Appendix I

Traffic impact assessment

Orange Grove
Sun Farm

Overland Sun Farming

Orange Grove Sun Farm

Traffic impact assessment

Prepared for Orange Grove Sun Farm Pty Ltd | 11 May 2018

Orange Grove Sun Farm

Traffic impact assessment

Prepared for Orange Grove Sun Farm Pty Ltd | 11 May 2018

Ground Floor, Suite 01, 20 Chandos Street
St Leonards, NSW, 2065

T +61 2 9493 9500
F +61 2 9493 9599
E info@emmconsulting.com.au

www.emmconsulting.com.au

Orange Grove Sun Farm

Final

Report J17210RP1 | Prepared for Orange Grove Sun Farm Pty Ltd | 11 May 2018

Prepared by	**Tim Brooker**	Approved by	**Claire Burnes**
Position	Associate - Transport Planner	Position	Associate – Environmental Assessment & Management
Signature		Signature	
Date	11 May 2018	Date	11 May 2018

Document Control

Version	Date	Prepared by	Reviewed by
V1	2 March 2018	Tim Brooker	Claire Burnes
V2	11 May 2018	Tim Brooker David Richards	Claire Burnes

T +61 (0)2 9493 9500 | F +61 (0)2 9493 9599

Ground Floor | Suite 01 | 20 Chandos Street | St Leonards | New South Wales | 2065 | Australia

www.emmconsulting.com.au

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1 Introduction

1.1 Overview

OVERLAND Sun Farming Pty Ltd (OVERLAND) on behalf of Orange Grove Sun Farm Pty Ltd (the proponent) proposes to develop the Orange Grove Sun Farm, a large-scale solar photovoltaic (PV) generation facility and associated building and electrical infrastructure including grid connection works near the township of Gunnedah in north-west NSW (Figure 1.1) (the project). The project is proposed to be developed on a site within the Gunnedah Shire local government area (LGA), approximately 12 kilometres (km) east of the township of Gunnedah (Figure 1.2).

The project is a State significant development (SSD) under the State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP). A development application (DA) for the project is required to be submitted under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The NSW Minister for Planning, or the Minister's delegate, is the consent authority.

An environmental impact statement (EIS) is a requirement of the approval process. This traffic impact assessment (TIA) forms part of the EIS. It documents the traffic impact assessment methods and results, the initiatives built into the project design to avoid and minimise associated traffic impacts, and the additional mitigation and management measures proposed to address any residual impacts not able to be avoided.

1.2 Assessment guidelines and requirements

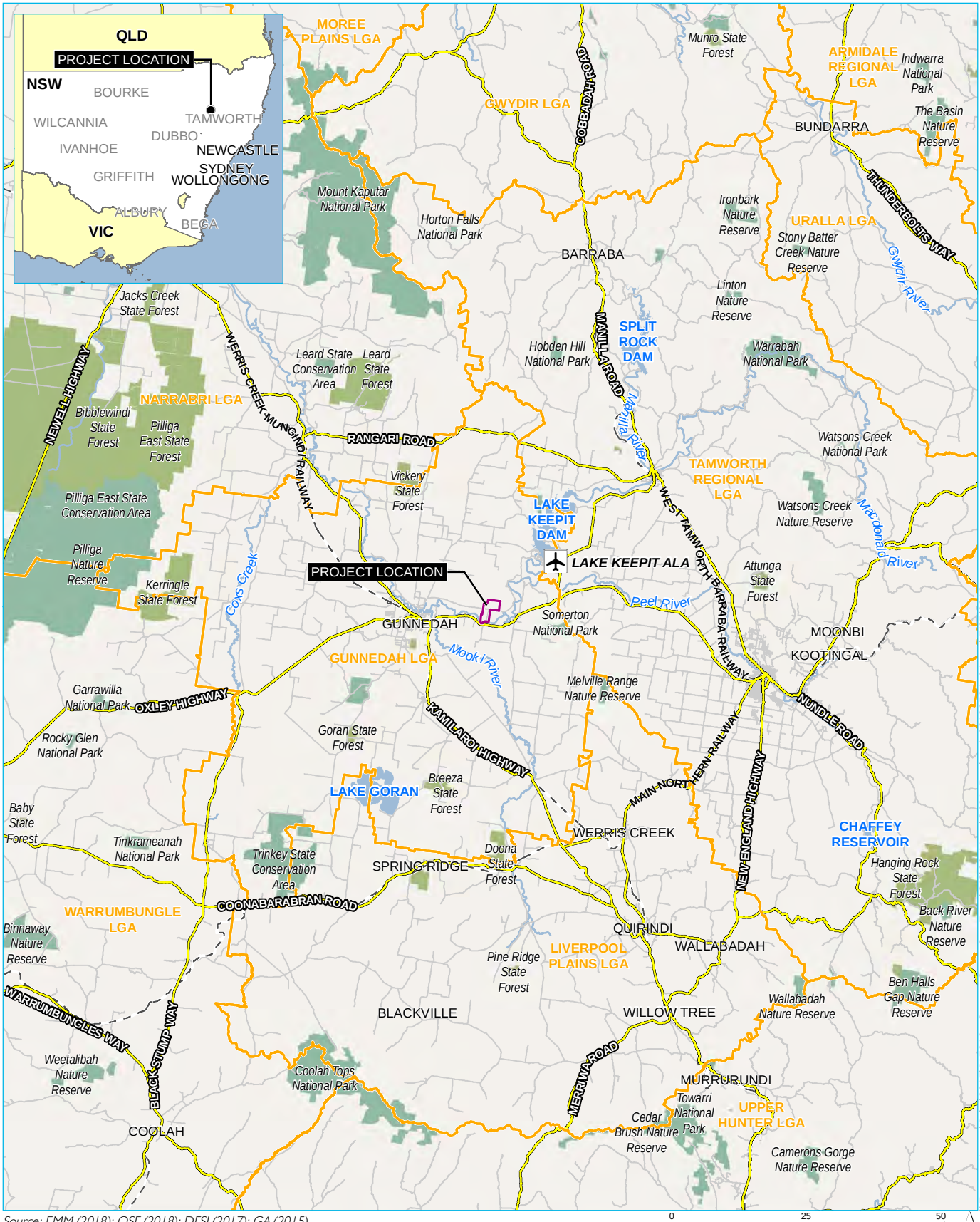
This TIA has been prepared in accordance with the relevant governmental assessment requirements, guidelines and policies, and in consultation with the relevant government agencies.

The assessment is based on the following general scope for matters to consider in a TIA, which is defined by NSW Roads and Maritime Services' (RMS), *Guide to Traffic Generating Developments* (RTA 2002):

- the existing locality and surrounding land uses;
- the existing road network and intersections;
- traffic and car parking generation characteristics of the project;
- traffic and car parking impacts of the project; and
- a summary of the assessed traffic impacts and any traffic management or mitigation measures.

The TIA also addresses the requirements of the NSW Department of Planning and Environment (DPE). These were set out in the Secretary's Environmental Assessment Requirements (SEARs) for the project, issued on 20 December 2017.

The SEARs must be addressed in the EIS. A copy of the SEARs is attached to the EIS as Appendix A, while Table 1.1 lists the individual requirements relevant to this TIA and where they are addressed in this report.



Source: EMM (2018); OSF (2018); DFSI (2017); GA (2015)

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GDA 1994 MGA Zone 56

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KEY

- Orange Grove Sun Farm site boundary
- Local government area (LGA) boundary
- Rail line
- Main road
- Local road
- Major waterway
- Waterbody
- NPWS reserve
- State forest

Regional project location

Orange Grove Sun Farm
Traffic impact assessment
Figure 1.1

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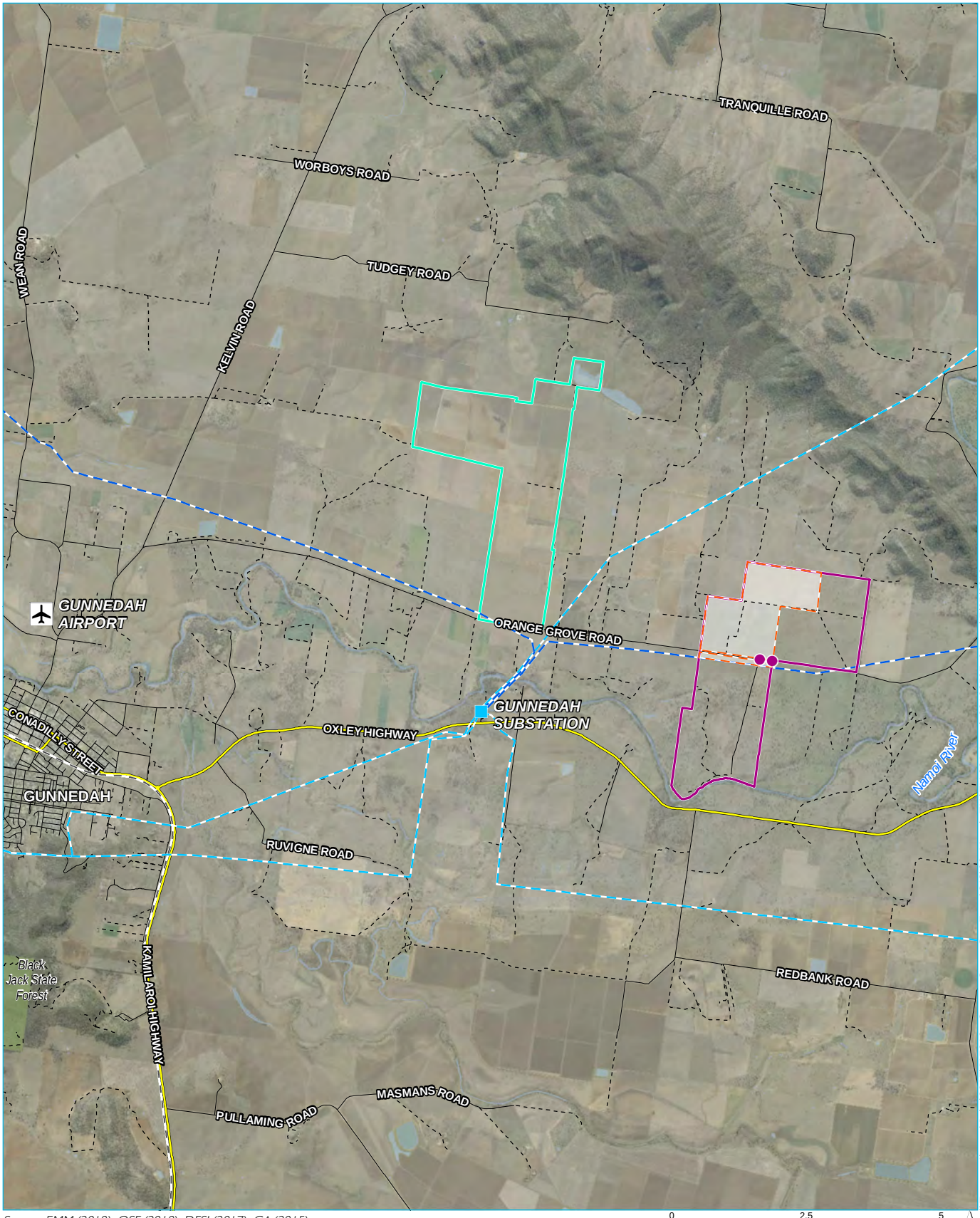

Source: EMM (2018); OSF (2018); DFSI (2017); GA (2015)

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GDA 1994 MGA Zone 56

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KEY

LABEL

- Orange Grove Sun Farm site boundary
- Development footprint
- Indicative site access point
- Gunnedah Solar Farm (SSD 8658 - proposed by Photon Energy Generation Pty Ltd)*
- 132 kV transmission line
- 66 kV transmission line
- Rail line
- Main road
- Local road
- Vehicular track
- Waterbody
- State forest

* DPE 2017, Gunnedah Solar Farm, viewed 11 October 2017, http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=8658

Location of the Orange Grove Sun Farm

Orange Grove Sun Farm
Traffic impact assessment
Figure 1.2

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Table 1.1 Relevant matters raised in SEARs

Requirement	Section addressed
Site access route (including the Kamilaroi Highway, Oxley Highway, Orange Grove Road and Kelvin Road)	Sections 2.1 and 3.1
Site access point	Sections 3.1, 4.2 and 4.3
Any potential rail safety issues	Not applicable – the project will not affect the rail corridor along the Kamilaroi Highway
Likely transport impacts and cumulative transport impacts (including peak and average traffic generation, over-dimensional vehicles and construction worker transportation) of the development on the capacity and condition of roads (including on any Crown land)	Sections 4.1 and 4.2 The Gunnedah Solar Farm is proposed to be constructed within proximity of the project, with vehicular access also via Orange Grove Road (refer Figure 1.2). Potential cumulative impacts are considered in Section 4.1.4.
Measures to be implemented to mitigate impacts during construction	Chapter 5
Description of any proposed road upgrades developed in consultation with the relevant road and rail authorities (if required)	Sections 5.2 and 5.3 – no required road or intersection upgrades have been identified for the project
Demonstration about potential cost sharing	No potential cost-sharing arrangements with the nearby proposed Gunnedah Solar Farm in relation to any future road and/or intersection improvements on Orange Grove road have currently been identified

To inform preparation of the SEARs, DPE invited other government agencies to recommend matters to be addressed in the EIS. These matters were taken into account by the Secretary for DPE when preparing the SEARs. Copies of the RMS and Gunnedah Shire Council (GSC) advice to DPE were attached to the SEARs and matters relevant to the TIA are listed in Table 1.2 and Table 1.3, respectively.

Table 1.2 Government agency (RMS) traffic impact assessment recommendations

Requirement	Section addressed
Traffic Impact Assessment (TIA) prepared by a suitably qualified person in accordance with Austroads Guide to Traffic Management Part 12, the complementary Roads and Maritime Supplement and RTA Guide to Traffic Generating Developments, which addresses:	In this report, the format of the assessment generally follows the structure which is requested by the *Guide to Traffic Generating Developments* (RTA 2002).
The total impact of existing and proposed development on the road network with consideration for a 10 year horizon	Sections 4.1 and 4.2. A ten year timeframe is not specifically relevant to this project as the majority of the project generated traffic movements will occur during the nine month construction period and generated traffic movements would be much lower during the subsequent project operations
The volume and distribution of traffic generated by the proposed development	Sections 3.4 and 3.5
Intersection sight distances at key intersections along the primary haul route	Section 3.1
Existing and proposed site access standards	Sections 3.1 and 5.2
Details of proposed improvements to affected intersections, particularly any connections to the Oxley Highway or Kamilaroi Highway	Section 5.2 – there are no proposed improvements to connections to the Oxley Highway or Kamilaroi Highway
Details of servicing and parking arrangements	Section 3.6
Impacts of road traffic noise and dust generated along the primary haul routes	Section 4.5
Consideration of the impact of glare and/or reflectivity of infrastructure visible from public roads	Section 4.4
Impact on public transport and consideration for alternative transport modes such as walking and cycling	Not applicable – no impact on public transport is anticipated and alternative modes of transport are generally impractical
Consideration for a Construction Traffic Management Plan and Driver Code of Conduct	Section 5.1

Table 1.3 GSC traffic impact assessment recommendations

Requirement	Section addressed
A road safety audit be conducted on all proposed routes to identify all safety concerns, both during construction, operations and in decommissioning of the site.	Section 2.5
It is recommended that all heavy vehicles access to the site on Orange Grove Road from the Kamilaroi Highway, via Blue Vale Road, Old Blue Vale Road and Kelvin Road. No heavy vehicles are able to travel east from the site as there is a weight limited bridge on Orange Grove Road (Keepit Dam end). In addition, B-Double sized trucks are unable to utilise Cohen's Bridge on Kelvin Road, as the bridge is not a designated B-Double route. Signage at the approaches to the bridge may be required.	Section 2.1 All heavy vehicles will travel along the heavy vehicle route identified in Figure 2.2
Orange Grove Road is of part gravel construction along the frontage of the development site. Due to the estimate 9-12 months of construction, it is recommended that the road be sealed at the least be treated with an approved polymer additive to prevent dust nuisance. Consideration should also be given to the internal access with respect to nearby residences.	Section 5.3 The proponent will treat the road surface of the unsealed section of Orange Grove Road to reduce potential dust generation by project-related traffic during the project's construction period.

2 Existing traffic conditions

2.1 Road network

The main transport routes that connect the township of Gunnedah to a range of other areas throughout NSW are shown on Figure 1.1 and Figure 1.2, and are:

- The Oxley Highway (B 56) – a state funded rural highway, which connects in a general east-west direction, from Nevertire in the west, linking up with the Mitchell Highway at various points, and running via Gunnedah and Tamworth to Port Macquarie on the eastern coast of NSW. At Tamworth, the New England Highway connects this region with Newcastle in the south and, Brisbane in the north.

- The Kamilaroi Highway (B 51) – a state funded highway, which runs north-west from Willow Tree to Narrabri, via Gunnedah, before continuing west to Bourke. This connects Gunnedah to the main route from Newcastle in a more direct line than the Oxley Highway.

The Oxley Highway is a two-lane route with a speed limit of 100 km/hr generally on the rural sections. It has a relatively straight and level alignment, with good visibility. Both the centre line and edge lines of the road are usually marked. Overtaking is permitted intermittently on sections of the highway between Gunnedah and Tamworth. Almost all intersections on the Oxley Highway lack additional turning lanes or other traffic capacity or safety improvements, and consist mostly of basic T-intersections. There is a large three-way roundabout where this road meets the Kamilaroi Highway south-east of the township of Gunnedah.

Similarly, the Kamilaroi Highway is a two-lane route with a speed limit of 100 km/hr generally on the rural sections. It has a relatively straight and level alignment, with good visibility on most sections. Both the centre line and edge lines of the road are marked. Overtaking is generally permitted between Gunnedah and Willow Tree where the Kamilaroi Highway joins the New England Highway. Almost all intersections on the Kamilaroi Highway lack additional turning lanes or other traffic capacity or safety improvements, and consist mostly of basic T-intersections.

The following two local roads make up the main route between the township of Gunnedah and the development footprint, approximately 12 km to the east:

- Orange Grove Road – a local road, which is the main access to the development footprint. It connects the agricultural plots north of the Namoi River between Gunnedah and Carroll.

- Kelvin Road – a local road, which connects agricultural plots to the north of Gunnedah.

Orange Grove Road is a two-lane local road with a speed limit of 100 km/hr. It has a straight and level alignment and good visibility; however, it has no centreline markings. All intersections on Orange Grove Road are basic T-intersections.

Orange Grove Road is sealed from the intersection with Kelvin Road for approximately 6.5 km to the east. The sealed section of Orange Grove Road finishes approximately 4 km west of the development footprint and then the road is unsealed to the proposed access locations for the project, a distance of approximately 5.4 km (Figure 2.1). The unsealed section of Orange Grove Road continues further east through to the intersection with Keepit Dam Road.

This 5.4 km unsealed section of Orange Grove Road will be used by all project-related traffic during both the construction and operational stages of the project.

Kelvin Road is a two-lane local road with a speed limit of 100 km/hr. It has a straight and level alignment and good visibility. While it is not marked for most of its length, the segment that would generally be used by most project-related traffic has centreline markings. All intersections on Kelvin Road are basic T-intersections. On the approach to Gunnedah, Kelvin Road connects into O'Keefe Avenue where there is a narrow two lane bridge (Cohens Bridge) crossing over the Namoi River and the road then continues as Chandos Street to the centre of Gunnedah.

All light vehicles will use the Kelvin Road and Orange Grove Road route to access the development footprint (refer Figure 2.2). No vehicle movements to or from the east of the development footprint along Orange Grove Road, Keepit Dam Road and Rushes Creek Road are proposed.

Due to restrictions on Cohens Bridge (refer Figure 2.2), all project-related heavy vehicles will access Kelvin Road via an alternative route. This would involve turning on to Blue Vale Road off the Kamilaroi Highway approximately 5.5 km north-west of Gunnedah. The heavy vehicles would then turn right on to Old Blue Vale Road and finally rejoin Kelvin Road, thereby bypassing Cohens Bridge. This heavy vehicle route is shown in Figure 2.2.

Blue Vale Road is a two-lane, local road with a speed limit of 100 km/hr. It has a relatively straight and level alignment with good visibility. Both the centre and edge lines are marked. Except for major intersections, such as the Kamilaroi Highway/Blue Vale Road intersection which has extra turning lanes, all intersections are basic T-intersections.

Old Blue Vale Road is a one-lane, two-way local road with a speed limit of 100 km/hr. It has a straight and level alignment with excellent visibility. The road is not marked. All intersections along Old Blue Vale Road are basic T-intersections.

Two access road locations off Orange Grove Road will be used to access the development footprint, one each for the northern and southern portions of the development footprint, respectively (Figure 2.1). Both of these access intersections will consist of a three-way intersection with Orange Grove Road, with a connecting access road extending into the respective northern and southern portions. Project traffic during both the construction and operations stages will principally access the northern portion of the development footprint. Gravel shoulder widening will be constructed at both locations to facilitate turning movements to and from the development footprint by large trucks.

Within the development footprint, roads will generally be unsealed internal roads. As noted above, some gravel shoulder widening within the Orange Grove Road reserve will be required at the proposed access road locations, to facilitate safe turning movements by large trucks on and off Orange Grove Road. The sight distance visibility along Orange Grove Road is excellent for the future potential turning traffic at both of the access road locations. The sight distance visibility is discussed in further detail in Section 3.1.

Source: EMM (2018); OSF (2018); DFSI (2017); GA (2015)

0 250 500 m

GDA 1994 MGA Zone 56

N

KEY

- Development footprint
- Potential site access point
- 132 kV transmission line
- Main road
- Local road
- Cadastral boundary
- Waterbody

Potential site access locations

Orange Grove Sun Farm
Traffic impact assessment
Figure 2.1

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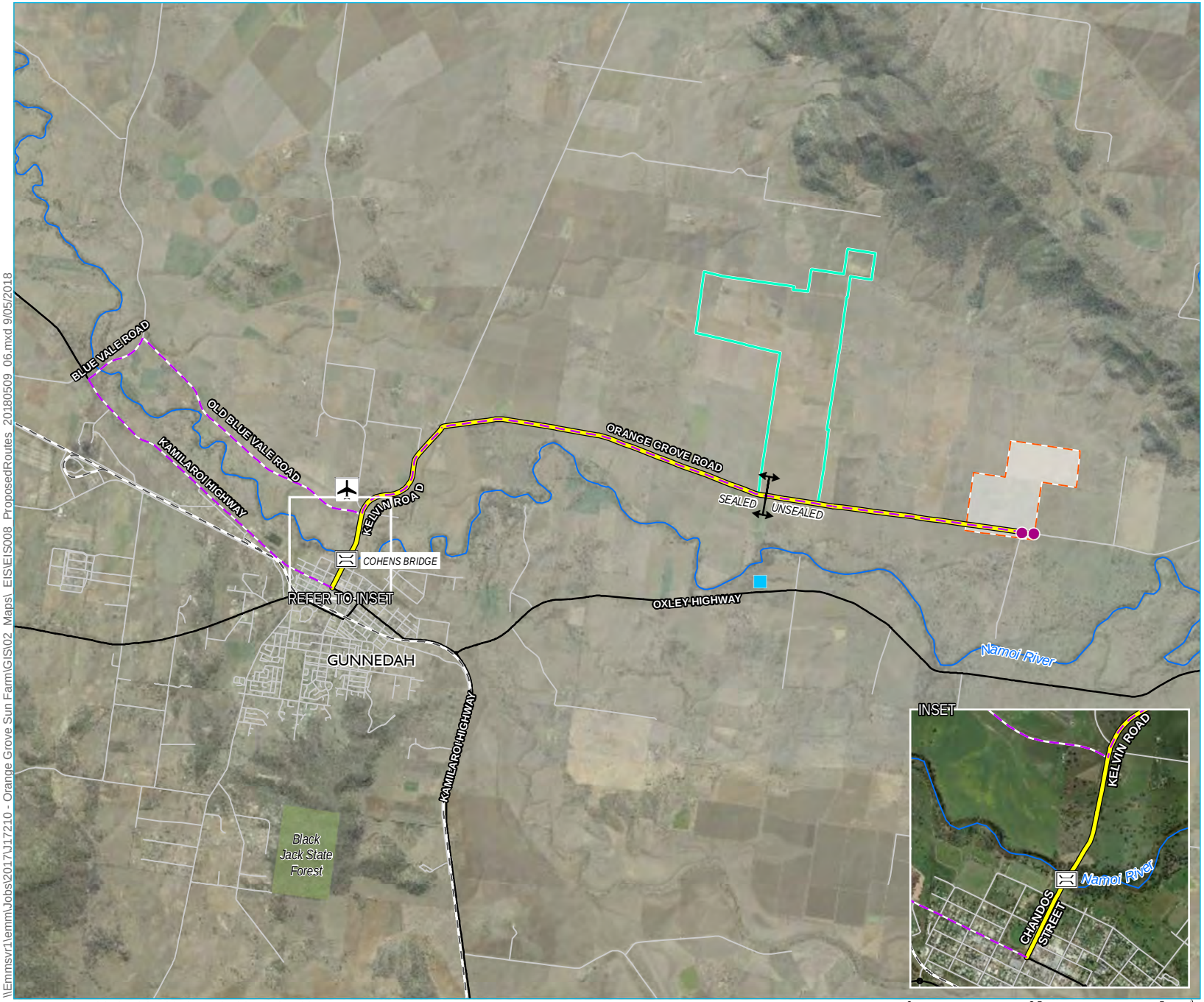

KEY

- Development footprint
- Potential site access point
- Gunnedah Solar Farm (SSD 8658 - proposed by Photon Energy Generation Pty Ltd)*
- Gunnedah Substation
- Gunnedah Airport
- Narrow bridge (Cohens Bridge)
- Main road
- Local road
- Rail line
- Namoi River
- State forest

Proposed traffic routes

- Light vehicle traffic route
- Heavy vehicle traffic route

\\Emmsvr1\emm\Jobs\2017\117210 - Orange Grove Sun Farm\GIS\02 Maps\ EIS\EIS008 ProposedRoutes 20180509 06.mxd 9/05/2018

Source: EMM (2018); OSF (2018); DFSI (2017); GA (2015)

** DPE 2017, Gunnedah Solar Farm, viewed 11 October 2017, http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=8658*

0 2.5 5 km

GDA 1994 MGA Zone 56

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Proposed traffic routes

Orange Grove Sun Farm
Traffic impact assessment
Figure 2.2

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2.2 Traffic volumes and capacity standards

Baseline daily traffic volumes for the main project access routes have been determined from published RMS daily traffic surveys, for the years where the data is available, between 2007 and 2017. To establish baseline 2018 daily traffic volume, it is standard practice in most rural areas of NSW to add +1% annual (linear) traffic growth to the most recent annual survey, which is summarised in Table 2.1.

Table 2.1 Historic and projected daily traffic volumes on major roads

Road	Historic daily traffic volumes			2018 projected daily traffic volume[1]	Average proportion of heavy vehicles
	2007	2011	2017		
Kamilaroi Highway at Gunnedah	5,931	6,250	N/A	6,690	N/A
Kamilaroi Highway, south of Gunnedah (near Curlewis)	1,633	N/A	N/A	1,810	17%
Kamilaroi Highway, north-west of Gunnedah (near Blue Vale)	1,595	N/A	N/A	1,770	18%
Oxley Highway, east of the development footprint (near Carroll)	2,520	1,504	N/A	1,610	13%
Oxley Highway, west of the development footprint (3.7 km east of Gunnedah)	N/A	N/A	3,588	3,620	17%

Note: + 1% annual (linear) traffic growth has been adopted, which gives a growth factor x 1.01 from the 2017 volume, x 1.07 from the 2011 volumes and x 1.11 from the 2007 volumes.

RMS data is very limited for minor rural roads. However, the most recent available traffic count data relating to Kelvin Road, Orange Grove Road and Blue Vale Road was supplied by GSC. This is shown below in Table 2.2.

Table 2.2 Historic and projected daily traffic volumes on local roads

Road	Year	Historic daily traffic volume	2018 projected daily traffic volume[1]	Average proportion of heavy vehicles
Kelvin Road south of Orange Grove Road	2014	559	581	4.0%
Kelvin Road north of Orange Grove Road	2015	372	383	5.2%
Orange Grove Road (sealed portion)	2015	166	171	3.3%
Orange Grove Road (unsealed section)	2015	86	89	3.4%
Blue Vale Road[2]	2018	300	300	70%

Note: 1: + 1% annual (linear) traffic growth has been adopted, which gives a growth factor x 1.03 from the 2015 volumes and x 1.04 from the 2014 volume.

2: Data for Blue Vale Road was not formally surveyed by GSC, but an estimate of the daily volume and average proportion of heavy vehicles was provided.

3. Kelvin Road north of Orange Grove Road has not been considered further as part of this assessment as no project-related traffic is proposed to travel along this section of Kelvin Road.

No formal traffic data was available for Old Blue Vale Road. However, GSC indicated that the current daily traffic volume for Old Blue Vale Road is low and primarily relates to traffic to and from rural dwellings along Old Blue Vale Road. As such, it is appropriate to estimate the baseline traffic volume for Old Blue Vale Road using the methodology for estimating traffic generation in the RMS (2013) *Guide to Traffic Generating Developments Updated Traffic Surveys*. According to this methodology, the number of dwellings using a section of rural road is multiplied by a factor of 7.4. The estimated daily traffic volume for Old Blue Vale Road, based on nine dwellings observed on the road, is 67 daily vehicle movements.

Road width design standards for low volume (generally rural) roads are defined by the Austroads *Guide to Road Design* (Austroads 2010) and are based on daily traffic volumes. The current design standards, which are applicable to major roads in the Gunnedah Shire LGA, are presented in Table 2.3.

Table 2.3 Daily traffic volumes and corresponding design standards

Daily traffic volume	Austroads (2010) design standard	Applicable roads	Meets design standard?
1–150	8.7 m wide total carriageway (if unsealed), or minimum 3.7 m wide seal	Orange Grove Road (unsealed segment), Old Blue Vale Road	Yes
150–500	Minimum 7.2 m wide seal	Orange Grove Road (sealed segment), Kelvin Road north of Orange Grove Road, Blue Vale Road	Yes
500–1,000	Minimum 7.2 m – 8 m wide seal	Kelvin Road south of Orange Grove Road	Yes
1,000–3,000	Minimum 9 m wide seal	Kamilaroi Highway south-east of Gunnedah, Kamilaroi Highway north-west of Gunnedah, Oxley Highway east of the development footprint	Yes
>3,000	Minimum 10 m wide seal	Kamilaroi Highway at Gunnedah, Oxley Highway west of the development footprint	Yes

As shown in Table 2.3, the current cross sections of the major and local roads that are proposed to be used for the project access meet the Austroads (2010) road design standard for the daily traffic volumes that are currently using these roads.

In most cases, the existing rural road standard provides a reasonable margin of spare traffic capacity for the existing traffic and can accommodate some daily traffic increases, without requiring any increase to the design standard of the route. Urban road cross sections generally have width for multiple traffic lanes and a much higher acceptable traffic volume than rural roads.

An urban road cross section is generally provided along both the Kamilaroi Highway and Oxley Highway routes throughout the 50 km/hr speed zone areas within the town centre of Gunnedah.

2.3 Warrants for intersection improvements

Rural intersection operations are assessed from the combination of the peak hourly through and turning traffic movements that are occurring at each intersection. This determines the need for additional intersection turning lanes in accordance with the current Austroads design standards, which are shown in Appendix A and the Austroads Warrant design charts shown in Figure 2.3.

There are separate design charts for roads with either 100 km/hr or higher design speeds or design speeds lower than 100 km/hr. The design speeds for all intersections on Orange Grove Road in the locality of the development footprint are 100 km/hr. For this design speed, additional left or right turn traffic lanes are only required where the major road peak hourly traffic volume exceeds 120 vehicles per hour and the minor road traffic also exceeds the level shown on the Warrant Chart in Figure 2.2.

Details of the relevant standard road designs (Austroads 2010) for rural intersection widening (type BAR/BAL shoulder widening) are included in the relevant extracts from the Austroads (2010) *Road Design Guide* in Appendix A

The current year 2018 baseline daily traffic volume for Orange Grove Road running through the development footprint (see Table 2.2) has been calculated to be 89 daily vehicles, which corresponds to approximately 9 vehicles per hour during the peak hourly traffic periods. The proposed access intersections on Orange Grove Road into the northern and southern portions of the development footprint are therefore acceptable without additional left or right turn traffic lanes, as the major road peak hourly traffic volume is well under 120 vehicles along Orange Grove Road in the unsealed section.

The current year 2018 baseline daily traffic volume for Kelvin Road south of the Kelvin Road/Orange Grove Road intersection has been calculated as 581 vehicles (see Table 2.2). This corresponds to approximately 58 vehicles per hour during the peak hourly traffic periods. The existing Kelvin Road/Orange Grove Road intersection therefore currently satisfies the standard design requirements without additional left or right turn traffic lanes, as the major road peak hourly traffic volume is under 120 vehicles along Kelvin Road.

The current year 2018 baseline daily traffic volume for the Kamilaroi Highway west of Gunnedah has been calculated as 1,770 daily vehicles (see Table 2.2). This corresponds to approximately 177 vehicles per hour during the peak hourly traffic periods.

The baseline volume for Blue Vale Road has been calculated as 300 daily vehicles, which corresponds to approximately 30 vehicles per hour during the peak hourly traffic periods. Assuming that all of these vehicles would be turning onto Blue Vale Road at the Kamilaroi Highway/Blue Vale Road intersection, based on the warrant chart provided in Figure 2.3, the current intersection, which already features additional turning lanes, satisfies the standard design requirements.

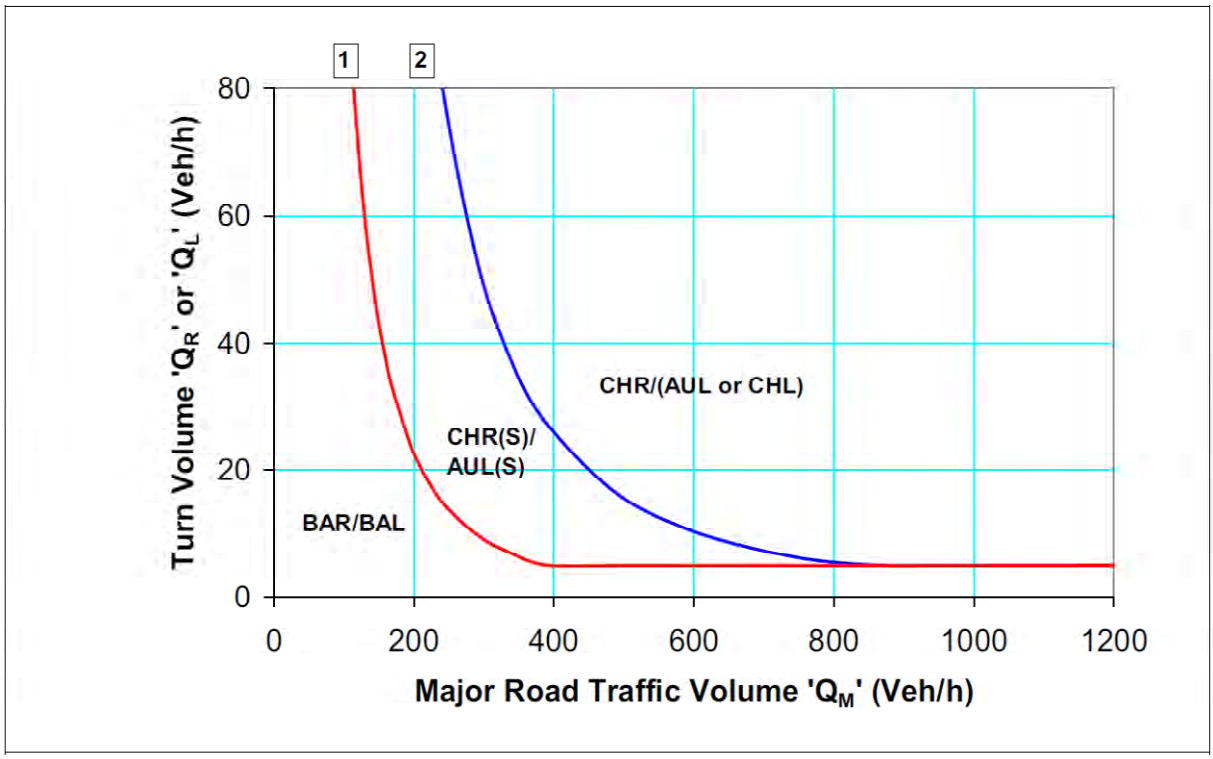
As noted above, the estimated baseline peak hourly traffic volume for Blue Vale Road is approximately 30 peak hourly vehicles. Given that this is significantly less than 120 peak hourly movements and that Old Blue Vale Road has very low traffic volumes, the current Blue Vale Road/Old Blue Vale Road intersection satisfies the standard design requirements without a requirement for additional left or right turn traffic lanes.

As noted above, the baseline peak hourly traffic volume for Kelvin Road is approximately 58 peak hourly vehicles. Given that this is well under 120 peak hourly movements, and that Old Blue Vale Road has very low traffic volumes, the current Kelvin Road/Old Blue Vale Road intersection satisfies the standard design requirements without a requirement for additional left or right turn traffic lanes.

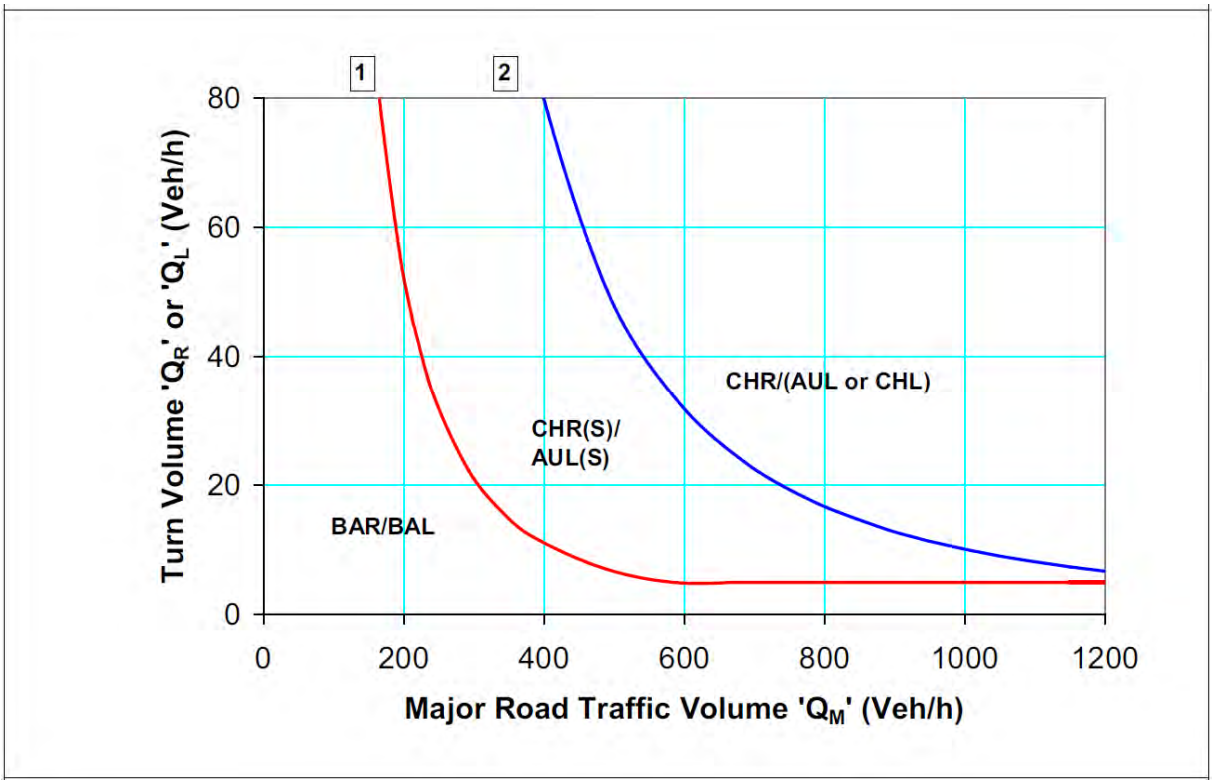
A detailed assessment of the potential impacts of project-generated traffic at the proposed access locations and other relevant intersections during both the construction and operational of the project, is presented in Chapter 4.

2.4 Public transport

The Country Link Explorer train services Gunnedah to and from Sydney daily. There is a local bus service as well as taxis and hire cars. Gunnedah is also serviced by a number of private coach companies. Hopes Coaches operates a morning (8:00 am) and afternoon (4:00 pm) school bus service on school days along Orange Grove Road.



Warrant Chart for additional turn lanes for traffic volumes for design speeds 100 km/hr or greater.



Warrant Chart for additional turn lanes for traffic volumes for design speeds lower than 100 km/hr.

Figure 2.3 Austroads warrant design charts for rural intersection turn lanes

2.5 Traffic safety

Traffic safety conditions in the vicinity of Orange Grove Road and Kelvin Road are considered to be acceptable, with good intersection visibility in both directions at all locations along Kelvin Road and Orange Grove Road. This is discussed in further detail in Chapter 3.

The general traffic safety conditions on the major roads in the Gunnedah Shire LGA such as the Kamilaroi Highway and the Oxley Highway have been reviewed for the most recent five year accident history (for the years 2012 to 2016 inclusive) using the Transport for NSW (TfNSW) interactive accident history database.

Over this five year period, for the Gunnedah Shire LGA as a whole, there were 155 recorded traffic accidents of which six accidents (or 4% of all accidents recorded) resulted in fatalities. In the overall NSW State accident statistics for the same period, less than 1% of all recorded traffic accidents resulted in fatalities.

There were no recorded traffic accidents on Kelvin Road, Orange Grove Road, Blue Vale Road or Old Blue Vale Road. There were a total of 11 recorded traffic accidents on the Oxley Highway between Gunnedah and Carroll over the five year period. This is a relatively moderate total number of accidents, when considering the 19 km route length between Gunnedah and Carroll (0.6 accidents per km of road). Of the 11 recorded accidents, three (27%) resulted in fatalities. This is a high proportion of fatal accidents in comparison with both the Gunnedah Shire LGA and NSW State averages.

There were a total of 37 recorded traffic accidents on the Kamilaroi Highway between Gunnedah and Willow Tree (which includes sections of the route within the adjoining Liverpool Plains LGA) over the five year period. This is a relatively low total number of accidents, when considering the 95 km route length between Gunnedah and Willow Tree (0.3 accidents per km of road). Of the 37 recorded accidents, three (8%) resulted in fatalities. This is also a relatively high proportion of fatal accidents in comparison with both the Gunnedah Shire LGA and NSW State averages.

The majority of the road pavement along the Oxley Highway between Gunnedah and Carroll has a sealed width of between 7 m and 8 m and the road centre line and edge lines are generally clearly marked along the entire route. The Kamilaroi Highway is similar, with full markings along its length.

The route designs along both these highways meet the relevant Austroads (2010) road design standard for the current daily traffic volumes and there appear to be no inherent traffic safety deficiencies for these routes. Driver behaviour and the delays in persons receiving medical treatment after road accidents due to the remoteness of some accident locations are probably significant contributory factors in the above average proportion of fatal traffic accidents which have occurred in recent years on these sections of the Oxley Highway and Kamilaroi Highway.

3 Traffic and parking demands for the proposal

3.1 Site access

Two access intersections are proposed for the project (refer to Figure 2.1). Both of these access points are off Orange Grove Road, which can be accessed via Kelvin Road to the west. The eastern access intersection will provide access to the northern portion of the development footprint and the western access intersection will provide access to the southern portion of the development footprint.

The eastern access intersection for the northern portion of the development footprint would consist of a three-way intersection with Orange Grove Road and a connecting access road extending into the northern portion of the development footprint.

The western access intersection for the southern portion of the development footprint would also consist of a three-way intersection with Orange Grove Road and a connecting access road extending into the southern portion of the development footprint.

Gravel shoulder widening would be constructed at the proposed access intersections to facilitate turning movements to and from the development footprint by large trucks.

At the eastern access intersection location for the northern portion of the development footprint, which is shown in Photograph 3.1, the sight distances for approaching traffic along Orange Grove Road are very good. The road is straight and level in both directions and drivers can clearly see for at least 1 km to the east and west of the intersection. The excellent visibility can be seen below in Photograph 3.2 and Photograph 3.3.

Photograph 3.1 Eastern access intersection looking into the northern portion of the development footprint

Photograph 3.2 Eastern access intersection looking east

Photograph 3.3 Eastern access intersection looking west

The majority of the project traffic during both the construction and operations stages would require access to the northern portion of the development footprint. A limited number of vehicles will require access to the southern portion of the development footprint during the construction stage of the project (ie to facilitate the installation of connection infrastructure to connect the project to TransGrid's 132 kV transmission line).

At the access intersection location for the southern portion of the development footprint, which is shown in Photograph 3.4, the sight distances for approaching traffic along Orange Grove Road are also very good. The road is straight and level in both directions and drivers can clearly see for at least 1 km to the east and west of the intersection. The excellent visibility can be seen below in Photograph 3.5 and Photograph 3.6. The access intersection location for the southern portion of the development footprint will utilise an existing double gateway (refer Photograph 3.4).

Photograph 3.4 Western access intersection looking into the southern portion of the development footprint

Photograph 3.5 Western access intersection looking east

Photograph 3.6 Western access intersection looking west

The Kelvin Road/Orange Grove Road intersection represents the main access point to Orange Grove Road. Visibility at the Kelvin Road/Orange Grove Road intersection is shown in Photograph 3.7, Photograph 3.8 and Photograph 3.9. The sight distances for approaching traffic along Kelvin Road are very good. The road is straight and level in both directions and drivers can clearly see for at least 700 m to the north and south of the intersection.

Photograph 3.7 **Visibility on Kelvin Road at Orange Grove Road intersection looking north**

Photograph 3.8 **Visibility on Kelvin Road at Orange Grove Road intersection looking north**

Photograph 3.9 Visibility on Kelvin Road at Orange Grove Road intersection looking south

As noted in Section 2.1, heavy vehicles would not cross Cohens Bridge on Kelvin Road and will follow an alternate route via Blue Vale Road (refer to Figure 2.2). The main intersections along this route are at:

- Kamilaroi Highway/Blue Vale Road;
- Blue Vale Road/Old Blue Vale Road; and
- Old Blue Vale Road/O'Keefe Avenue/Kelvin Road.

Visibility at the Kamilaroi Highway/Blue Vale Road intersection is shown in Photograph 3.10 and Photograph 3.11. The sight distances for approaching traffic along Kamilaroi Highway are very good. The road is straight and level in both directions and drivers can clearly see for at least 500 m to the north and south of the intersection.

Visibility at the Blue Vale Road/Old Blue Vale Road intersection is shown in Photograph 3.12 and Photograph 3.13. The sight distances for approaching traffic along Kelvin Road are very good. The road is only gently curved and level in both directions and drivers can clearly see for at least 500 m to the north and south of the intersection.

Visibility at the Old Blue Vale Road/O'Keefe Avenue/Kelvin Road intersection is shown in Photograph 3.14 and Photograph 3.15. The sight distances for approaching traffic along Kelvin Road and O'Keefe Avenue are very good. The road is only gently curved and level in both directions and drivers can clearly see for at least 500 m to the north and south of the intersection.

Photograph 3.10 Kamilaroi Highway/Blue Vale Road intersection looking north along the highway

Photograph 3.11 Kamilaroi Highway/Blue Vale Road intersection looking south along the highway

Photograph 3.12 **Blue Vale Road/Old Blue Vale Road intersection looking north along Blue Vale Road**

Photograph 3.13 **Blue Vale Road/Old Blue Vale Road intersection looking south along Blue Vale Road**

Photograph 3.14 **Old Blue Vale Road/O'Keefe Avenue intersection looking north to Kelvin Road**

Photograph 3.15 **Old Blue Vale Road/O'Keefe Avenue intersection looking south to O'Keefe Avenue**

3.2 Construction and other traffic generating activities

Construction of the project will take approximately nine months to complete. Peak construction is expected to extend for three months of the nine month construction period. Construction activities will be undertaken during the standard daytime construction hours of:

- 7am–6pm Monday to Friday; and
- 8am–1pm Saturday.

In general, no construction activities will occur on Sundays or public holidays. Exceptions to these hours may be required on limited occasions. GSC and surrounding landholders will be notified of any exceptions.

On an average construction day, approximately 80 full-time equivalents (FTEs) would constitute the construction workforce. During peak construction this would be approximately 100 FTEs.

When operational, the project will produce electricity for contribution to the grid network. The PV solar panels will operate during daylight hours, seven days per week, 365 days per year. The operational lifespan of the project may be in the order of 30 years, depending on the nature of solar PV technology and energy markets.

An operational workforce of three FTEs will be required for the project once construction has been completed. This workforce would undertake ongoing routine maintenance of the development footprint and the associated project infrastructure.

The future decommissioning of the development footprint, when it occurs, will require the full removal of all installed infrastructure from the development footprint. This would entail similar workforce requirements and daily traffic movements by both car and truck traffic as would previously have occurred during the construction stage of the project.

3.3 Site access and circulation

All vehicular access to the development footprint will occur via one of the two proposed access locations from Orange Grove Road (refer to Section 3.1). The eastern access intersection would service the northern portion of the development footprint and the western access intersection would service the southern portion of the development footprint. Both access intersections will involve:

- construction of an access road from Orange Grove Road; and
- gravel shoulder widening corresponding to the Austroads type BAR/BAL intersection standard (which is shown in Appendix A) on Orange Grove Road on the approaches to and departures from the intersections on the western sides, which is the direction to and from which all the project-related traffic would be travelling.

The above intersection requirements have been discussed with GSC and agreed in principle. GSC will be consulted further in relation to the detailed design and road maintenance program proposed for the unsealed section of Orange Grove Road for the duration of the construction period.

Internal access roads to material storage compounds and the on-site substation will be approximately 4–6 m width whilst general internal roads will be approximately 3.5–5 m width. The indicative locations of the internal access roads are illustrated in the infrastructure layout plan (refer to Figure 3.1 in the EIS).

During construction, a suitable number of parking spaces will be available within the temporary construction compound.

The northern portion of the development footprint will be fenced off by a chain mesh fence, which will be approximately 1.8–2.4 m high. Fencing will restrict public access to the northern portion of the development footprint.

3.4 Traffic generation

The following generated daily traffic movements and corresponding vehicle types have been calculated for the average construction, peak construction and operations stage activities for the project (Table 3.1). Table 3.1 represents traffic volumes assuming that employees will generally use private vehicles to travel to and from the development footprint. Truck traffic movements will typically be semi-trailer type truckloads for all deliveries of plant and equipment to the development footprint:

- Average construction – this period would typically be the site establishment stage and final commissioning. There will be on average 32 daily truck movements to and from the development footprint and 48 light vehicle visits, corresponding to 80 daily traffic movements in total.
- Peak construction – this period would typically occur during the early and mid stages of construction including earthworks and delivery activities, there will be on average 56 daily truck deliveries to and from the development footprint and 60 light vehicle visits, corresponding to 116 daily traffic movements in total.
- Typical operation – there will be on average four daily truck deliveries to the development footprint and six light vehicle visits, corresponding to an average of 10 daily traffic movements in total.
- Decommissioning – this assumes there will be full removal of all of the installed plant and equipment from the development footprint. This would entail similar workforce requirements and daily traffic movements by both car and truck traffic as would previously have occurred during the project construction stage.

The daily traffic volumes for the project are presented in Table 3.1, including the estimated peak hourly traffic volumes for each stage of the project.

Table 3.1 Additional daily and hourly traffic volumes generated by the project

Project phase	Average construction		Peak construction		Operation	
	Daily	Peak hour	Daily	Peak hour	Daily	Peak hour
Workforce (light vehicle) traffic movements	48	16	60	24	6	2
Delivery (truck) traffic movements	32	8	56	12	4	1
Total project-related traffic movements	**80**	**24**	**116**	**36**	**10**	**3**

The daily traffic will be greatest during the peak construction stage, with approximately 116 daily vehicle movements (60 light vehicle trips and 56 truck trips), and up to 36 peak hourly vehicle movements (24 light vehicle trips and 12 truck trips) during both the morning and afternoon peak hourly traffic periods.

During the average stages of project construction, there will be approximately 80 daily vehicle movements, with up to 24 peak hourly vehicle movements (16 light vehicle trips and 8 truck trips) during the morning and afternoon peak hourly traffic periods.

During operation, there will be much lower daily traffic movements, which are estimated to be an average of 10 daily vehicle movements, with up to three peak hourly vehicle movements (two light vehicle trips and one truck trip) during the morning and afternoon peak hourly traffic periods.

During project decommissioning, the project generated daily and peak hourly traffic movements have not been specifically calculated and assessed as these movements have been assumed to be similar, in principle, to the daily and peak hourly project-related light vehicle and truck traffic movements generated during the construction stage.

3.5 Traffic distribution

The proposed transport routes for the project light vehicle (workforce car) traffic and heavy vehicle (truck) traffic will primarily be as follows:

- For the workforce (light vehicle) traffic:
    - 40% of the workforce will be based in the Gunnedah area, residing in either permanent or temporary accommodation, travelling to and from the development footprint via Kelvin Road and Orange Grove Road;
    - 40% of the workforce will be either permanently or temporarily residing in Tamworth and surrounds to the east and commuting to and from the development footprint in a range of vehicles including private cars, utes and small trucks via the Oxley Highway; and
    - 20% of the workforce will be permanently or temporarily residing in Narrabri, Boggabri and surrounds to the north and commuting to and from the development footprint in a range of vehicles including private cars, utes and small trucks via the Kamilaroi Highway.
- For construction vehicles and deliveries (heavy vehicle) traffic:
    - 60% of heavy vehicle traffic will travel to and from the south via the Kamilaroi Highway (ie deliveries from Sydney/Melbourne);
    - 20% will travel to and from the north via the Kamilaroi Highway (ie deliveries from Brisbane); and
    - 20% will travel to and from the east via the Oxley Highway (10% coming from the north and 10% from the south – using the Oxley Highway as an alternative to the Kamilaroi Highway).

The major proportion of heavy vehicle traffic will be using the Kamilaroi Highway travelling to and from the south including Sydney but also Melbourne where deliveries of key imported items for the project such as PV solar panels may be sourced from. All heavy vehicle traffic will access Kelvin Road via Blue Vale Road and Old Blue Vale Road. The project light vehicle traffic is well spread amongst local roads in Gunnedah, the Oxley Highway coming from Tamworth to the east and the Kamilaroi Highway coming from Narrabri and Boggabri to the north. All light vehicle traffic will access the development footprint from Kelvin Road via Cohens Bridge. There will be no access to the development footprint from Orange Grove Road east of the development footprint (ie along Orange Grove Road east of the development footprint, Keepit Dam Road and Rushes Creek Road).

As there are no PV solar panels proposed to be installed in the southern portion of the development footprint, the vast majority of traffic will be entering the northern portion of the development footprint. It is assumed that both light and heavy vehicle traffic will be split 98% and 2% between the northern and southern portions of the development footprint, respectively. These vehicles will enter via the two proposed access points being considered directly off Orange Grove Road (refer to Section 3.1).

The daily traffic distributions for the proposed project light vehicle and truck traffic are shown on the map of proposed access routes (traffic distribution) in Figure 3.1.

3.6 Car parking

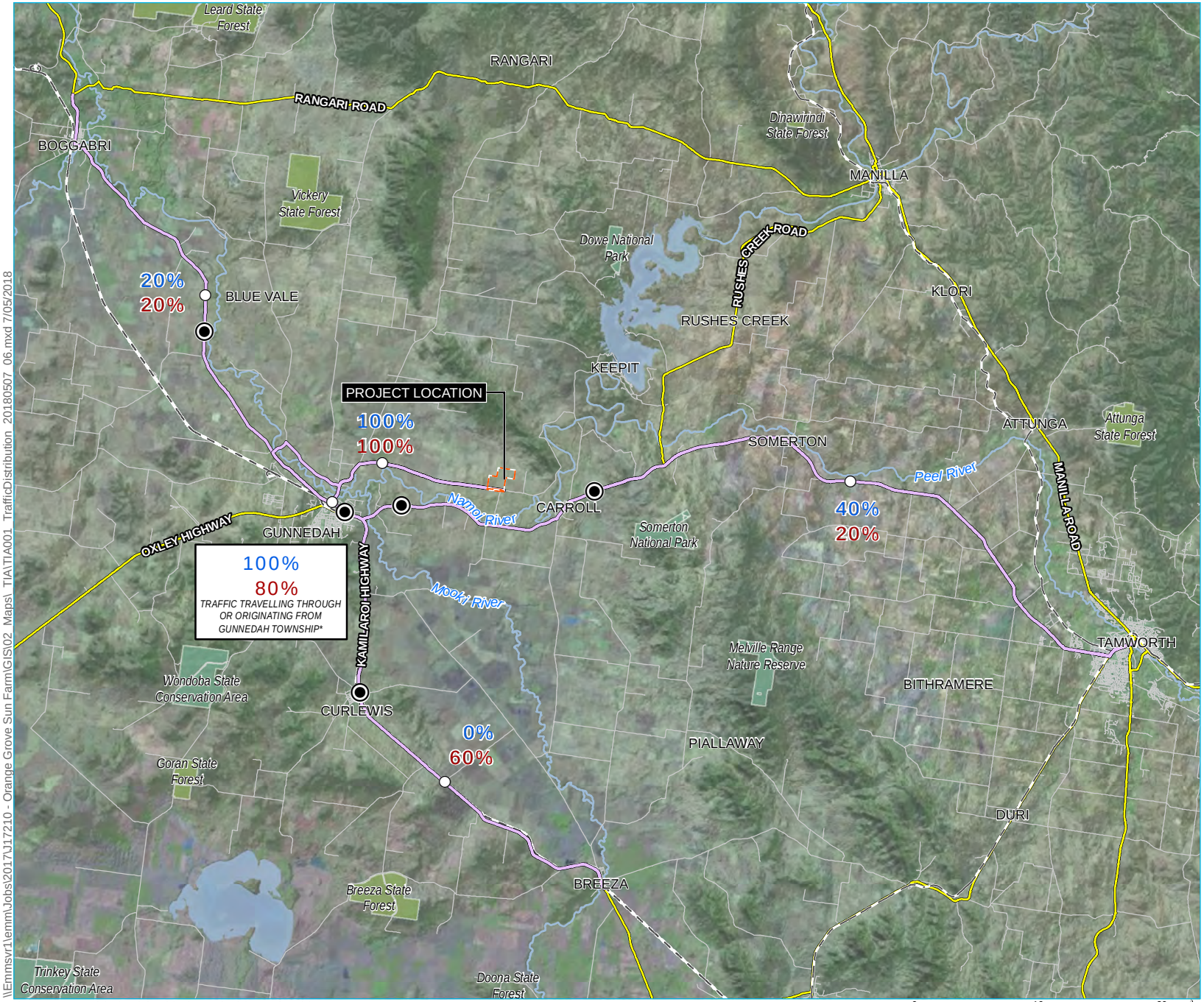
Parking for the project construction and operations workforces will be provided within the development footprint in gravel surfaced parking areas with appropriate dimensions to accommodate the number and size of vehicles.

3.7 Other transport

There is no formal proposal to use shuttle buses for any specific task of the project construction workforce transport arrangements. However, ordinary full-size buses, shuttle buses or mini vans could potentially be used at times to transport a proportion of the construction workforce to and from the development footprint at times of peak construction from areas of relatively high population concentration in the region such as Gunnedah.

3.8 Other developments in the locality

Photon Energy proposes to construct and operate the Gunnedah Solar Farm, a 155 megawatt (MW) PV solar farm at 765 Orange Grove Road, west of the development footprint. This solar farm will be on Lot 1 of DP186590; Lot 1 of DP1202625; Lots 151, 153 and 264 of DP754954; and Lot 2 of DP801762. The Gunnedah Solar Farm will also be using the same construction access route as are proposed for the project. It should be conservatively assumed that the two projects may have coincidental construction times. A cumulative traffic analysis of the project traffic (including the traffic volumes expected for the Gunnedah Solar Farm) has also been undertaken, which is discussed in further detail in Chapter 4.



KEY

- Development footprint
- Rail line
- Main road
- Local road
- Major waterway
- Waterbody
- NPWS reserve
- State forest
- Traffic survey location
- Main project traffic routes

Traffic distribution

- Estimated traffic distribution
- 00% Light vehicle
- 00% Heavy vehicle

*40% of light vehicle traffic is likely to originate from within Gunnedah township and surrounds

Source: EMM (2018); OSF (2018); DFSI (2017); GA (2015)

0 10 20 km

GDA 1994 MGA Zone 56

N

\\Emmsvr1\emm\Jobs\2017\J17210 - Orange Grove Sun Farm\GIS\02 Maps\ TIA\TIA001 TrafficDistribution 20180507 06.mxd 7/05/2018

Traffic distribution

Orange Grove Sun Farm
Traffic impact assessment
Figure 3.1

EMM

4 Impact assessment

4.1 Traffic volumes on the road network

The existing daily traffic volumes (projected baseline volumes for the year 2018 based on historical data) for the Oxley Highway and the Kamilaroi Highway, as well as those estimated for Kelvin Road and Orange Grove Road and the existing adequacy of the road design standards for these roads is discussed in Section 2.2.

The existing road network in the Gunnedah area (the Gunnedah Shire LGA generally) is believed to be adequately designed to accommodate the existing traffic volumes and the intersection traffic safety. This is indicated by the sight distances at all the relevant intersection on the roads surrounding the project area, as is shown by the photographs of each intersection in Chapter 3.

The current daily traffic capacities for these roads, according to the current Austroads (2010) *Road Design Guide* standards for rural roads, are:

- Oxley Highway, east of Gunnedah urban area >3,000 daily vehicles;
- Kamilaroi Highway, north and south of Gunnedah urban area >1,000 daily vehicles;
- Kelvin Road, north of Orange Grove Road 150–500 daily vehicles;
- Kelvin Road, south of Orange Grove Road 500–1,000 daily vehicles;
- Orange Grove Road, sealed segment 150–500 daily vehicles;
- Orange Grove Road, unsealed segment 1–150 daily vehicles;
- Blue Vale Road, south of Old Blue Vale Road 150–500 daily vehicles; and
- Old Blue Vale Road, 1–150 daily vehicles.

The daily traffic capacity for the urban sections of the Oxley Highway and Kamilaroi Highway which travel through Gunnedah is determined by other urban road capacity standards, which generally allow significantly higher daily traffic volumes, depending on the number of lanes on the road.

The project generated truck traffic will observe all the sign-posted heavy vehicle routes which direct truck traffic travelling through the town of Gunnedah.

The additional daily traffic volumes generated by the project during the average construction, peak construction and operations stages and the potential cumulative traffic impacts with the Gunnedah Solar Farm, are assessed for the relevant travel routes in the following sections 4.1.1 to 4.1.5 of this report.

4.1.1 Average construction traffic

Table 4.1 summarises the project baseline traffic conditions within the local road network and the predicted future daily traffic during the average construction phase of the project.

Table 4.1 Future daily traffic assessment for project average construction traffic

RMS traffic count location or road with estimated number of dwellings	Projected baseline daily traffic volume (year 2018)	Daily traffic from the project	Future total daily traffic	Percent traffic increase	Austroads rural daily traffic volume standard
Kamilaroi Highway at Gunnedah	6,688	80	6,768	1.2%	>3,000
Kamilaroi Highway south-west of the development footprint (near Curlewis)	1,813	19	1,832	1%	1,000–3,000
Kamilaroi Highway north-west of the development footprint (near Blue Vale)	1,770	16	1,786	0.9%	1,000–3,000
Oxley Highway east of the development footprint (near Carroll)	1,609	26	1,635	1.6%	1,000–3,000
Oxley Highway west of the development footprint (3.7 km east of Gunnedah)	3,624	26	3,650	0.7%	>3,000
Kelvin Road (south of Orange Grove Road)	581	80	661	13.8%	500–1,000
Orange Grove Road (sealed segment)	171	80	251	46.8%	150–500
Orange Grove Road (unsealed segment)	89	80	169	89.9%	150–500
Blue Vale Road south of Old Blue Vale Road	300	32	332	10.7%	150–500
Old Blue Vale Road	67	32	99	47.8%	1–150

The results in Table 4.1 show the estimated proportional increases on the projected baseline traffic volumes for 2018 on relevant roads during the average construction period. The highest proportional daily traffic increases from the project will be on Orange Grove Road (+46.8% and +89.9% for the sealed and unsealed sections, respectively), Old Blue Vale Road (+47.8%), Kelvin Road (+13.8%) and Blue Vale Road (+10.7%). The predicted traffic increases will cause the unsealed segment of Orange Grove Road to move into a higher band in the Austroads rural daily traffic volume classification system (from 1–150 to 150–500). While these increases are proportionally quite significant, they would only apply for the construction period and the traffic volumes would subsequently decrease following the completion of construction, as is shown in Section 4.1.3 and Table 4.3.

On all other assessed traffic locations, the increases in daily traffic are expected to be much lower (consistently less than 2%). These increases are minimal. With the exception of the unsealed section of Orange Grove Road, the average construction stage traffic capacity for the assessed routes in Table 4.1 will be within the Austroads (2010) rural road design and capacity standards and the increases should not have a significant long-term effect on the future traffic capacity, levels of service or traffic safety for these roads.

4.1.2 Peak construction traffic

Table 4.2 summarises the project baseline traffic conditions within the local road network and the predicted future daily traffic during the peak construction phase of the project.

Table 4.2 Future daily traffic assessment for project peak construction traffic

Route	Projected baseline daily traffic volume (year 2018)	Daily traffic from the project	Future total daily traffic	Percent traffic increase	Austroads rural daily traffic volume standard
Kamilaroi Highway at Gunnedah	6,688	116	6,804	1.7%	>3,000
Kamilaroi Highway south-west of the development footprint (near Curlewis)	1,813	34	1,847	1.9%	1,000–3,000
Kamilaroi Highway northwest of the development footprint (near Blue Vale)	1,770	23	1,793	1.3%	1,000–3,000
Oxley Highway east of the development footprint (near Carroll)	1,609	35	1,644	2.2%	1,000–3,000
Oxley Highway west of the development footprint (3.7 km east of Gunnedah)	3,624	35	3,659	1%	>3,000
Kelvin Road (south of Orange Grove Road)	581	116	697	20.0%	500–1,000
Orange Grove Road (sealed segment)	171	116	287	67.8%	150–500
Orange Grove Road (unsealed segment)	89	116	205	130.3%	150–500
Blue Vale Road south of Old Blue Vale Road	300	56	356	18.7%	150–500
Old Blue Vale Road	67	56	123	83.6%	1–150

The results in Table 4.2 show the highest proportional daily traffic increases from the project will be on Orange Grove Road (+67.8% and +130.3% for the sealed and unsealed sections, respectively), Old Blue Vale Road (+83.6%), Kelvin Road (+20.0%) and Blue Vale Road (+18.7%). As with the average construction traffic, the predicted traffic increases will cause the unsealed segment of Orange Grove Road to move into a higher band in the Austroads rural daily traffic volume classification system (from 1–150 to 150–500). While these increases are proportionally quite significant, they would only apply for the peak construction period (approximately three months) and the traffic volumes would subsequently decrease back to those calculated in Table 4.1 for the average construction period and further following the completion of construction, as is shown in Section 4.1.3 and Table 4.3.

For the duration of the project construction program, a road maintenance program will be undertaken for the unsealed section of Orange Grove Road to maintain the safety and serviceability of the road for all road users.

On all other assessed traffic locations, the increases in daily traffic are expected to be much lower (generally less than 2%). These increases are minimal. With the exception of the unsealed section of Orange Grove Road, the peak construction stage traffic capacity for the assessed routes in Table 4.1 will be within the Austroads (2010) rural road design and capacity standards and the increases should not have a significant long-term effect on the future traffic capacity, levels of service or traffic safety for these roads.

4.1.3 Operational traffic

Table 4.3 summarises the project baseline traffic conditions within the local road network and the longer term predicted future daily traffic volumes during the operational phase of the project.

Table 4.3 Future daily traffic assessment for project operations traffic

Route	Projected baseline daily traffic volume (year 2018)	Daily traffic from the project	Future total daily traffic	Percent traffic increase	Austroads rural daily traffic volume standard
Kamilaroi Highway at Gunnedah	6,688	10	6,698	0.1%	>3,000
Kamilaroi Highway south-west of the development footprint (near Curlewis)	1,813	2	1,815	0.1%	1,000–3,000
Kamilaroi Highway northwest of the development footprint (near Blue Vale)	1,770	2	1,772	0.1%	1,000–3,000
Oxley Highway east of the development footprint (near Carroll)	1,609	3	1,612	0.2%	1,000–3,000
Oxley Highway west of the development footprint (3.7 km east of Gunnedah)	3,624	3	3,627	0.1%	>3,000
Kelvin Road (south of Orange Grove Road)	581	10	591	1.7%	500–1,000
Orange Grove Road (sealed segment)	171	10	181	5.8%	150–500
Orange Grove Road (unsealed segment)	89	10	99	11.2%	1–150
Blue Vale Road south of Old Blue Vale Road	300	4	304	1.3%	150–500
Old Blue Vale Road	67	4	71	6.0%	1–150

The results in Table 4.3 show that on all the traffic routes considered, including Orange Grove Road, Kelvin Road and Old Blue Vale Road, once operational, there would be only small (and mostly negligible) proportional increases on the projected 2018 baseline traffic volumes as a result of the project operations traffic. The predicted traffic increases are between 11.2% and 0.1% (and are mostly less than 2%).

Importantly, during the operational phase, the unsealed segment of Orange Grove Road will return to a 1–150 vehicles per day band.

These daily traffic increases should not generally be noticeable on any of these roads and will have no effects on the future traffic levels of service or traffic safety for the future traffic using these routes.

4.1.4 Future cumulative traffic impacts

As part of this TIA, it has been conservatively assumed that the proposed Gunnedah Solar Farm (west of the development footprint) could also be constructed during a similar time period as the project. The future combined (cumulative) traffic assessment has assumed the peak stage of construction for both projects may occur simultaneously.

It is assumed, based on the information provided within the preliminary environmental assessment (PEA) for the Gunnedah Solar Farm (Pitt&Sherry 2017), that a maximum of 90 daily vehicle movements from the Gunnedah Solar Farm may be expected, but these movements would probably only travel on the sealed section of Orange Grove Road and not use the unsealed section. As these movements could potentially be occurring concurrently with the peak daily construction stage traffic movements (116 vehicles daily) from the Orange Grove Sun Farm, a summary of the combined cumulative traffic movements from both projects in presented in Table 4.4.

It has been assumed that heavy vehicles for the Gunnedah Solar Farm would follow a similar route to the project's heavy vehicle traffic (ie along Blue Vale Road and Old Blue Vale Road).

Table 4.4 Future cumulative construction traffic assessment

Route	Projected baseline daily traffic volume (year 2018)	Orange Grove Sun Farm	Gunnedah[1] Solar Farm	Future total daily traffic	Percent traffic increase	Austroads rural daily traffic volume standard
Kamilaroi Highway at Gunnedah	6,688	116	90	6,894	3.1%	>3,000
Kamilaroi Highway south-west of the development footprint (near Curlewis)	1,813	34	26	1,873	3.2%	1,000–3,000
Kamilaroi Highway northwest of the development footprint (near Blue Vale)	1,770	23	18	1,811	2.3%	1,000–3,000
Oxley Highway east of the development footprint (near Carroll)	1,609	35	27	1,671	3.9%	1,000–3,000
Oxley Highway west of the development footprint (3.7 km east of Gunnedah)	3,624	35	27	3,686	1.7%	>3,000
Kelvin Road (south of Orange Grove Road)	581	116	90	787	35.5%	500–1,000
Orange Grove Road (sealed segment)	171	116	90	377	120.5%	150–500
Orange Grove Road (unsealed segment)	89	116	0	205	130.3%	150–500
Blue Vale Road south of Old Blue Vale Road	300	56	43	399	33.0%	150–500
Old Blue Vale Road	67	56	43	166	147.8%	150–500

Notes: 1. Traffic distribution amongst major roads in the Gunnedah area is assumed to be similar to that for the Orange Grove Sun Farm.

The results in Table 4.4 show the highest potential daily traffic increases from the concurrent construction of the two projects will be on Orange Grove Road (+120.5% and +130.3% for the sealed and unsealed sections, respectively), Old Blue Vale Road (+147.8%), Kelvin Road (+35.5%) and Blue Vale Road (33.0%). As has been the case for both the average and peak construction traffic analyses shown in Tables 4.1 and 4.2, the predicted traffic increases will move the unsealed segment of Orange Grove Road into a higher band in the Austroads rural daily traffic volume classification system (from 1–150 to 150–500).

Importantly, under the cumulative scenario presented in Table 4.4, unlike the peak construction scenario for the project-related traffic (refer Table 4.2), the combined heavy vehicle traffic along Old Blue Vale Road from the concurrent construction of the project and the Gunnedah Solar Farm would move it into a higher band in Austroads rural daily traffic volume classification system (from 1–150 to 150–500).

The exceedance of the 1-150 daily traffic volume standard on Old Blue Vale Road is marginal (ie 16 daily vehicle movements) and assumes concurrent construction of the project and the Gunnedah Solar Farm. During consultation with GSC, it was noted that road upgrade works are currently scheduled for Old Blue Vale Road in 2019. These upgrades would likely include widening the sealed width of Old Blue Vale Road from 4 m to 7.2 m. The scheduled upgrades to Old Blue Vale Road would satisfy the Austroads (2010) design standard for daily traffic volumes of 150-500 vehicle movements.

Therefore, at the completion of the proposed works, no further upgrades would be required for the maximum cumulative construction traffic of the project and the Gunnedah Solar Farm.

While the increases to daily traffic volumes on Kelvin Road, Orange Grove Road and Old Blue Vale Road are significant (refer Table 4.4), they would only apply for the peak construction period of the project (approximately three months) and future traffic volumes would decrease to lower levels during the average construction period and to significantly lower levels following the completion of all construction work for both projects.

A road maintenance program will be required on the unsealed section of Orange Grove Road for the duration of the project's construction (refer to Section 5.3).

At the assessed locations on the Kamilaroi and Oxley Highways, the cumulative construction traffic increases are expected to be much lower (between 1.7% and 3.9%), which will not generally be noticeable for most of the traffic using these roads, and will comply with the future traffic capacity design standards for these routes according to the Austroads (2010) rural road design and capacity standards.

Overall these traffic increases would not have any significant long-term effect on the future traffic capacity, levels of service or traffic safety for these roads, provided that a road maintenance program is undertaken for the unsealed section of Orange Grove Road.

4.1.5 Summary of the effect of future project traffic increases

The Oxley and Kamilaroi Highways have a consistent sealed width of 9-10 m in the Gunnedah area, which is appropriate for daily vehicle movements of 1,000–3,000 and >3,000 vehicles. This road cross section is adequate to accommodate the proposed future route daily traffic volumes including the peak construction stage traffic for the project along with potential cumulative impacts from the concurrent construction of the project with the Gunnedah Solar Farm, which would be up to 6,894 daily vehicle movements, as summarised in Table 4.4.

The sealed section of Orange Grove Road has generally been improved and mostly has a sealed width of 7.2 m, which is appropriate for its expected construction period volume of 150-500 daily vehicle movements. However, during the average, peak and combined cumulative impact construction traffic scenarios considered, the unsealed section of Orange Grove Road will require a road maintenance program in order to accommodate the projected temporary increase in the daily traffic volume to over 150 vehicle movements daily.

The cross section of Kelvin Road (7.2 m sealed width) is generally adequate to accommodate the assessed future daily construction traffic volumes (500-1,000 daily vehicle movements), which would potentially be up to 787 daily vehicle movements during the combined peak construction stage for both projects as summarised in Table 4.4.

The cross section of Blue Vale Road (8 m sealed width) is adequate to accommodate the assessed future daily traffic volumes (150-500 daily vehicle movements), which could potentially be up to 399 daily vehicle movements during the combined peak construction stage for both projects.

The cross section of Old Blue Vale Road (4 m sealed width) is normally adequate to accommodate the assessed future daily traffic volumes (generally 1-150 daily vehicle movements). However, during the combined peak construction stage for the project and the Gunnedah Solar Farm these volumes would potentially exceed the Austroads (2010) limits for a road of this cross-section by up to 16 vehicles. However, this is a marginal exceedance of the Austroads (2010) limit, and the likelihood that a combined peak construction period for the two projects would occur is considered to be very low.

Further as noted in Section 4.1.4, GSC has indicated that the sealed width of Old Blue Vale Road will be widened in 2019. The scheduled upgrades to Old Blue Vale Road would satisfy the Austroads (2010) design standard for daily traffic volumes of 150-500 vehicle movements. Therefore, at the completion of the proposed works, no further upgrades would be required for the maximum cumulative construction traffic of the project and the Gunnedah Solar Farm.

4.2 Traffic impact at intersections

At the locations of the proposed access intersections, the existing peak hourly volume of eastbound and westbound through traffic using Orange Grove Road (approximately 9 vehicles per hour) is anticipated to increase as a result of the project traffic which is approximately +36 vehicles per hour at the peak stage of the project construction. Therefore, a maximum of approximately 45 peak hourly movements could be expected at the proposed access intersections which are on the unsealed section of Orange Grove Road.

The potential need for additional intersection widening at these intersection locations has been assessed with reference to the 100 km/hr Austroads intersection design warrant chart in Figure 2.3 and the Austroads intersection road design guide extracts, which are included as Appendix A.

It has been assumed that 98% of the future project traffic would turn left into the northern portion of the development footprint. This bias for the northern portion of the development footprint is based on the fact that no PV solar panels are proposed to be installed on the southern portion of the development footprint and, therefore, the vast majority of traffic during all phases of construction and operations will be accessing the northern portion of the development footprint. It should be noted; however, that certain periods such as the construction of the grid connection infrastructure may cause peaks in traffic movements to the southern portion of the development footprint.

From the forecast future project traffic volumes in Section 4.1, for each stage of construction, and assuming that all the project traffic is travelling to and from the west with 98% turning left into the northern portion of the development footprint, the estimated volumes of turning vehicles are summarised in Table 4.5, for the morning and afternoon peak hour traffic periods.

Table 4.5 Future forecast turning traffic volumes using the proposed access intersections from Orange Grove Road

Stage	Peak hour	Hourly traffic entering the development footprint		Hourly traffic leaving the development footprint	
Site activity	**Time of day**	**From the west**	**From the east**	**To the west**	**To the east**
Average construction	Morning peak hour	23	0	2	0
	Afternoon peak hour	2	0	23	0
Peak construction	Morning peak hour	35	0	3	0
	Afternoon peak hour	3	0	35	0
Operation	Morning peak hour	3	0	0	0
	Afternoon peak hour	0	0	3	0

During the busiest period for the future project traffic (the peak construction stage) the summary of the access intersection traffic volumes in Table 4.5, shows the maximum future traffic volume turning into the northern portion of the development footprint from the west will be 35 vehicles. This volume when combined with the maximum major road through traffic flow using Orange Grove Road (9 hourly vehicles) would only require the minimum (Type BAR/BAL) intersection shoulder widening, according to the 100 km/hr Austroads intersection warrant chart (refer to Figure 2.3).

As the major road (Orange Grove Road) is currently and will remain unsealed, the required intersection widening would be constructed in the form of gravel shoulder widening.

At the Kelvin Road/Orange Grove Road intersection, it is assumed that Kelvin Road will maintain a future peak hourly through traffic volume of approximately 58 vehicles. Assuming all the peak hourly turning traffic associated with the Gunnedah Solar Farm and Orange Grove Sun Farm projects would be travelling in the opposite direction to the existing Orange Grove Road traffic during the morning and afternoon traffic peak hours, the maximum future turning traffic movements at the intersection would be approximately 64 vehicles per hour. This traffic would also only require the existing minimum (Type BAR/BAL) intersection left or right turn safety treatments, according to the 100 km/hr Austroads intersection warrant chart (refer to Figure 2.3).

As noted in Section 2.4, the current year 2018 baseline peak hourly traffic volume for the Kamilaroi Highway north-west of Gunnedah has been calculated as approximately 177 vehicles per hour during the peak hourly traffic periods. The baseline volume for Blue Vale Road has been calculated as 300 daily vehicles, which corresponds to approximately 30 vehicles per hour during the peak hourly traffic periods. In addition to this, and assuming that all project-related heavy vehicle traffic for both the project and the Gunnedah Solar Farm would utilise this intersection, the peak hourly traffic turning onto Blue Vale Road would increase to 51. Based on the warrant chart provided in Figure 2.3, the current intersection, which already features additional turning lanes, would satisfy the standard design requirements.

The estimated baseline peak hourly traffic volume for Blue Vale Road is approximately 30 peak hourly through vehicles. Given that this is significantly less than 120 peak hourly movements and that, under the cumulative scenario, Old Blue Vale Road would have a maximum turning volume of 28 peak hourly vehicles, the current Blue Vale Road/Old Blue Vale Road intersection would satisfy the standard design requirements without a requirement for additional left or right turn traffic lanes.

The baseline peak hourly traffic volume for Kelvin Road is approximately 58 peak hourly vehicles. Given that this is significantly less than 120 peak hourly movements, and that, under the cumulative scenario, Old Blue Vale Road would have a maximum of 28 peak hourly vehicles turning into Kelvin Road, the current Kelvin Road/Old Blue Vale Road intersection satisfies the standard design requirements without a requirement for additional left or right turn traffic lanes.

4.3 Site access road traffic impact

The maximum project daily traffic using the proposed access road for the northern portion of the development footprint will be up to 98% of the future total predicted project traffic during each of the construction and operations stages of the project. This is approximately:

- 78 daily vehicle trips, during average construction;
- 114 daily vehicle trips, during peak construction; and
- 9 daily vehicle trips during operation.

For these daily traffic volumes, a variable lane width, unsealed rural road is acceptable. Additional gravel shoulder widening is proposed at the intersection with Orange Grove Road to facilitate the turning movements by large vehicles to and from Orange Grove Road, which should accommodate the swept path turning requirements for the largest type of construction vehicle that would require access to the development footprint.

4.4 Driver distraction from glare

The potential for low angled reflected sunlight to cause a distraction to drivers travelling either eastbound or westbound along Orange Grove Road and the Oxley Highway was considered. Due to the anti-reflective properties of the PV solar panels, they are not expected to cause a distraction to motorists on either Orange Grove Road or the Oxley Highway. Visual impacts of the project are addressed in the EIS and accompanying visual impact assessment.

4.5 Dust and noise generation impacts

The impacts of road traffic noise and dust generated along the primary haul routes would be minimal because the primary haul routes are generally either sealed regional highways (separated from dwellings and businesses), or sealed major urban roads that already have significant daily traffic volumes.

The unsealed section of Orange Grove Road may cause significant dust generation, but this portion of road is well separated from the nearest dwelling, which is approximately 250 m north of Orange Grove Road, west of the development footprint.

To minimise dust generation, the proponent will treat the road surface of the unsealed section of Orange Grove Road to reduce potential dust generation by the project-related traffic during the construction period.

Noise impacts are addressed in the EIS and accompanying noise and vibration impact assessment.

5 Mitigation measures

5.1 Construction traffic management

A construction traffic management plan (CTMP) and Driver Code of Conduct will be incorporated into the environmental management plan (EMP) and will be prepared prior to commencement of construction, which will incorporate the proposed access intersection treatments utilising Austroads and RMS guidelines for the major road intersection operations and worksite traffic control throughout the project construction period.

As part of input on the SEARs, RMS has noted the following requirements are to be included in the CTMP and Driver Code of Conduct for the project:

- map of the primary haulage routes highlighting critical locations;
- safety initiatives for haulage through residential areas and/or school zones;
- an induction process for vehicle operators and regular toolbox meetings;
- a complaint resolution and disciplinary procedure, and
- any community consultation measures for peak haulage periods.

In order to minimise impacts on traffic flow along Orange Grove Road, deliveries and other vehicle movements will avoid peak hour and school bus times, whenever possible.

Generally, during the construction period, the largest vehicles which are anticipated to be visiting the development footprint for construction deliveries on a regular basis will be 19 m long semi trailers. Temporary traffic control arrangements may be required at the proposed access intersections during the peak stages of construction traffic activity or on days when deliveries by oversize vehicles may be required.

5.2 Intersection improvements

Two new intersections are proposed for access into the development footprint, both of which will be located on Orange Grove Road, serving the southern and northern portions of the development footprint, respectively (refer Section 3.1).

Both of these access intersections will consist of a three-way intersection with Orange Grove Road, with a connecting access road extending into the respective northern and southern portions of the development footprint. Project traffic during both the construction and operations stages will principally access the northern portion of the development footprint.

Any proposed intersections would require some gravel shoulder widening on the approaches to and from Orange Grove Road, generally within the Orange Grove Road reserve, to accommodate the swept path turning movement by the largest types of trucks requiring access to the development footprint.

The sight distance visibility along Orange Grove Road is excellent for the future potential turning traffic at both potential access locations and no additional vegetation clearing would be required to improve visibility.

The proponent would be required to lodge a Section 138 Certificate (Work on Public Lands) for GSC approval before any future road work for the proposed intersection construction/improvement is carried out.

5.3 Road maintenance program

During the project construction period, which is estimated to continue for nine months, a road maintenance program will be implemented for the 5.4 km unsealed section of Orange Grove Road, west of the proposed access intersection for the northern portion of the development footprint, which will include regrading of the road surface to repair potholes and road corrugations (at three monthly intervals) and a commitment by the proponent to restore the gravel road surface to its pre-construction condition, at the completion of the project's construction.

The proponent will treat the road surface of the unsealed section of Orange Grove Road to reduce potential dust generation by project-related traffic during the construction period.

6 Summary and conclusions

The traffic impacts from the proposed Orange Grove Sun Farm have been assessed and the key findings are as follows:

- Access to the development footprint will be from Orange Grove Road via one of two access intersections. The proposed access intersections would include gravel shoulder widening to accommodate the swept paths of the largest types of trucks which are proposed to visit the development footprint.

- Orange Grove Road is both straight and level at each of the proposed access intersection locations being considered. The intersection sight distances provide for very good traffic safety and the sight distances are more than adequate for the road speed limit which is 100 km/hr.

- The existing daily traffic volumes using the Kamilaroi Highway and the Oxley Highway have been reviewed and +1% annual traffic growth adjustments used to determine projected 2018 baseline daily traffic volumes from the published RMS daily traffic volume surveys during the period 2007 to 2017. For Kelvin Road, Orange Grove Road and Blue Vale Road data supplied by GSC was used. For Old Blue Vale Road, the existing daily traffic volume was estimated based on the number of rural dwellings along the length of Old Blue Vale Road, in accordance with the RMS (2010) *Guide to Traffic Generating Developments* methodology. The year 2018 baseline traffic volumes satisfy the current Austroads (2010) design standards for daily traffic volumes for the typical design standard and sealed width of each of these roads.

- The predicted additional daily traffic usage of the surrounding roads at the peak stage of project construction will be approximately 116 daily vehicle trips, reducing to approximately 80 daily vehicle trips during the earlier and later (average) stages of project construction and an average of 10 daily trips during operation. Peak construction is expected to extend for three months of the nine month construction period. To accommodate the peak construction phase traffic, the unsealed section of Orange Grove Road will require a road maintenance program to maintain the safety and serviceability of the road for all road users. Also to minimise dust generation, the proponent will treat the road surface of the unsealed section of Orange Grove Road to reduce potential dust generation by project traffic during the nine month construction period.

- Additional traffic generated by the project will not cause the future daily traffic volumes on the Kamilaroi Highway, the Oxley Highway, Kelvin Road, Blue Vale Road or the sealed portion of Orange Grove Road, to increase above the relevant Austroads (2010) daily traffic volume design levels that would trigger road widening improvements.

- There is potential for a marginal exceedance of the Austroads (2010) design level of Old Blue Vale Road under the cumulative peak construction scenario, which assumes that the peak construction period for the project and the Gunnedah Solar Farm would coincide. However, the likelihood of a cumulative peak construction scenario is very low. Further, during consultation, GSC noted that Old Blue Vale Road will be upgraded in 2019.

- The additional peak hourly project access traffic would not affect the Austroads intersection warrant design requirements for additional turning lanes at rural intersections and additional intersection turning lanes would not be required. The existing minimum type BAR/BAL right and left turn sealed shoulder widening will be sufficient for the intersection of Kelvin Road with Orange Grove Road.

- The internal access roads and car parking within the development footprint will be constructed to serve the project's construction access and car parking needs. Internal access roads to material storage compounds and the on-site substation will be approximately 4–6 m width whilst general internal roads will be approximately 3.5–5 m width. Car parking for the project construction and operations workforces will be provided in appropriate gravel surfaced car parking areas with appropriate dimensions to accommodate the required number of vehicles.

- A CTMP will be prepared in consultation with RMS and in accordance with the RMS *Traffic Control at Worksites Manual* (RTA 2010).

Appendix A

Austroads Design standards for intersection turning lanes

2.3.6 Warrants for BA, AU and CH Turn Treatments

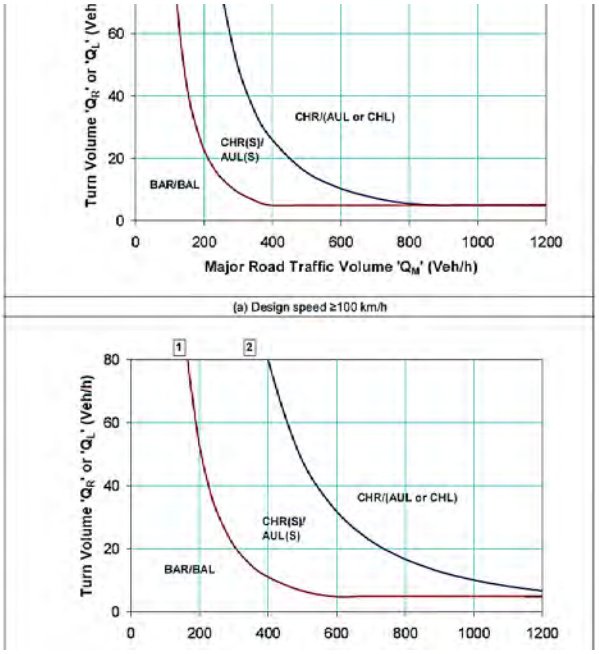
These warrants apply to major road turn treatments for the basic, auxiliary lane and channelised layouts discussed in Section 2.2.2, 2.2.3 and 2.2.4. The warrants are shown in Figure 2.23 and provide guidance on where a full-length deceleration lane must be used and where a shorter lane, designated AUL(S) and CHR(S), may be acceptable based on traffic volume. Figure 2.23 contains two graphs for the selection of turn treatments on roads with a design speed:

- greater than or equal to 100 km/h. Figure 2.23(a) is appropriate for high speed rural roads
- less than 100 km/h. Figure 2.23(b) is appropriate for urban roads, including those on the urban fringe and lower speed rural roads.

If a particular turn from a major road is associated with some geometric minima (for example, limited sight distance, steep grade), consideration should be given to the adoption of a turn treatment of a higher order than that indicated by the warrants. For example, if the warrants indicate that a BAR turn treatment is acceptable for the relevant traffic volumes, but limited visibility to the right-turning vehicle is available, consideration should be given to the adoption of a CHR(S) or CHR turn treatment instead. Another example is a major road on a short steep downgrade where numerous heavy vehicles travel quickly down the grade, in which case it would not be appropriate to adopt a BAL turn treatment. Instead, an AUL(S) or an AUL would be a preferred treatment.

Development of the warrants in this section is detailed in Arndt and Troutbeck (2006) and briefly discussed in Commentary 5.

[see Commentary 5]



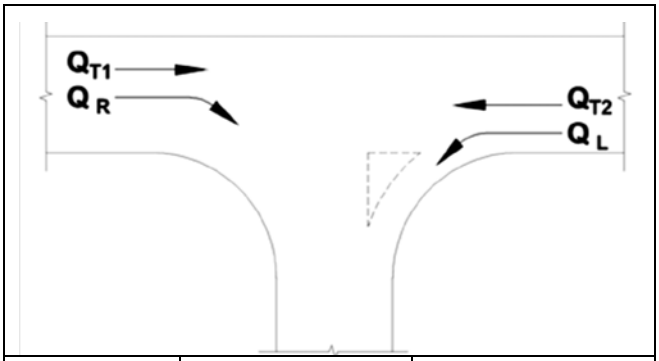
Source: Arndt and Troutbeck (2006).

Figure 2.23: Warrants for turn treatments on the major road at unsignalised intersections

In applying the warrants in Figure 2.23 designers should note that:

- Curve 1 represents the boundary between a BAR and a CHR(S) turn treatment and between a BAL and an AUL(S) turn treatment.

- Curve 2 represents the boundary between a CHR(S) and a CHR turn treatment and between an AUL(S) and an AUL or CHL turn treatment. The choice of CHL over an AUL will depend on factors such as the need to change the give way rule in favour of other manoeuvres at the intersection and the need to define more appropriately the driving path by reducing the area of bitumen surfacing.
- The warrants apply to turning movements from the major road only (the road with priority).
- Figure 2.24 is to be used to calculate the value of the major road traffic volume parameter (Q_M).
- Traffic flows applicable to the warrants are peak hour flows, with each vehicle counted as one unit (i.e. do not use equivalent passenger car units [pcus]). Where peak hour volumes or peak hour percentages are not available, assume that the design peak hour volume equals 8% to 10% of the AADT for urban situations and that the design hour volume equals 11% to 16% of AADT for rural situations.
- If more than 50% of the traffic approaching on a major road leg turns left or right, consideration needs to be given to possible realignment of the intersection to suit the major traffic movement. However, route continuity issues must also be considered (for example, realigning a highway to suit the major traffic movement into and out of a side road would be unlikely to meet driver expectation).
- If a turn is associated with other geometric minima, consideration should be given to the adoption of a turn treatment of a higher order than that indicated by the warrants.
- Some road authorities may consider that the CHR(S) treatment is not a suitable arrangement in all instances. Where this occurs, the Main Roads Western Australia AUR treatment may be used as an alternative (Part 4a of the *Guide to Road Design*, Austroads 2010). However the CHR(S) treatment is considered to be preferable for general use on major roads.
- Where the major road has four lanes (e.g. two in each direction) the value used for Q_M is the volume in the closest through lane to the turning movement.



Turn type	Splitter island	Q_M (veh/h)
Right	No	$= Q_{T1} + Q_{T2} + Q_L$
Right	Yes	$= Q_{T1} + Q_{T2}$
Left	Yes or no	$= Q_{T2}$

Source: Arndt and Troutbeck (2006).

Figure 2.24: Calculation of the major road traffic volume Q_M

7.3 Right-turn Bans at Signalised Intersections

Consideration should be given to banning a right turn where:

- a right-turn lane cannot be provided and the right-turning traffic would cause a safety and/or a capacity problem
- sight distance is poor and cannot be corrected, and other options such as erecting advance signs are not satisfactory.

If the right-turn can be banned, several options may be considered as described in Section 2.2.3 of the *Guide to Traffic Management – Part 6: Intersections, Interchanges and Crossings* (Austroads 2007) and illustrated in Section 4.14 of this guide.

7.4 Right-turn Lanes for Cyclists

Right-turn lanes for cyclists are rarely used and should generally not be provided for cyclists at right-turn treatments on arterial roads or busy traffic routes because of the difficulty and crash risk for cyclists moving from the left of an intersection to the centre of the road in order to utilise such treatments. Conditions for the use of cyclist right-turn lanes and illustrations of their use at an intersection are provided in Section 10.6.4 of this guide.

7.5 Rural Right-turn Treatments – Undivided Roads

All the turn treatments described in this section are applicable to two-lane two-way rural roads. They can also be applied to multi-lane rural roads (divided and, less commonly, undivided), except for the BAR turn treatment.

7.5.1 Rural Basic Right-turn Treatment (BAR)

The basic right-turn treatment (BAR) shown in Figure 7.5 is the minimum treatment for right-turn movements from a through road to side roads and local access points. This treatment provides sufficient trafficable width for the design through vehicle to pass on the left of a stationary turning vehicle. This is achieved by widening the shoulder to provide a minimum width sufficient to allow the vehicles to pass. Substantial speed reduction (potentially half of the design speed) is a feature of this layout.

Other aspects of the design are:

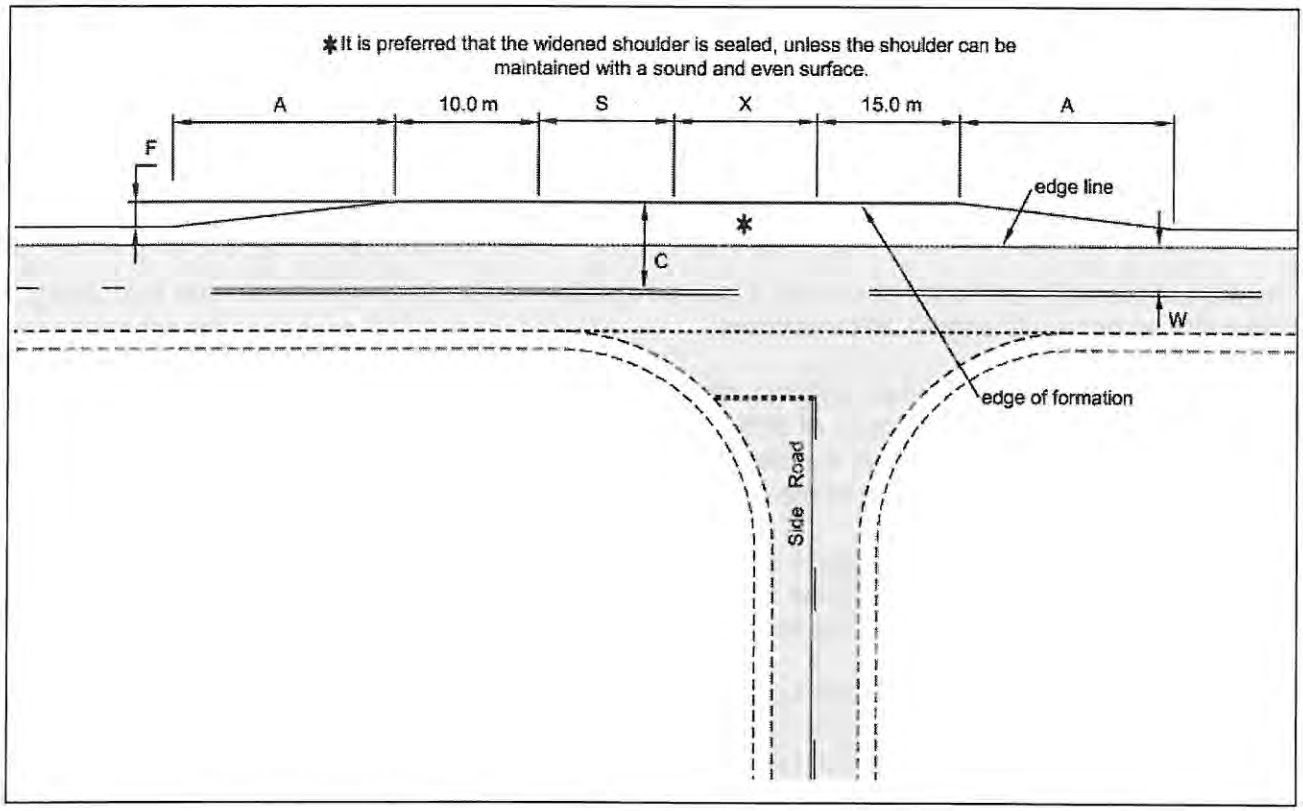
- on a terminating intersection leg no special provision is usually made for right-hand turns when a BAR is used
- this layout can be used on both sealed and unsealed roads
- it is preferred that the widened shoulder at BAR turn treatments is sealed, unless the shoulder can be maintained with a sound and even surface
- this layout should not be used where there is reduced visibility to the turn treatment. Right turning drivers on the major road need to perceive the location of the side road and stop if necessary in the through lane before the intersection.

Where adequate through sight distance exists, BAR turn treatments will generally be marked with a broken centreline to allow overtaking on the major road through the intersection. This will not restrict overtaking opportunities, thereby minimising delays. However, there may be instances where a BAR turn treatment on a section of road with good overtaking opportunities will yield a high likelihood of crashes resulting from inappropriate overtaking through the intersection. In such cases, a barrier line should be used. Examples of such instances include the following:

- The turn treatment is located after a significant length of roadway that has no overtaking opportunities. This geometry would result in drivers often overtaking through the intersection because of the large amount of time spent following other vehicles prior to the intersection. The increased exposure of overtaking may result in an excessively high overtaking-intersection vehicle crash rate.
- There are reasonably high right-turning volumes.
- The warrants dictate that a higher-level turn treatment is appropriate.

It is suggested that BAR treatments should generally have a barrier line on the major road approaches to reduce the likelihood of overtaking vehicles colliding with vehicles entering from the side road. Consideration should only be given to the use of a broken centreline in situations where overtaking opportunities are limited and the volume on the side road is very low.

The BAR turn treatment on a two-lane rural road as shown in Figure 7.5 has limited applications. It is mainly applicable at the junction of side roads and rural arterial roads with lower traffic volumes. Such turn treatments can record high crash rates, especially in high-speed areas. A more desirable treatment at such sites is a CHR(S) turn treatment discussed in Section 7.5.2.



Notes:

1. This treatment applies to the right turn from a major road to a minor road.
2. The dimensions of the treatment are defined thus:

W = **Nominal through lane width (m) (including widening for curves). Width to be continuous through the intersection.**

C = **On straights – 6.5 m minimum**

7.0 m minimum for Type 1 & Type 2 road trains

On curves – widths as above + curve widening (based on widening for the design turning vehicle plus widening for the design through vehicle).

A = $\frac{0.5VF}{3.6}$

Increase length A on tighter curves (e.g. those with a side friction demand greater than the maximum desirable). Where the design through vehicle is larger than or equal to a 19 m semi-trailer the minimum speed used to calculate A is 80 km/h.

V = **Design speed of major road approach (km/h).**

F = **Formation/carriageway widening (m).**

S = **Storage length to cater for one design turning vehicle (m) (minimum length 12.5 m).**

X = **Distance based on design vehicle turning path, typically 10–15 m.**

Source: QDMR (2006).

Figure 7.5: Basic right (BAR) turn treatment on a two-lane rural road

7.5.2 Rural Channelised T-junction – Short Lane Type CHR(S)

The CHR(S) turn treatment shown in Figure 7.6 is a more desirable treatment than the BAR treatment because it provides greater protection for vehicles waiting to turn right from the centre of the road. This treatment is suitable where there are low to moderate through and turning volumes. For higher volume sites, a full-length CHR turn treatment (Figure 7.7) is preferred.

This type of intersection can only be used with linemarking. It is not to be used with raised or depressed islands as the turn lane is short and it is desirable that right-turning drivers travel over the painted chevron to exit the through traffic stream as soon as possible.

For the CHR(S) turn treatment, all through traffic is required to deviate, hence the deviation must be designed to suit the operating speed. A minimum shoulder width of 1.0 m must be used on the through lane deviation.

The start of the right-turn taper occurs as a painted median width of 2.0 m, in lieu of the full turning lane width as per a full length CHR treatment.

The length of turn slot is based on a right-turning vehicle slowing to 80% of the design speed on the approach (i.e. a speed reduction of 20% in the through lane), prior to moving into the turn lane and decelerating. This is based on the assumption that drivers decelerate at a maximum value of 3.5 m/s^2 from the start of the taper to the start of the storage length.

Although some deceleration of the right-turning vehicles occurs in the through lane, this treatment records far fewer rear-end crashes than do BAR turn treatments. The good safety performance occurs by removing stationary turning vehicles from the through traffic stream.

CHR(S) turn treatments should not be used where there is reduced visibility to the turn treatment. Right-turning drivers on the major road need to perceive the location of the deceleration lane and the side road in time to make the necessary speed reduction in the through lane prior to diverging.

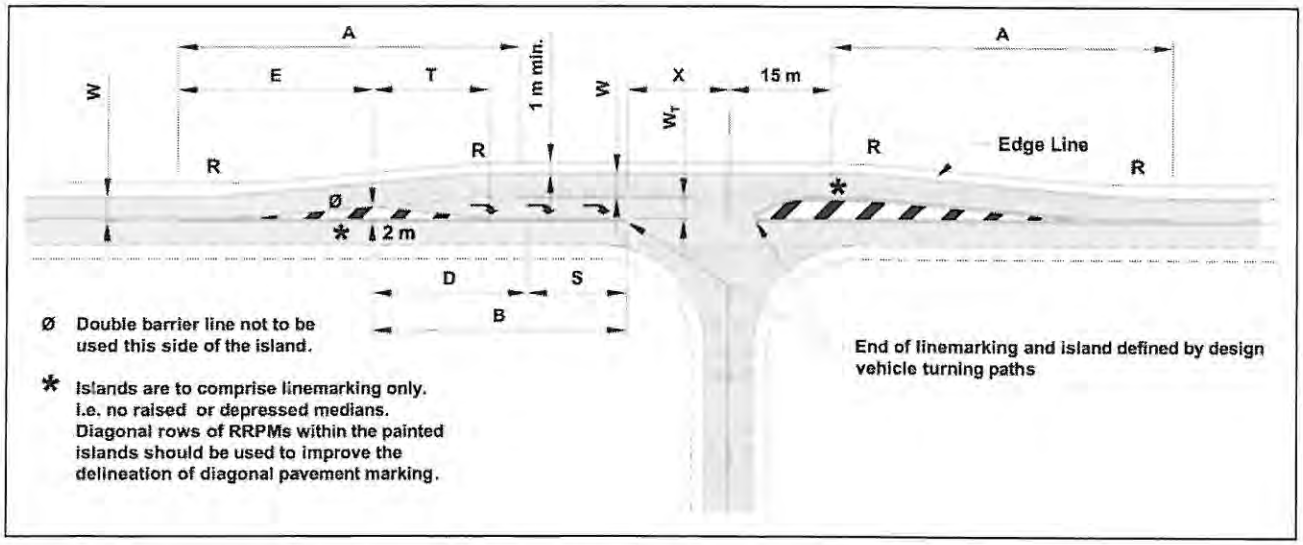
Table 7.1 provides the dimensions of the CHR(S) treatment for various design speeds.

Table 7.1: Dimensions of CHR(S) treatment for various design speeds

Design speed of major road approach (km/h)	Lateral movement length A (m)1	Diverge/ deceleration length D (m)2	Desirable radius R (m)	Taper length T (m)3
50	40[4]	15	110	15
60	50[4]	25	175	15
70	60	35	240	20
80	65	45	280	20
90	75	55	350	25
100	85	70	425	30
110	95	85	500	30
120	100	100	600	35

Notes:

1. Based on a diverge rate of 1m/sec and a turn lane width of 3.0 m. Increase lateral movement length if the turn lane width >3 m. If the through road is on a tight horizontal curve (e.g. one with a side friction demand greater than the maximum desirable), the lateral movement length should be increased so that a minimal decrease in speed is required for the through movement.
2. Based on a 20% reduction in through road speed at the start of the taper to a stopped condition using a value of deceleration of 3.5 m/s^2 (Table 5.2). Adjust for grade using the 'correction to grade' factor in Table 5.3.
3. Based on a turn lane width of 3.0 m.
4. Where Type 2 road trains are required, minimum A = 60 m.



Note: The dimensions of the treatment are defined below and values of A, D, R and T are shown in Table 7.1:

W = Nominal through lane width (m) (including widening for curves). For a new intersection on an existing road, the width is to be in accordance with the current link strategy.

W_T = Nominal width of turn lane (m), including widening for curves based on the design turning vehicle = 3.0 m minimum.

B = Total length of auxiliary lane including taper, diverge/deceleration and storage (m).

E = Distance from start of taper to 2.0 m width (m) and is given by:

$$E = 2\left(\frac{A}{W_T}\right)$$

T = Taper length (m) and is given by:

$$T = \frac{0.33xVxW_T}{3.6}$$

S = Storage length to cater for one design turning vehicle (m).

V = Design speed of major road approach (km/h).

X = Distance based on design vehicle turning path, typically 10–15 m.

Source: QDMR (2006).

Figure 7.6: Channelised right-turn treatment with a short turn slot [CHR(S)] two-lane rural road

7.5.3 Rural Channelised T-junction – Full Length (CHR)

For this layout, all traffic is required to deviate and therefore the road alignment for the through movement must be designed to suit the operating speed. This deviation requires the pavement to be widened to provide a full-length right-turn lane as shown in Figure 7.7.

The minimum lengths of deceleration (D) for different design speeds are shown in Table 5.2 and should be based on the comfortable deceleration rate of 2.5 m/s^2. The storage length (S) is usually determined through the use of computer programs such as aaSIDRA.

Details of the departure end of the right-turn lane should be determined using turning path templates (minimum radius 15.0 m). This will depend on the width and the angle of intersection of the road that the turning vehicle is entering.

There are no numerical warrants for the provision of raised medians in lieu of the painted medians, and some jurisdictions may require road lighting where raised medians are provided.

Pavement marking should be provided as shown in Figure 7.7. If the painted separation between opposing traffic flows is wider than a double white line, then the median should be delineated with diagonal markings and raised retroreflective pavement markers (Figure 6.5).

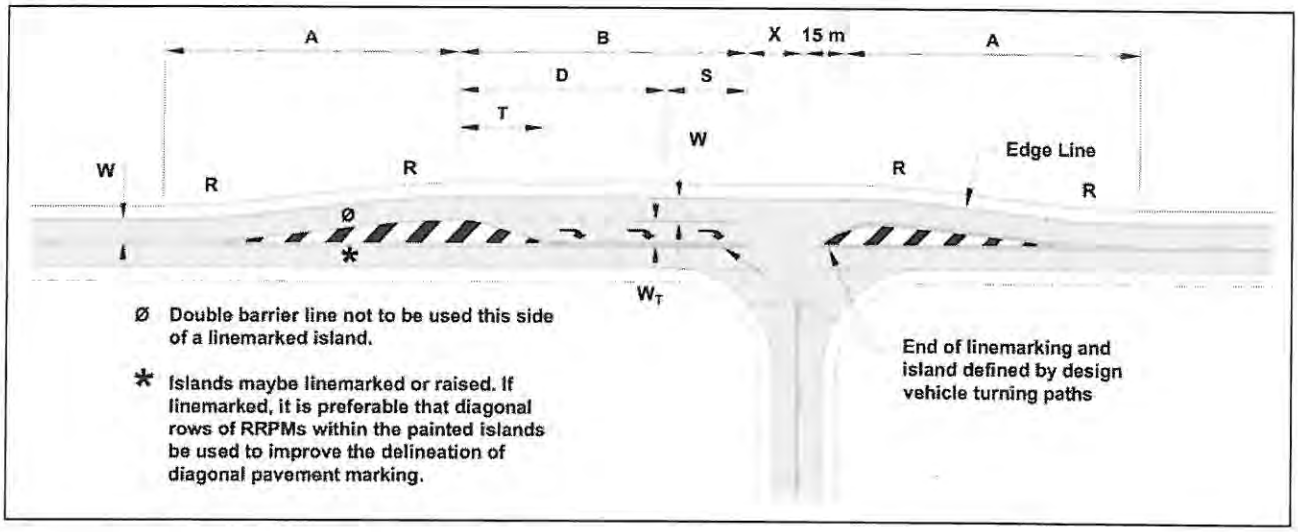
Table 7.2 provides the dimensions of the CHR treatment for various design speeds.

Table 7.2: Dimensions of CHR treatment for various design speeds

Design speed of major road approach (km/h)	Lateral movement length A (m) [1]		Desirable radius R (m)
	W_T=3.5 m	W_T=3.0 m	
50	50 [2]	40 [2]	110
60	60	50 [2]	175
70	70	60	240
80	80	65	280
90	90	75	350
100	100	85	425
110	110	95	500
120	120	100	600

Notes:

1. Based on a diverge rate of 1 m/sec. If the through road is on a tight horizontal curve (e.g. one with a side friction demand greater than the maximum desirable) increase the lateral movement length so that a minimal decrease in speed is required for the through movement.
2. Where Type 2 road trains are required minimum A = 60.0 m.



Notes:

1. An alternative to the double white line on the offside edge of the right-turn slot is a 1.0 m painted median. The 1.0 m median is particularly useful when the major road is on a tight horizontal curve and oncoming vehicles track across the centreline. Provision of this median will require the dimension 'A' to be increased.
2. A raised concrete median on the minor road may be used with this treatment to minimise 'corner cutting', particularly for higher turning volumes.
3. The dimensions of the treatment are defined below and values of A, D, R and T are shown in Table 7.2:

W = **Nominal through lane width (m) (including widening for curves). For a new intersection on an existing road, the width is to be in accordance with the current link strategy.**

W_T = **Nominal width of turn lane (m), including widening for curves based on the design turning vehicle. Desirable minimum = W, absolute minimum = 3.0 m.**

B = **Total length of auxiliary lane including taper, diverge/deceleration and storage (m).**

D = **Diverge/deceleration length including taper. Adjust for grade using the 'correction to grade' factor (Section 5)**

T = **Physical taper length (m) and is given by:**

$$T = \frac{0.33VW_T}{3.6}$$

S = **Storage length (m) should be the greater of:**

1. the length of one design turning vehicle or

2. (calculated car spaces –1) x 8 m (*Guide to Traffic Management – Part 3: Traffic Studies and Analysis* (Austroads 2009h), or use computer program e.g. aaSIDRA).

V = **Design speed of major road approach (km/h)**

X = **Distance based on design vehicle turning path, typically 10–15 m**

Source: Based on QDMR (2006).

Figure 7.7: Channelised right turn (CHR) on a two-lane rural road

7.5.4 *Rural Right-Left Staggered T*

Basic two-lane two-way road

This layout should be designed to ensure that:

- the stagger distance between the minor legs is large enough to discourage drivers from 'taking a short-cut on the wrong side of the traffic islands (e.g. at least 15 m to 25 m depending on the site characteristics)
- the island treatments in the minor roads are long enough to also discourage wrong way movements
- sufficient width is provided on the major road within the intersection to enable through vehicles to pass slowly to the left of vehicles waiting to turn right (e.g. 12 m), a similar principle to the BAR treatment.

SYDNEY
Ground floor, Suite 01, 20 Chandos Street
St Leonards, New South Wales, 2065
T 02 9493 9500 F 02 9493 9599

NEWCASTLE
Level 1, Suite 6, 146 Hunter Street
Newcastle, New South Wales, 2300
T 02 4907 4800 F 02 4907 4899

BRISBANE
Level 4, Suite 01, 87 Wickham Terrace
Spring Hill, Queensland, 4000
T 07 3839 1800 F 07 3839 1866