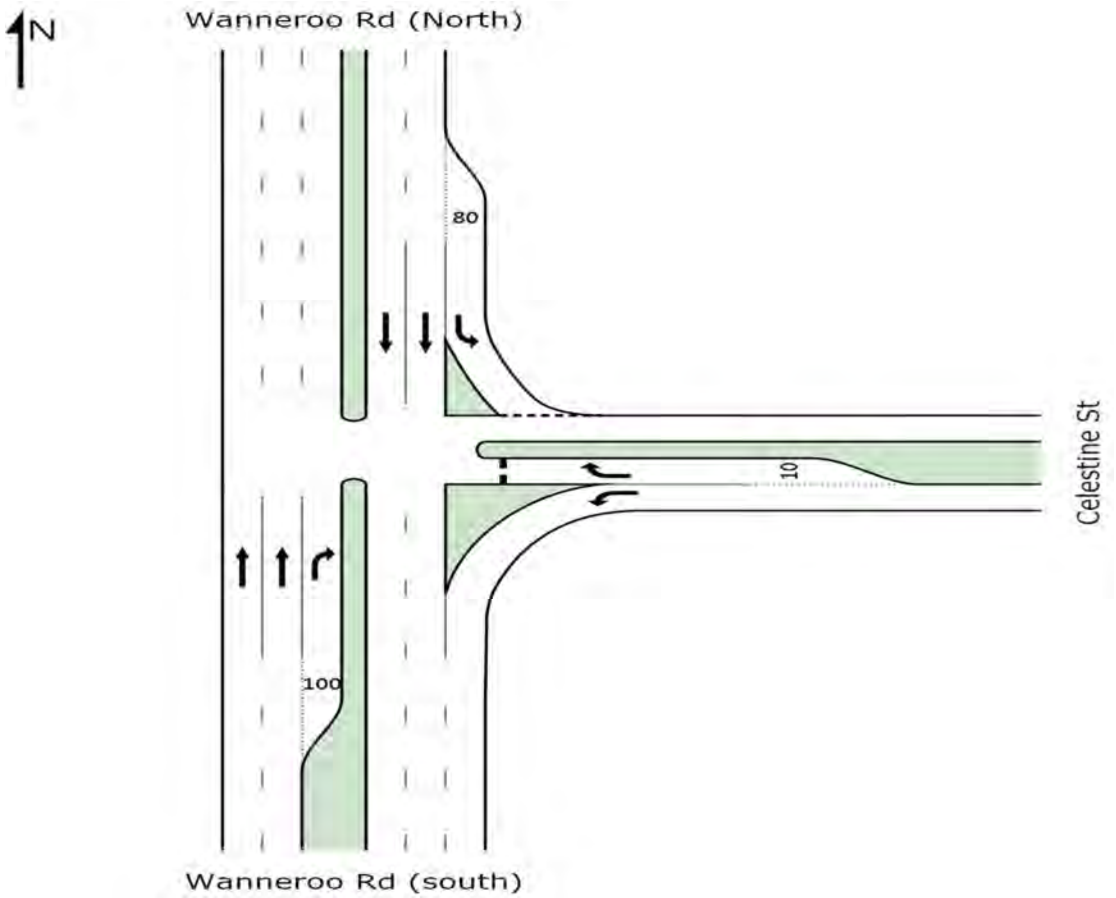
**Wanneroo Road/Celestine Road Intersection 2031**

Existing Geometry




Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry
A number of options have been tested however a good operational performance has not been achieved. The best operation for an unsignalised intersection is indicated below and includes acceleration lanes for the right and left turns from Celestine Street. Improved performance would be gained by traffic signals however it would not be practical to signalise all side road intersections.




Wannerro Rd / Celestine St 2031 With LHS Upgraded unsignalised Geometry AM To Median
Giveway / Yield (Two-Way)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (south) | | | | | | | | | | | |
| 2 | T | 1344 | 5.0 | 0.357 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| 3 | R | 84 | 5.0 | 1.398 | 844.5 | LOS F | 34.0 | 248.5 | 1.00 | 3.20 | 2.5 |
| Approach | | 1428 | 5.0 | 1.398 | 49.6 | NA | 34.0 | 248.5 | 0.06 | 0.19 | 25.4 |
| East: Celestine St | | | | | | | | | | | |
| 4 | L | 230 | 5.0 | 0.128 | 7.7 | X | X | X | X | 0.59 | 49.8 |
| 6 | R | 60 | 5.0 | 1.000 [3] | 121.4 | LOS F | 3.4 | 24.9 | 1.00 | 1.22 | 13.9 |
| Approach | | 290 | 5.0 | 1.000 | 31.2 | LOS D | 3.4 | 24.9 | 0.21 | 0.72 | 32.5 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 106 | 5.0 | 0.085 | 7.9 | LOS A | 0.3 | 2.3 | 0.15 | 0.56 | 48.9 |
| 8 | T | 2098 | 5.0 | 0.555 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| Approach | | 2204 | 5.0 | 0.555 | 0.4 | NA | 0.3 | 2.3 | 0.01 | 0.03 | 59.3 |
| All Vehicles | | 3922 | 5.0 | 1.398 | 20.6 | NA | 34.0 | 248.5 | 0.04 | 0.14 | 38.3 |

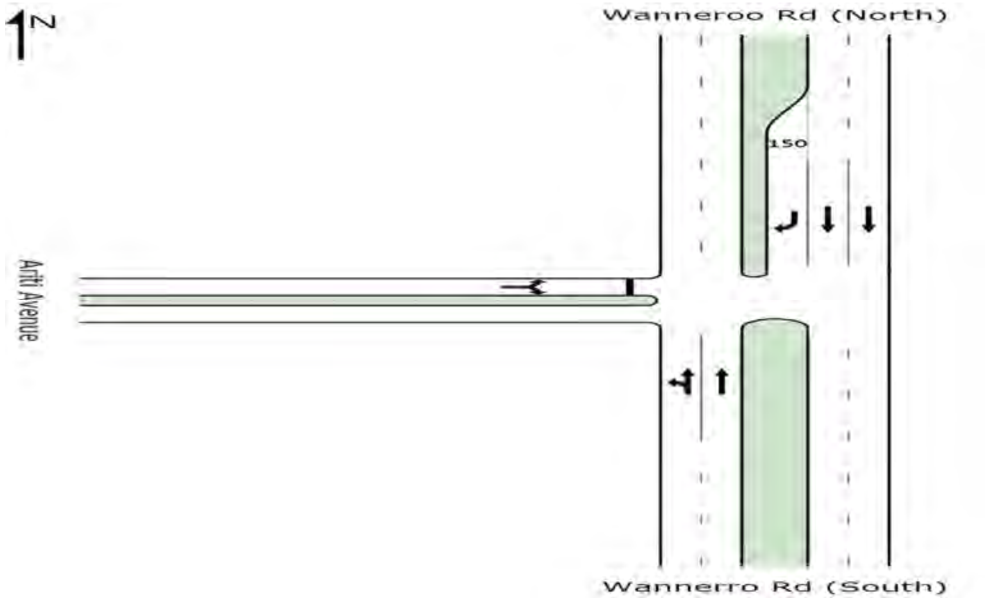
Wannerro Rd / Celestine St 2031 With LHS  Upgraded unsignalised Geometry PM To Median
Giveway / Yield (Two-Way)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Rd (south) | | | | | | | | | | | |
| 2 | T | 2522 | 5.0 | 0.669 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| 3 | R | 260 | 5.0 | 1.079 | 218.0 | LOS F | 34.0 | 248.4 | 1.00 | 3.55 | 8.6 |
| Approach | | 2782 | 5.0 | 1.079 | 20.4 | NA | 34.0 | 248.4 | 0.09 | 0.33 | 38.5 |
| East: Celestine St | | | | | | | | | | | |
| 4 | L | 163 | 5.0 | 0.091 | 7.7 | X | X | X | X | 0.60 | 49.8 |
| 6 | R | 40 | 5.0 | 1.000 [3] | 207.1 | LOS F | 3.4 | 24.9 | 1.00 | 1.26 | 9.0 |
| Approach | | 203 | 5.0 | 1.000 | 47.0 | LOS E | 3.4 | 24.9 | 0.20 | 0.73 | 26.4 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 7 | L | 50 | 5.0 | 0.044 | 8.7 | LOS A | 0.2 | 1.3 | 0.34 | 0.60 | 48.0 |
| 8 | T | 1351 | 5.0 | 0.358 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.00 | 60.0 |
| Approach | | 1401 | 5.0 | 0.358 | 0.3 | NA | 0.2 | 1.3 | 0.01 | 0.02 | 59.5 |
| All Vehicles | | 4386 | 5.0 | 1.079 | 15.2 | NA | 34.0 | 248.4 | 0.07 | 0.25 | 42.3 |

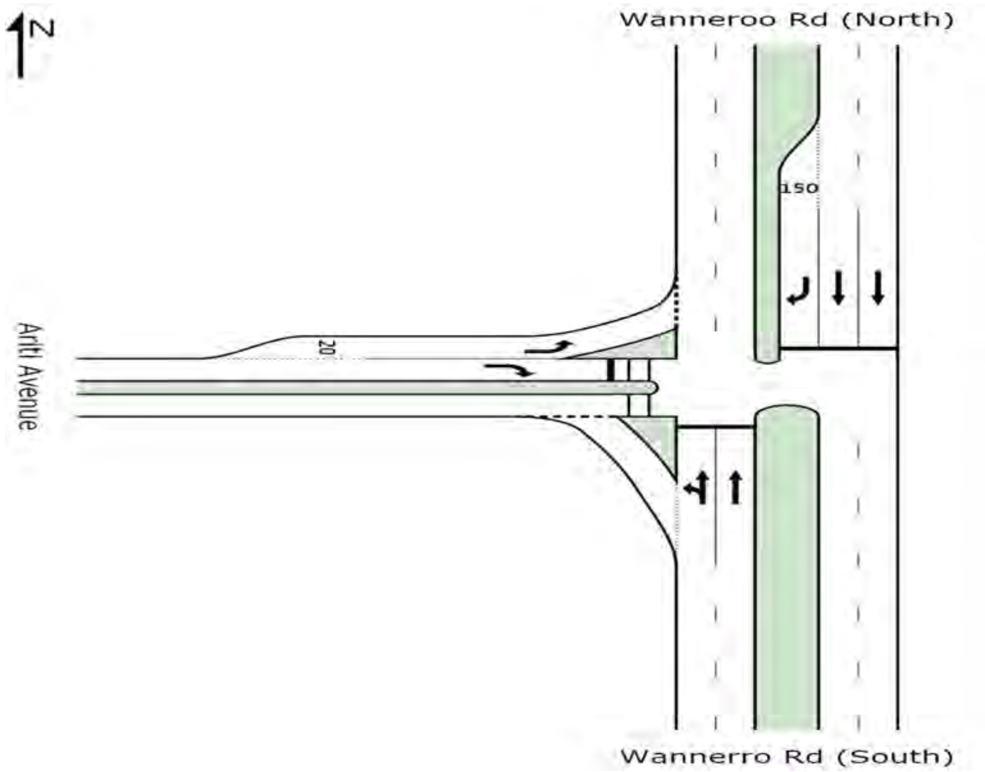
**Wanneroo Road/Ariti Ave Intersection 2031**

Existing Geometry




Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry – Recommended.



Wanneroo Road / Ariti Ave 2031 with LHS Ultimate Geometry am Signals
Signals - Fixed Time    Cycle Time = 111 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wannerro Rd (South) | | | | | | | | | | | |
| 1 | L | 18 | 7.4 | 0.514 | 16.6 | LOS B | 16.2 | 120.4 | 0.48 | 0.95 | 42.9 |
| 2 | T | 1360 | 7.4 | 0.514 | 7.9 | LOS A | 16.3 | 121.0 | 0.48 | 0.44 | 47.5 |
| Approach | | 1378 | 7.4 | 0.514 | 8.0 | LOS A | 16.3 | 121.0 | 0.48 | 0.45 | 47.4 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 8 | T | 2123 | 7.4 | 0.688 | 4.0 | LOS A | 22.5 | 167.2 | 0.44 | 0.41 | 52.1 |
| 9 | R | 52 | 7.4 | 0.545 | 68.0 | LOS E | 3.0 | 22.2 | 1.00 | 0.76 | 21.0 |
| Approach | | 2175 | 7.4 | 0.688 | 5.5 | LOS A | 22.5 | 167.2 | 0.45 | 0.42 | 50.3 |
| West: Ariti Avenue | | | | | | | | | | | |
| 10 | L | 76 | 7.4 | 0.340 | 11.3 | LOS B | 1.0 | 7.8 | 0.32 | 0.67 | 46.1 |
| 12 | R | 77 | 7.4 | 0.692 | 68.6 | LOS E | 4.5 | 33.2 | 1.00 | 0.83 | 20.8 |
| Approach | | 153 | 7.4 | 0.692 | 40.1 | LOS D | 4.5 | 33.2 | 0.66 | 0.75 | 28.7 |
| All Vehicles | | 3706 | 7.4 | 0.692 | 7.9 | LOS A | 22.5 | 167.2 | 0.47 | 0.44 | 47.7 |

Wanneroo Road / Ariti Ave 2031 with LHS Ultimate Geometry pm Signals
Signals - Fixed Time    Cycle Time = 142 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

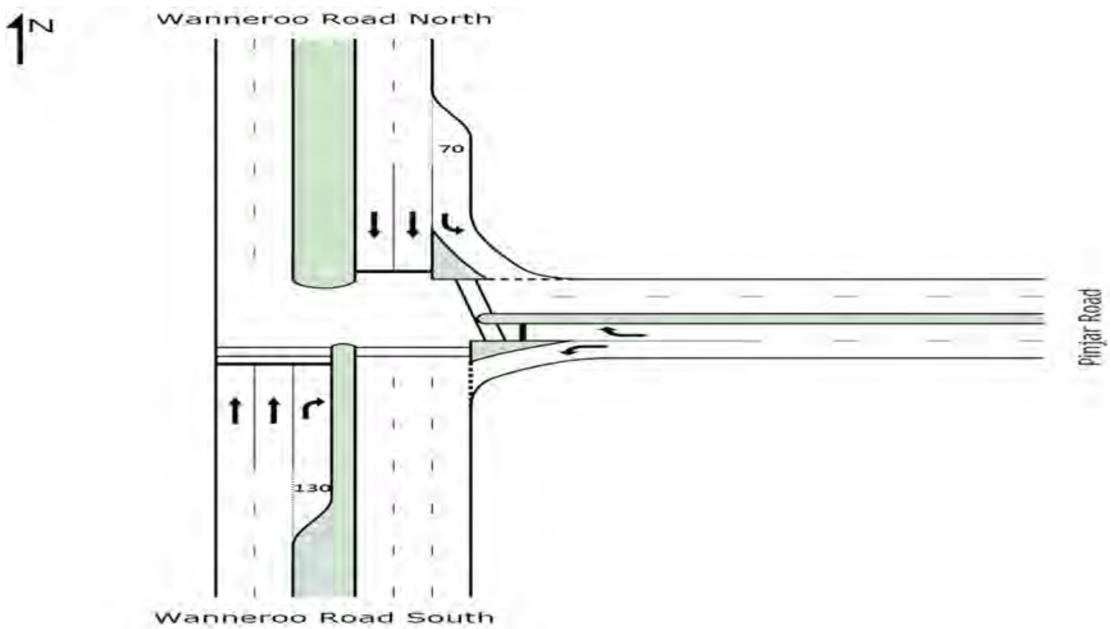
| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wannerro Rd (South) | | | | | | | | | | | |
| 1 | L | 95 | 7.4 | 0.871 | 20.6 | LOS C | 58.4 | 434.8 | 0.76 | 0.96 | 40.5 |
| 2 | T | 2412 | 7.4 | 0.871 | 12.0 | LOS B | 58.8 | 437.9 | 0.76 | 0.73 | 42.6 |
| Approach | | 2507 | 7.4 | 0.871 | 12.4 | LOS B | 58.8 | 437.9 | 0.76 | 0.74 | 42.5 |
| North: Wanneroo Rd (North) | | | | | | | | | | | |
| 8 | T | 1366 | 7.4 | 0.420 | 1.9 | LOS A | 9.2 | 68.5 | 0.22 | 0.20 | 55.9 |
| 9 | R | 87 | 7.4 | 0.875 | 92.2 | LOS F | 6.8 | 50.6 | 1.00 | 0.98 | 17.0 |
| Approach | | 1453 | 7.4 | 0.875 | 7.3 | LOS A | 9.2 | 68.5 | 0.26 | 0.25 | 49.2 |
| West: Ariti Avenue | | | | | | | | | | | |
| 10 | L | 56 | 7.4 | 0.569 | 32.0 | LOS C | 2.3 | 17.5 | 0.64 | 0.75 | 32.2 |
| 12 | R | 35 | 7.4 | 0.470 | 85.3 | LOS F | 2.5 | 19.0 | 1.00 | 0.73 | 17.9 |
| Approach | | 91 | 7.4 | 0.569 | 52.5 | LOS D | 2.5 | 19.0 | 0.78 | 0.74 | 24.7 |
| All Vehicles | | 4051 | 7.4 | 0.875 | 11.4 | LOS B | 58.8 | 437.9 | 0.58 | 0.56 | 43.9 |

The above analysis with LHS, indicates that a signalised intersection is likely to accommodate forecast traffic volumes to 2031. A LoS of A/B is forecast and stop rates of less than 1. A signalised intersection is therefore recommended.

Land resumption is not required.

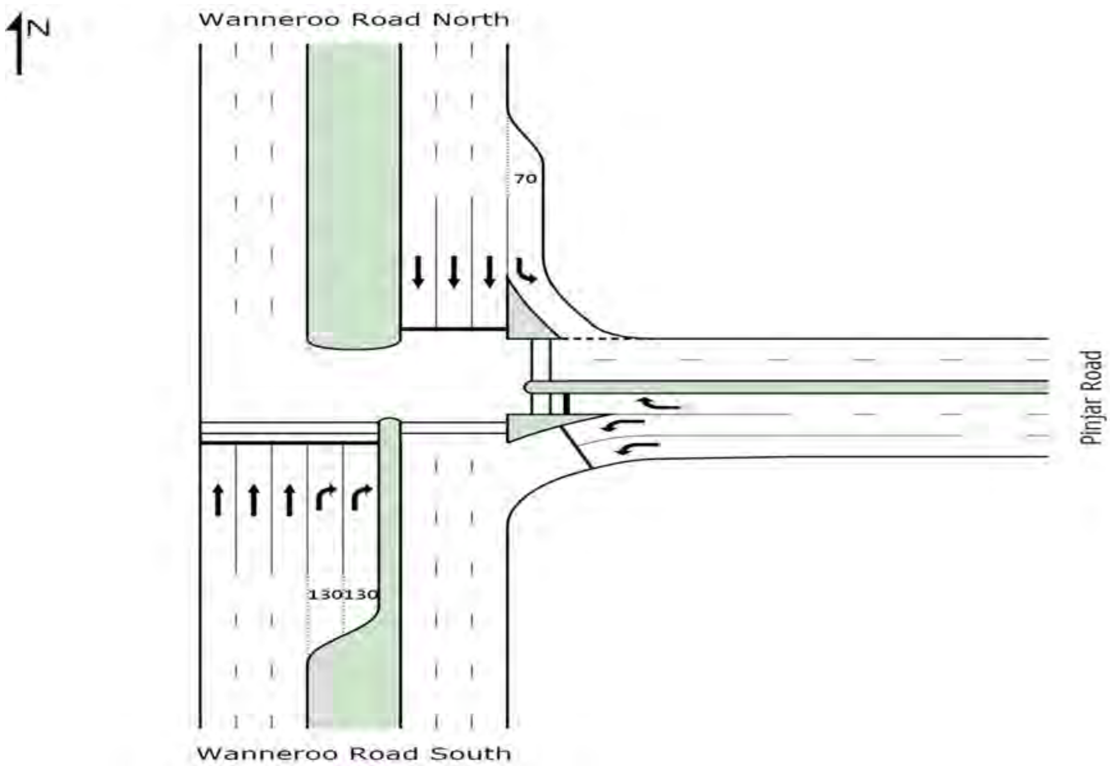
**Wanneroo Road/Pinjar Road Intersection 2031**

Existing Geometry




Analysis indicates that the existing intersection will not accommodate forecast traffic volumes to 2031 with LHS.

Proposed Ultimate Geometry



Wanneroo Road/Pinjar Road 2031 with LHS Ultimate Geometry am
Signals - Fixed Time  Cycle Time = 131 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Road South | | | | | | | | | | | |
| 2 | T | 1432 | 5.0 | 0.368 | 9.0 | LOS A | 12.5 | 91.1 | 0.45 | 0.40 | 46.4 |
| 3 | R | 751 | 5.0 | 0.831 | 64.0 | LOS E | 24.6 | 179.9 | 1.00 | 0.93 | 21.9 |
| Approach | | 2183 | 5.0 | 0.831 | 27.9 | LOS C | 24.6 | 179.9 | 0.64 | 0.58 | 33.5 |
| East: Pinjar Road | | | | | | | | | | | |
| 4 | L | 1342 | 5.0 | 0.721 | 33.4 | LOS C | 32.5 | 237.5 | 0.83 | 0.86 | 31.5 |
| 6 | R | 304 | 5.0 | 0.766 | 62.2 | LOS E | 19.0 | 138.8 | 1.00 | 0.88 | 22.3 |
| Approach | | 1646 | 5.0 | 0.766 | 38.7 | LOS D | 32.5 | 237.5 | 0.86 | 0.86 | 29.3 |
| North: Wanneroo Road North | | | | | | | | | | | |
| 7 | L | 297 | 5.0 | 0.466 | 12.6 | LOS B | 5.5 | 39.9 | 0.37 | 0.69 | 44.7 |
| 8 | T | 1801 | 5.0 | 0.816 | 40.7 | LOS D | 35.4 | 258.7 | 0.96 | 0.90 | 27.1 |
| Approach | | 2098 | 5.0 | 0.816 | 36.7 | LOS D | 35.4 | 258.7 | 0.88 | 0.87 | 28.7 |
| All Vehicles | | 5927 | 5.0 | 0.831 | 34.0 | LOS C | 35.4 | 258.7 | 0.79 | 0.76 | 30.5 |

Wanneroo Road/Pinjar Road 2031 with LHS Ultimate Geometry pm
Signals - Fixed Time  Cycle Time = 108 seconds (Optimum Cycle Time - Minimum Delay)

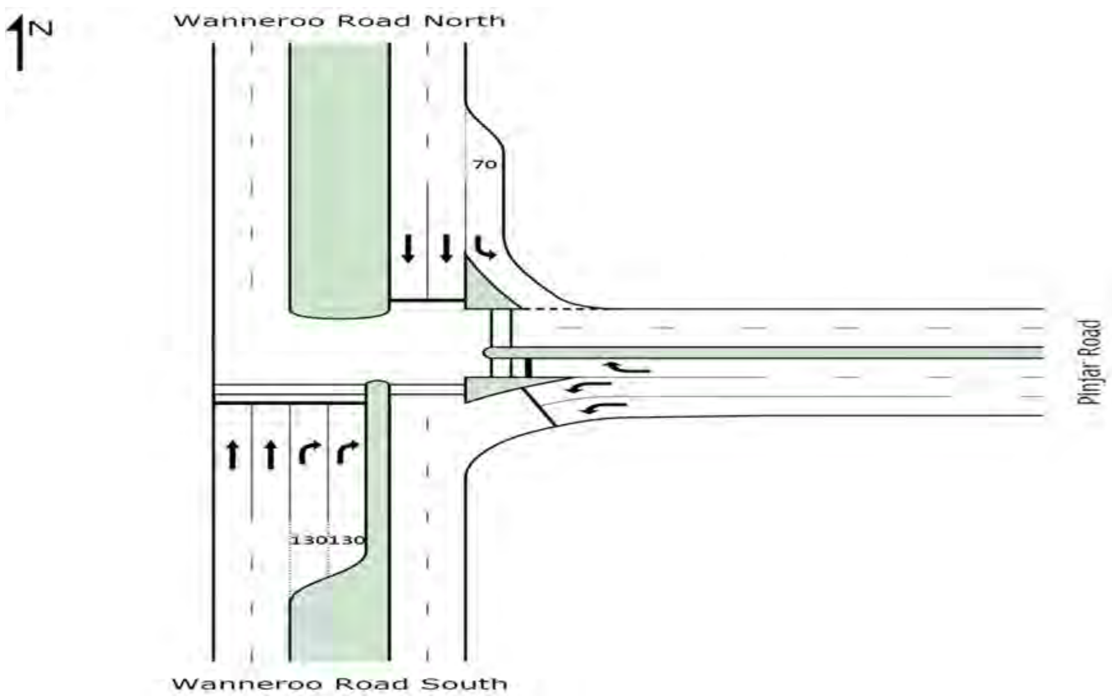
**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Road South | | | | | | | | | | | |
| 2 | T | 2662 | 5.0 | 0.764 | 15.7 | LOS B | 33.6 | 245.2 | 0.78 | 0.72 | 39.4 |
| 3 | R | 1187 | 5.0 | 1.000 [3] | 41.5 | LOS D | 29.1 | 212.2 | 1.00 | 0.89 | 28.2 |
| Approach | | 3849 | 5.0 | 1.000 | 23.7 | LOS C | 33.6 | 245.2 | 0.85 | 0.78 | 35.1 |
| East: Pinjar Road | | | | | | | | | | | |
| 4 | L | 764 | 5.0 | 0.303 | 14.0 | LOS B | 7.4 | 54.3 | 0.40 | 0.71 | 43.6 |
| 6 | R | 410 | 5.0 | 0.852 | 56.5 | LOS E | 23.2 | 169.7 | 1.00 | 0.96 | 23.6 |
| Approach | | 1174 | 5.0 | 0.852 | 28.9 | LOS C | 23.2 | 169.7 | 0.61 | 0.80 | 33.7 |
| North: Wanneroo Road North | | | | | | | | | | | |
| 7 | L | 237 | 5.0 | 0.434 | 16.8 | LOS B | 5.3 | 38.5 | 0.52 | 0.72 | 41.2 |
| 8 | T | 1024 | 5.0 | 0.976 | 90.5 | LOS F | 26.8 | 195.5 | 1.00 | 1.36 | 16.7 |
| Approach | | 1261 | 5.0 | 0.976 | 76.6 | LOS E | 26.8 | 195.5 | 0.91 | 1.24 | 18.9 |
| All Vehicles | | 6284 | 5.0 | 1.000 | 35.3 | LOS D | 33.6 | 245.2 | 0.82 | 0.87 | 29.7 |

The above analysis with LHS, indicates that a signalised intersection is likely to accommodate forecast traffic volumes to 2031. A LoS of C/D is forecast and stop rates of less than 1 during the am peak hour but the southbound through movement is 1.36 during the pm peak hour. Significant land resumption is required.

A compromise design is indicated as follows which avoids land acquisition. The performance is not as good as the optimal upgrade however the site is constrained. It should be noted that a good operational; performance cannot be achieved with the compromise design with unacceptable queues and delays and is not therefore recommended.

Compromise Design




Wanneroo Road/Pinjar Road 2031 with LHS Compromise Geometry am
Signals - Fixed Time    Cycle Time = 149 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Road South | | | | | | | | | | | |
| 2 | T | 1432 | 5.0 | 0.509 | 8.2 | LOS A | 20.8 | 151.9 | 0.45 | 0.41 | 47.3 |
| 3 | R | 751 | 5.0 | 0.975 | 78.6 | LOS E | 29.1 | 212.2 | 1.00 | 0.91 | 19.0 |
| Approach | | 2183 | 5.0 | 0.975 | 32.4 | LOS C | 29.1 | 212.2 | 0.64 | 0.58 | 31.3 |
| East: Pinjar Road | | | | | | | | | | | |
| 4 | L | 1342 | 5.0 | 0.871 | 55.9 | LOS E | 48.0 | 350.4 | 0.99 | 0.94 | 23.9 |
| 6 | R | 304 | 5.0 | 0.972 | 117.6 | LOS F | 30.2 | 220.1 | 1.00 | 1.13 | 14.2 |
| Approach | | 1646 | 5.0 | 0.972 | 67.3 | LOS E | 48.0 | 350.4 | 0.99 | 0.98 | 21.2 |
| North: Wanneroo Road North | | | | | | | | | | | |
| 7 | L | 297 | 5.0 | 0.498 | 13.4 | LOS B | 6.3 | 45.7 | 0.36 | 0.69 | 44.0 |
| 8 | T | 1801 | 5.0 | 0.973 | 83.4 | LOS F | 89.3 | 652.2 | 1.00 | 1.19 | 17.7 |
| Approach | | 2098 | 5.0 | 0.973 | 73.5 | LOS E | 89.3 | 652.2 | 0.91 | 1.12 | 19.4 |
| All Vehicles | | 5927 | 5.0 | 0.975 | 56.6 | LOS E | 89.3 | 652.2 | 0.83 | 0.88 | 23.2 |

Wanneroo Road/Pinjar Road 2031 with LHS Compromise Geometry pm
Signals - Fixed Time    Cycle Time = 101 seconds (Optimum Cycle Time - Minimum Delay)

**Movement Performance - Vehicles**

| Mov ID | Turn | Demand Flow | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | 95% Back of Queue Distance | Prop. Queued | Effective Stop Rate | Average Speed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | veh/h | % | v/c | sec | | veh | m | | per veh | km/h |
| South: Wanneroo Road South | | | | | | | | | | | |
| 2 | T | 2606 | 5.0 | 1.064 | 178.5 | LOS F | 165.8 | 1210.1 | 1.00 | 2.02 | 10.0 |
| 3 | R | 1243 | 5.0 | 1.000 [3] | 43.9 | LOS D | 30.9 | 225.6 | 1.00 | 0.89 | 27.3 |
| Approach | | 3849 | 5.0 | 1.064 | 135.1 | LOS F | 165.8 | 1210.1 | 1.00 | 1.66 | 12.5 |
| East: Pinjar Road | | | | | | | | | | | |
| 4 | L | 764 | 5.0 | 0.336 | 16.8 | LOS B | 8.6 | 63.0 | 0.50 | 0.74 | 41.3 |
| 6 | R | 410 | 5.0 | 1.004 | 120.9 | LOS F | 36.1 | 263.5 | 1.00 | 1.36 | 14.0 |
| Approach | | 1174 | 5.0 | 1.004 | 53.2 | LOS D | 36.1 | 263.5 | 0.67 | 0.96 | 24.6 |
| North: Wanneroo Road North | | | | | | | | | | | |
| 7 | L | 237 | 5.0 | 0.428 | 18.2 | LOS B | 5.4 | 39.7 | 0.56 | 0.73 | 40.2 |
| 8 | T | 1024 | 5.0 | 0.996 | 96.4 | LOS F | 39.2 | 286.4 | 0.98 | 1.44 | 16.0 |
| Approach | | 1261 | 5.0 | 0.996 | 81.7 | LOS F | 39.2 | 286.4 | 0.91 | 1.31 | 18.1 |
| All Vehicles | | 6284 | 5.0 | 1.064 | 109.1 | LOS F | 165.8 | 1210.1 | 0.92 | 1.46 | 14.8 |

# Appendix G - Council and Main Roads Response to Draft Measures and GHD Commentary

From: HOLMES Rob (RPO) [rob.holmes@mainroads.wa.gov.au]

**Sent: Monday, 26 November 2012 6:40 AM**

**To: Koroveshi, Jordan**

**Cc: Zamir, Marzia; BROADHURST Lindsay (MRP); MCKIRDY Justin (URPM)**

**Subject: TRIM: Local Housing Strategies -Girrawheen-Koondoola Housing Precinct & Wanneroo Housing Precinct**

**Hi Jordan**

**I refer to your email dated 5 November 2012 providing copies the following documents:**

**Draft Report for Wanneroo Housing Precinct Traffic Impact Assessment – September 2012; and .**

**Draft Report for Girrawheen-Koondoola Housing Precinct Traffic Impact Assessment – September 2012.**

**Please note that we were not provided a copy of Appendix A, C and D for either draft report so we are unable to provide feedback on the data / information contained within these sections.**

**I also make reference to our meeting on 5 November 2012 where discussion focused on the changes in R- Coding around the Wanneroo Centre and Girrawheen-Koondoola precincts, resulting from the implementation of Local Planning Policy 3.1, and the effect this will have on road networks.**

**It is our understanding that the City of Wanneroo is keen to understand future implications of the R-Coding changes with the intention of being able to progressively move toward an appropriate outcome. Main Roads is very supportive of this approach and is keen to remain involved in the process. The following comments are provided in response to your request for comments and are intended to be constructive without being a detailed critique:**

**General Comments**

**1. The draft reports appear to be a good start and provide some good information. We consider some of the recommendations debatable and worthy of further consideration and discussion.**

**2. Network analysis seems to have jumped to 'single solutions' too fast. What network options were considered and tested?**

***GHD Response***

***The planned road network as provided was analysed additional road networks are beyond the scope of this project.***

**3. Wanneroo Rd Metropolitan Region Scheme (MRS) amendment from Wallawa St to Dundebar Rd involves widening the road reservation to be consistent with the existing reserve width north and south of the Wanneroo town site. This widening is intended to**

**provide the opportunity of an additional lane in each direction. However, this lane is currently identified as a bus lane and therefore the existing four lane configuration should be utilised as the future configuration for Wanneroo Rd within this area.**

***GHD Response***

***Noted.***

***However as indicated a poor LoS is forecast if Wanneroo Road is not widened to include an additional traffic lane.***

**4. Further to Point 11, ARRB's North West Corridor Structure Plan Review – Strategic Assessment of Regional Transport Requirements – October 2009 concluded / recommended that:**

**Wanneroo Rd consist of four lanes through Wanneroo town site, with widening for turn lanes,but accepting it will be about 10% overloaded in 2031; and.**

**Additional north south capacity through the area is required and can be achieved by improvements to Lenore Rd / Franklin Rd and the proposed East Wanneroo North South Route.**

**These conclusions / recommendations were touched on in the draft report.**

***GHD Response***

***The ROM modelling included the North South Route however if Wanneroo Rd becomes congested then it is logical that traffic will divert to this route. This comment will be added to the report.***

**5. Future development of the land north of the Wanneroo town site in Sinagra will likely necessitate a new connection to Wanneroo Rd. The draft report suggests Road 2, connecting Wanneroo Rd opposite Hart Ct, should be signalised. Main Roads does not support this suggestion due to its proximity to Church St and Dundebar Rd intersections. Planning work associated with the Wanneroo Rd MRS amendment suggests a more appropriate location for a new connection may be within the vicinity of the existing Inghams Enterprises entrance. This location would be preferable to the Road 2 location because it will result in a more efficient arrangement of access along Wanneroo Rd. Nevertheless, at a spacing of approximately 500m from up and downstream signalised intersections, such an outcome would be detrimental to the operation of Wanneroo Rd. Consideration of implementing a parallel road connecting Pinjar Rd and Dundebar Rd may reduce the demand for this new connection and allow the proposed land development to access Wanneroo Rd via existing signalised connections.**

***GHD Response***

***As discussed in the report Pinjar Rd/Wanneroo Rd and Dundebar Rd/Wanneroo Rd intersections will be under pressure even without higher densities. It will be important to maintain at least left in/out to Wanneroo Rd from any new access to Wanneroo Road. GHD's analysis assumes a signalised intersection at Road 2 but the concerns of Main Roads regarding the proximity to other signalised intersections are acknowledged. This will be discussed in the report.***

**6. There are currently plans which promote the signalising of the Wanneroo Rd and Church St intersection even though the intersection is located only 150m from Dundebar Rd (which is signalised). It would be preferable that Church St not be signalised. A reconfiguration of access arrangements within the town precinct may actually produce a better outcome on a number of fronts.**

***GHD Response***

***Noted a preferred option may be to signalise Scenic Drive/Wanneroo Road which is located some distance south of the Town Centre. This will be discussed in the report.***

***The data available suggests there is/will be spare capacity on Scenic Drive.***

**7. Double right turn into Dundebar Rd, whilst desirable for efficiency, is unlikely to be possible due to land constraints.**

***GHD Response***

***A concept would be required to prove or disprove.***

**8. Removal of pedestrian phases from the Wanneroo Rd, Hastings St and Conlan Ave intersection is interesting but may be undesirable if pedestrian volumes are high. This may be likely given the proximity of the intersection to the centre of the town site.**

***GHD Response***

***This was a suggestion however in view of the proximity to the Shopping Centre the crossing facility should be maintained. Other options would be a grade separated crossing, but the feasibility would need to be examined and may not be as convenient for users.***

***The intention was not to remove all pedestrian movements; rather remove them from one crossing leg only (and to remove the scatter-phase (i.e all-ped phase).***

**9. Main Roads does not support signalising of the Wanneroo Rd and Ariti Ave intersection. Whilst queuing may be undesirable, the volume of traffic trying to access Wanneroo Rd at this location is insufficient to warrant traffic signals. This traffic can utilise other connections to Wanneroo Rd which have traffic signals to assist right turning traffic.**

***GHD Response***

***Noted.***

***Signalising Scenic Drive/Wanneroo Road would be preferable.***

**10. Section 6.2.4 (Wanneroo Rd / Celestine Rd intersection 2031) is an excellent example to consider when dealing with side road connections. We agree with the statement in this section that all side road intersections cannot be signalised. Similarly, there needs to be consideration of how to deal with traffic at the Wanneroo Rd and Celestine Rd intersection (or any other specific location). We would promote the idea of a network review to determine how the network could be structured to make best use of locations which are chosen for the higher level of service afforded by signalisation. The**

**suggestion of acceleration lanes is considered inappropriate in the context of adjacent intersections and vehicle crossovers to properties. The separation between intersections is insufficient, as is available land.**

***GHD Response***

***Noted.***

***The option remains to signalise Elliot Road and retain this intersections as is.***

**11. Wanneroo Rd and Elliot Rd intersection analysis demonstrates that a reasonable level of service could be achieved for this intersection in 2031. However, it is important to recognise that modelling undertaken by Main Roads for the East Wanneroo North South Route and the East Wanneroo Structure Plan has indicated that ultimate volumes at this intersection could be three times, or more, than that analysed in the study undertaken for Wanneroo Housing Strategy. Accordingly, whilst the suggested intersection configuration may prove to be satisfactory at this time, it is highly probable that significant adjustments will be required in the future. This is likely to take the form of longer turning lanes and expansion of Elliot Rd to four lanes.**

***GHD Response***

***Noted.***

***Will be included in report.***

**12. As part of our review of the draft report, a suggested possible alternative road network option has been prepared to help illustrate the intent behind our comments (refer attached copy). This alternative road network aims to retain the integrity of Wanneroo Rd and its function of a Primary Regional Road, whilst highlighting the need to promote the use of Lenore Rd / Franklin Rd and Scenic Dr as parallel routes to share the transport demand through this area.**

***GHD Response***

***Connection of Shaw Rd to Wanneroo Rd***

***This intersection is unlikely to operate to a good LoS as a three way, if constructed as a 4 way would likely result in unacceptable congestion. However overall network would need to be tested.***

***Hastings/Conlan left in/out***

***Likely to result in significant pressure on Dundebar/Wanneroo Int and other connections to Wanneroo Rd. Impacts would need to be tested.***

***Scenic Drive/Wanneroo Rd Signals***

***Should be tested as part of the broader network, but would provide good access to the area west of Wanneroo Road.***

***Promotion of Lenore Rd and realignment to Hartman Dr (future)***

***Would seem logical and should be supported.***

***A broader model would be required to test the overall impacts of the Main Roads proposals.***

`

**13. It aims to achieve a more appropriate distribution of signalised connections to Wanneroo Rd at strategic locations, in order to service the development whilst maintaining the traffic safety and efficiency on the regional route and access to adjacent residential and commercial areas.**

**It is understood that Lenore Rd / Franklin Rd is planned to ultimately become an 'Other Regional Rd' to service the current and future development in the Wanneroo and East Wanneroo areas. It is understood that Scenic Dr is currently a local distributor road however, given the proposed development and the geographically isolated nature of the land use it services, it should perhaps be considered as a district distributor with controlled connections to the regional network.**

***GHD Response***

***Agreed.***

**14. The current signalisation works at Wanneroo Rd and Wallawa St are an anomaly that could become an opportunity. Serious consideration should be given to how Scenic Dr could be connected to Wanneroo Rd at the northern end. Wallawa St provides an opportunity if the link between Scenic Dr and Banyandah Bvd or Kilindi Cr can be created.**

***GHD Response***

***Agreed. The opportunity of connecting Scenic Drive to Wanneroo Road vai Wallawa Street should be examined, not part of this project scope.***

**Thank you for informing Main Roads of these proposals and for the opportunity to comment. It is hoped that the City finds this feedback beneficial. The opportunity to discuss our feedback would also be welcomed should the City desire. If you require any further information please contact Justin McKirdy, Urban Road Planning Manager North, on 9323 4991.**

**Regards**

**Lindsay Broadhurst**

**Manager Road Planning**

### City of Wanneroo Comments

1. **Local roads – Comment re local road impacts.**

***GHD Response***

***Will add comments re local roads as per email.***

***The above analysis considers road requirements to the key road network, i.e Local Distributor classification and above, there are however a number of Access Streets within the internal road network and commentary on these roads is provided as follows.***

***The WAPC document 'Liveable Neighbourhoods' indicates the anticipated traffic volumes for residential streets:***

*Access Street Type C (single carriageway 7.2m to 7.5m wide): 3,000vpd*

*Access Street Type D (single carriageway, 5.5m to 6m wide): 1,000vpd*

*The physical capacity of a single carriageway road is 8,000-12,000vpd at a good level of service C, based on the assessment of the precinct it is clear considerable capacity is available within the lower order roads in the study area and the planned increased residential density is unlikely to adversely impact these roads requiring the need to upgrade.*

*The following intersection thresholds are indicated by Austroads below which capacity analysis is unnecessary.*

| *Major Road Flow* | *Minor Road Flow* |
|---|---|
| *400vph* | *250vph* |
| *500vph* | *200vph* |
| *650vph* | *100vph* |

*Based on the above thresholds, minor road intersections within the precinct are not expected to exceed these volumes on full development and therefore not anticipated to require significant upgrade for capacity reasons.*

2. **Traffic apportioning and clarity**

   *GHD Response*

   *Will add to report as suggested by City.*

3. **Upgrade trigger/threshold**

   *GHD Response*

   *GHD have undertaken a staging analysis (looking at 25% and 50% development horizons). This analysis has been included into the body of the report.*

4. **Cost apportioning should be b-a/b**

   *GHD Response*

   *Noted will add to report.*

5. **Involvement of Main Roads. Confirm consultation.**

   *GHD Response*

   *Will add to report.*

6. **Consistency, Wanneroo Rd/Celestine not recommended for signals in Appendix. Remove mention of traffic signals.**

   *GHD Response*

   *Noted re Wanneroo Rd/Celestine will amend report.*

7. **Cost estimates**

**Will prepare conceptual design for each location following CoW confirmation of agreed measure.**

**Six designs allowed for in tender, will price 2 additional options for concepts and cost estimation.**

**Main Roads Transport Modelling team comments:**

- **The greatest strength of Paramics is its dynamic assignment. This works to reroute traffic in response to congestion. However, the two models developed by GHD have little to none sensible route choices available, (acknowledged in sections 3.7). Furthermore SCATS is showing little congestion is occurring around this area (low saturation flow rates). This means traffic assignment becomes redundant. In my opinion, if you are building a model without route choice and with standard (4 leg & 3 leg) signalised intersections, Paramics isn't necessary, you might as well stick with SIDRA.**

***GHD Response***

***It is agreed that the networks being assessed have little logical alternate route choices (and no route choice at all in the case of the Wanneroo study network). However, one of the biggest drawbacks of using SIDRA analyses only is that the interaction and impact of upstream and downstream intersections cannot be efficiently considered. The microsimulation model enables the network to be considered as an integrated system and the interaction between junctions can be evaluated. In the case of the corridor network of the Wanneroo study area, the impact of queuing, vehicle platooning and signal co-ordination was easily considered within microsimulation framework. Additionally, the ability to visual see the simulation model in operation enables a greater understanding (particularly to non-technical persons) of the anticipated network performance.***

- **GHD have used fixed time signals rather than vehicle actuated signals. If traffic demand increases dramatically in the 2031 scenarios, the signal phasings may need to be modified.**

***GHD Response***

***During the 2031 scenario testing phase times were modified from the existing times to account for change in volumes, if required. Sidra models were initially run to obtain the starting point for signal operations, and then modified further through inspections of the models in operation.***

- **Heavy vehicles have been considered which is good.**
- **The reports are not clear whether or not public transport (bus routes) have been considered.**

***GHD Response***

***Bus routes were not coded into the models, as public transport operations were not critical to the traffic model component of the study.***

- **The calibration results are excellent. However this isn't surprising given the models have limited route choice.**

***GHD Response***

***Agree, given the study area networks a high level of calibration could be reasonably expected.***

- **The travel time validation criteria is stated as "*Percentage difference between total observed and total modelled journey times for each route should be less than 15% or 1-minute (whichever is greater).*" I am not sure where this criteria has come from. Is a reference available?**

***GHD Response***

***This travel time validation criteria is from the Design Manual for Roads and Bridges (DMRB) (prublished by Highways Agency, UK) and is also stated within the latest RMS (previously RTA) Traffic Modelling Guidelines (to be officially released shortly).***

- **The report is not clear whether the observed journey times where measured once each, or are averaged over multiple runs. Best practice is to measure multiple journey times on site, and then calculate both an average and a confidence interval for each journey (as per the RTA guidelines).**

***GHD Response***

***Observed travel times were the result (average) of multiple runs of a floating car travel time survey. The Wanneroo study area consisted 5 recordings for each direction and the Girrawheen study area 2 recordings for each network section (Note, there were 14 sections in total).***

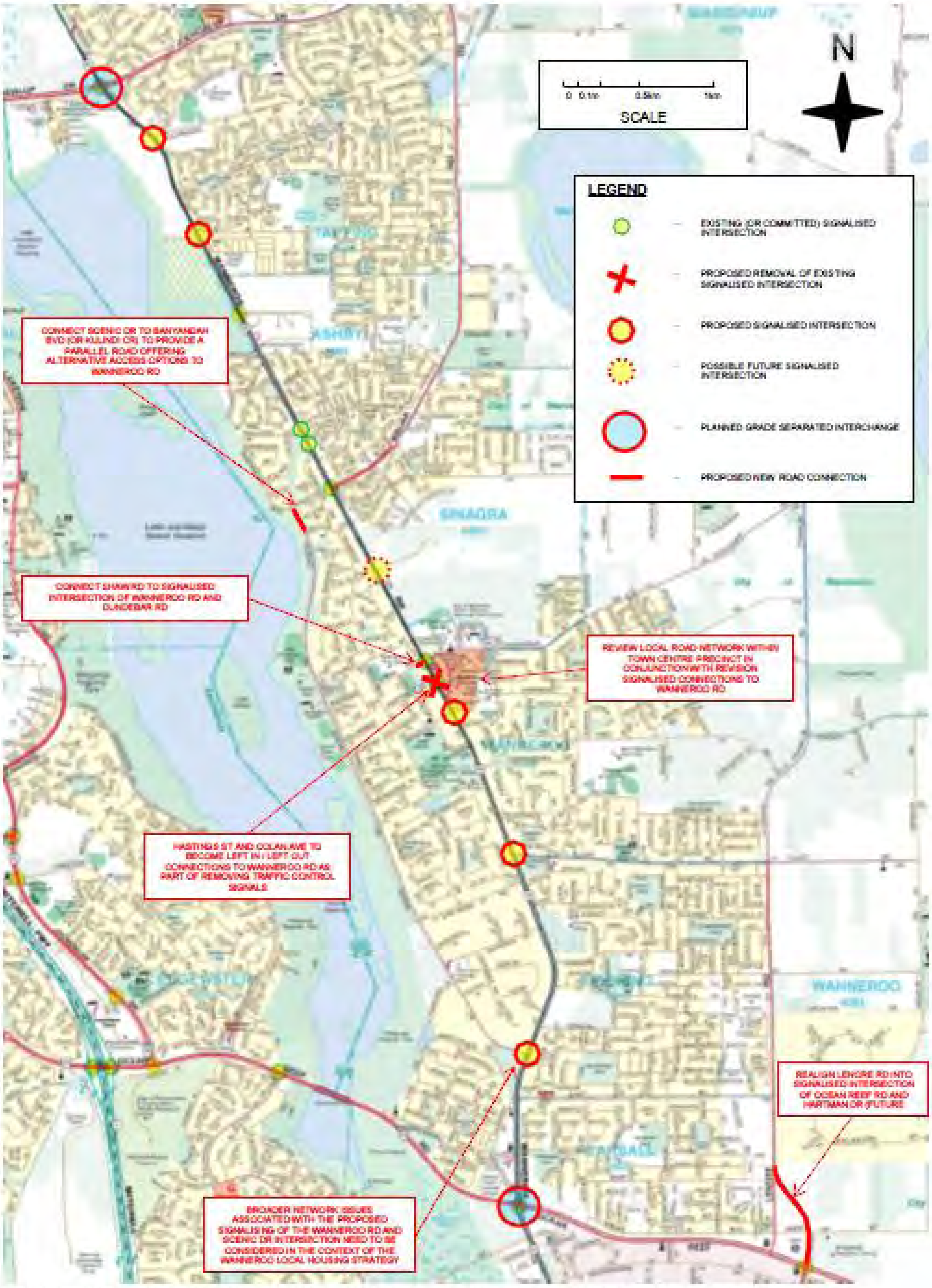
- **GHD have used an Azalient Ceejazz plugin which isn't owned by Main Roads. This means the model runs cannot be run by Main Roads (unless we purchase a plugin of our own)**

***GHD Response***

***These plugins enhance the functionality of the core simulation software (and are available from Azalient at a modest cost).***

- **Sections 5.3 demonstrates that the model is stable (no gridlocking) which is good.**

A copy of Main Roads preferred signal strategy for Wanneroo Road and road network option is shown overleaf.




**WANNEROO HOUSING PRECINCT - POSSIBLE ALTERNATIVE ROAD NETWORK OPTION 1**

MAIN ROADS Western Australia
Wanneroo Local Housing Strategy – Possible Alternative Road Network Option 1

GHD

GHD House, 239 Adelaide Tce. Perth, WA 6004
P.O. Box 3106, Perth WA 6832
T: 61 8 6222 8222   F: 61 8 6222 8555   E: permail@ghd.com.au



G:\61\28180\WP\128886.docx

Document Status

| Rev No. | Author | Reviewer | | Approved for Issue | | |
|---|---|---|---|---|---|---|
| | | Name | Signature | Name | Signature | Date |
| 0 | S McDermott<br>S Bennet | Paul Fisher | *Paul Fisher* | Paul Fisher | *Paul Fisher* | *22.1.13* |
| | | | | | | |
| | | | | | | |

www.ghd.com

# ATTACHMENT 4 – CITY OF WANNEROO AND WATER CORPORATION CORRESPONDENCE

## Stawarz, Nicholas

**From:** Peter Howard [Peter.Howard@watercorporation.com.au]
**Sent:** Monday, 11 August 2014 11:00 AM
**To:** Koroveshi, Jordan
**Cc:** Frank Kroll
**Subject:** RE: Water & sewer infrastructure upgrades related to infill recoding

Hi Jordan,

To confirm the information from our phone conversation under the 4 points contained in your email I advise as follows:

- *Other infill areas have not required much upgrading as the networks are sufficiently engineered for higher R-Codes;*

Our systems have been designed to serve the densities identified in local planning schemes. As development seldom reaches the densities identified in local authority town planning schemes; and water consumption per person has been declining; and pipe sizes are selected which are "rounded up" from the modelled hydraulic requirement, we estimate we have sufficient capacity in the reticulation systems to accommodate diffuse infill development in most locations across the metro area. This is being demonstrated in older suburbs which have been absorbing brownfield development over the past couple of decades without issue. Point load demands greater than the diffuse 2-5 dwelling type developments may require upgrades but these are development specific and can't be assessed in advance and will vary depending on the location.

- *The most appropriate time to conduct an upgrade would be at subdivision clearance;*

The requirement to upgrade the reticulation assets would be identified at subdivision, development or building application stage. As a lot of infill will be achieved through strata schemes these retic upgrades would be identified through the building process. So the most appropriate time to do the upgrades would be at these application times.

- *If Council chooses to pay for the upgrades, Council would also hire the contractors to do the work and consult with Water Corp at that stage*

Individual developers would need to seek the Corporation's advice on the availability of water or sewer capacity. The Corporation would advise if particular developments may trigger upgrades, and this would be informed via the subdivision clearance, development application and building application processes as applicable, to alert the City to commence the construction process.

The works would be constructed by the City under tender, and handed over to the Corporation. The same process as per Greenfields applies.

The Corporation will fund all works apart from reticulation via its Capital Investment program.

- *Council may incur additional expense if upgrades are conducted prior to being required;*

Council should not do upgrades to the reticulation upgrades identified in the Cardno planning study. The study is a desk top evaluation based on a range of assumptions. The actual upgrades would need to be based on the observed performance of the scheme and the solutions would be quite different to the theoretical conclusions of the study depending upon the rate of infill development, the location of the infill and the type of development. For example, the Corporation would not normally dig up a 150mm pipe to replace it with a 225mm pipe, but rather run another 150mm pipe down the other side of the road; other options may be to divert flows into another catchment; however these types of solutions would have to be designed in response to the performance issue being observed.

Also, creating capacity in the retic system before it is required is wasteful in a financial sense. Much more cost effective to utilise existing capacity that has been paid for and upgrade only when that capacity has been reached.

The Corporation would take the approach of identifying the expenditure as a required future project with costs to be refined closer to delivery and schedule it for a nominal 15yrs or so in the future. The project could be brought forward or pushed back depending on its need. I don't know whether your Council uses a similar capital works program model to allocate and schedule funds over a long period of time, but if you do it would allow you to keep the expenditure on your horizon and review it periodically.

- *Constraints Mapping*

With regards to the constraints mapping, I am not sure what assumptions have been used to identify these areas. As discussed previously the Cardno study is a theoretical desk top assessment using a range of assumptions. We would identify constraints based on performance issues of the systems. We have not observed any issues in these areas and would not expect any in the short to medium term depending on the type and scale of development. That is, incremental small scale infill development should not require retic upgrades any time soon.

I hope this helps. Please contact me if you need anything else

**Peter Howard**
Manager Land Planning Section
Development Services Branch
**Water Corporation**

**T:** (08) 9420 2769 | **F:** (08) 9420 3193 | **M:** 0403 398 953
629 Newcastle Street, Leederville, WA 6007
PO Box 100, Leederville, WA 6902
www.watercorporation.com.au

**From:** Koroveshi, Jordan [mailto:Jordan.Koroveshi@wanneroo.wa.gov.au]
**Sent:** Monday, 28 July 2014 11:18 AM
**To:** Peter Howard
**Subject:** FW: Water & sewer infrastructure upgrades related to infill recoding

Hi Peter,

Regarding our phone convo just now, I'd like to confirm what you said:

- Council may incur additional expense if upgrades are conducted prior to being required;
- Other infill areas have not required much upgrading as the networks are sufficiently engineered for higher R-Codes;
- The most appropriate time to conduct an upgrade would be at subdivision clearance;
- If Council chooses to pay for the upgrades, Council would also hire the contractors to do the work and consult with Water Corp at that stage.

Could you please confirm if this is correct?

Also, I've attached a map of the areas that need upgrades. Could you please ask your team whether the critical areas have had any enquiries thus far regarding capacity issues?

Regards,

**Jordan Koroveshi**
Project Planner
City Growth

City of Wanneroo

T : 08 9405 5523
F : 08 9405 5499
E : jordan.koroveshi@wanneroo.wa.gov.au

23 Dundebar Road, Wanneroo WA 6065
Locked Bag 1, Wanneroo WA 6946

**wanneroo.wa.gov.au**

---

**From:** Searles, Nyssa
**Sent:** Monday, 21 July 2014 1:42 PM
**To:**
**Cc:** Dickson, Mark
**Subject:** Water & sewer infrastructure upgrades related to infill recoding

Hi Peter,

Phil Thompson has passed on your contact details.

The City of Wanneroo is progressing the recoding of two of our housing precinct areas – Wanneroo and Girrawheen/Koondoola. Infrastructure studies we've had completed have identified a number of water and sewer upgrades that will be required to ensure sufficient infrastructure capacity to maximise infill development. I understand Phil Thompson and Jordan Koroveshi have previously met with you on this project.

We are now at a stage where one of the options available to Council is to fund the non-head works water and sewer infrastructure upgrades. We are investigating four scenarios based on 5, 10, 15 or 20 year funding scenarios.

In this regard, I am keen to discuss with Water Corporation how to progress the water and sewer infrastructure upgrades if Council agrees to fund them. Specifically I have the following questions:

- Does the City of Wanneroo fund the Water Corporation to complete the upgrades?
- If yes, over what timeframe are these upgrades likely to be completed? i.e do they need to be programmed into the Water Corporation's capital works program?
- If no, will the City of Wanneroo and Water Corporation need to develop an agreement to enable the City of Wanneroo to contract out the work to agreed contractors?

Do you have any time to discuss this over the phone? Alternatively I'm happy meet with yourself and other relevant staff at Water Corporation if this is preferred.

Kind regards,

**Nyssa Searles**
Business Development & Research Officer
City Growth

23 Dundebar Road  Wanneroo  WA  6065
Locked Bag 1  Wanneroo  WA  6946
☏ | 08 9405 5889 | 🖷 08 9405 5499  | ✉nyssa.searles@wanneroo.wa.gov.au

www.wanneroo.wa.gov.au

Adopted by resolution of the Council of the City of Wanneroo at the Ordinary meeting of the Council held on the 3rd day of February 2015.

...............................................
MAYOR

................................................
CHIEF EXECUTIVE OFFICER

Adopted for final approval by resolution of the City of Wanneroo at the meeting of the Council held on the day of and the Common Seal of the City of Wanneroo was hereunto affixed by the authority of a resolution of the Council in the presence of:

...............................................
MAYOR

................................................
CHIEF EXECUTIVE OFFICER

Recommended/Submitted for final approval

......................................................................
DELEGATED UNDER S.16 OF
PD ACT 2005

DATE ..........................................................

Final Approval Granted

......................................................................
MINISTER FOR PLANNING

DATE ..........................................................