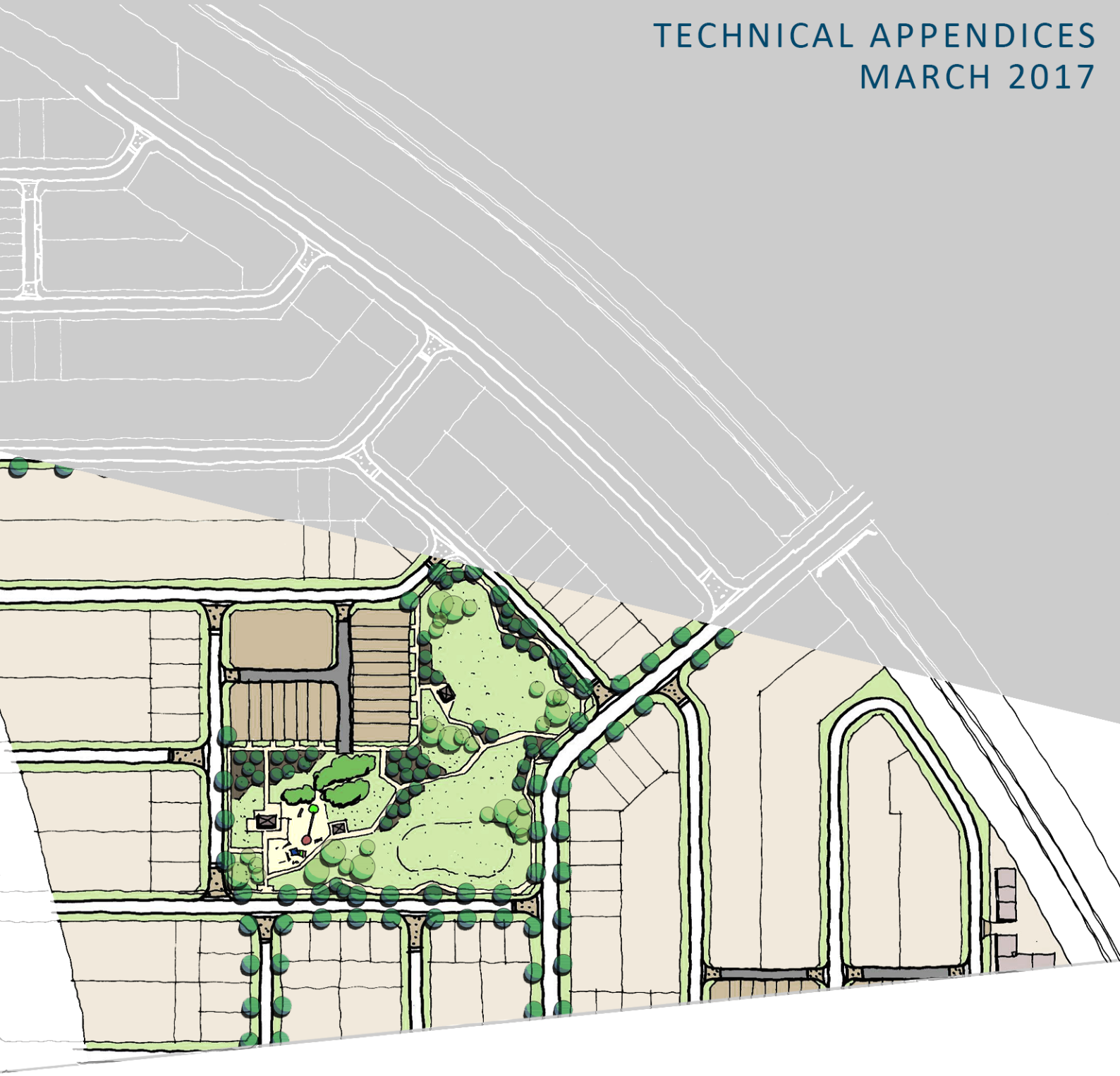
WESTERN PRECINCT
LOCAL STRUCTURE PLAN
LOT 6 TARONGA PLACE, EGLINTON

TECHNICAL APPENDICES
MARCH 2017



URBAN QUARTER

CLE
TOWN PLANNING + DESIGN

LOT 6 WESTERN PRECINCT LOCAL STRUCTURE PLAN

TECHNICAL APPENDICES

Prepared by:

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March 2017

APPENDICES

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APPENDIX 1

Certificate of Title

214D

REGISTER NUMBER	
6/D26989	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
2	25/10/2016

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

VOLUME 1909 FOLIO 63

UNDER THE TRANSFER OF LAND ACT 1893

The person described in the first schedule is the registered proprietor of an estate in fee simple in the land described below subject to the reservations, conditions and depth limit contained in the original grant (if a grant issued) and to the limitations, interests, encumbrances and notifications shown in the second schedule.

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 6 ON DIAGRAM 26989

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

DAWS & SON PTY LTD OF LEVEL 4 72 KINGS PARK ROAD WEST PERTH WA 6005
(T N466075) REGISTERED 24 OCTOBER 2016

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:
(SECOND SCHEDULE)

1. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 594/1933.
2. THE LAND THE SUBJECT OF THIS CERTIFICATE OF TITLE EXCLUDES ALL PORTIONS OF THE LOT DESCRIBED ABOVE EXCEPT THAT PORTION SHOWN IN THE SKETCH OF THE SUPERSEDED PAPER VERSION OF THIS TITLE. VOL 1909 FOL 063.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
* Any entries preceded by an asterisk may not appear on the current edition of the duplicate certificate of title.
Lot as described in the land description may be a lot or location.

----------END OF CERTIFICATE OF TITLE----------

STATEMENTS:

The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND:	1909-63 (6/D26989).
PREVIOUS TITLE:	1285-913.
PROPERTY STREET ADDRESS:	19 TARONGA PL, CARABOODA.
LOCAL GOVERNMENT AREA:	CITY OF WANNEROO.

APPENDIX 2

Environmental Assessment (Strategen)

intelligent outcomes | respected experience

19 (Lot 6) Taronga Place, Eglinton

Environmental Assessment

Prepared for
Urban Quarter
by Strategen

February 2017

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ENVIRONMENTAL

19 (Lot 6) Taronga Place, Eglinton

Environmental Assessment

Strategen is a trading name of
Strategen Environmental Consultants Pty Ltd
Level 1, 50 Subiaco Square Road Subiaco WA 6008
ACN: 056 190 419

February 2017

Limitations

Scope of services

This report ("the report") has been prepared by Strategen Environmental Consultants Pty Ltd (Strategen) in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Strategen. In some circumstances, a range of factors such as time, budget, access and/or site disturbance constraints may have limited the scope of services. This report is strictly limited to the matters stated in it and is not to be read as extending, by implication, to any other matter in connection with the matters addressed in it.

Reliance on data

In preparing the report, Strategen has relied upon data and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise expressly stated in the report, Strategen has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Strategen has also not attempted to determine whether any material matter has been omitted from the data. Strategen will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Strategen. The making of any assumption does not imply that Strategen has made any enquiry to verify the correctness of that assumption.

The report is based on conditions encountered and information received at the time of preparation of this report or the time that site investigations were carried out. Strategen disclaims responsibility for any changes that may have occurred after this time. This report and any legal issues arising from it are governed by and construed in accordance with the law of Western Australia as at the date of this report.

Environmental conclusions

Within the limitations imposed by the scope of services, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted environmental consulting practices. No other warranty, whether express or implied, is made.

Client: Urban Quarter

Report Version	Revision No.	Purpose	Strategen author/reviewer	Submitted to Client	
				Form	Date
Draft Report	A	For client review	C Courtauld / A Welker	Electronic	13 Jan 2017
Final Draft Report	B	For client review	D Panickar / D Walsh	Electronic	16 Feb 2017
Final Report	**0**	**For submission**	**D Panickar / D Walsh**	**Electronic**	**21 Feb 2017**

Filename: URQ16447_01 R003 Rev 0 - 21 February 2017

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1. Introduction

1.1 Background

Urban Quarter is proposing to develop 19 (Lot 6) Taronga Place, Eglinton, in the City of Wanneroo for residential and commercial development (the project). A Structure Plan has been prepared for a portion of the subject site which includes residential lots, roads and areas of active and managed public open space (POS).

This environmental assessment shall assist the Local Structure Plan (LSP) for the site as well as the environmental approvals process associated with the project. The results of the environmental assessment for the LSP area are summarised below.

1.2 Environmental context

1.2.1 Topography, Landform and Soils

The topography of the LSP area is undulating and ranges from 29 m to 44 m Australian Height Datum (AHD) (Figure 1). The soil type is characteristic of the Spearwood dunes and ranges from white to yellow sands to light brown sandy loam.

Based on a survey undertaken in 2007 by the Western Australian Speleological Group, karstic features are present with the LSP area (WASG 2007). Information provided in this survey, although restricted, suggests the presence of small karstic features across the LSP area as well as two caves outside the LSP area, one of which is located in the Resource Enhancement Wetland adjacent to the northern boundary of the Lot (Figure 1).

A preliminary karst assessment was undertaken in 2016 by CMW Geosciences to quantify the presence of karst features and inform a geotechnical assessment (CMW 2016). Everything east of the line shown on Figure 2 was assessed as being susceptible to instability as a result of karst features (CMW 2016). Areas west of the line were assessed as posing a very low risk to instability due to karst and can be managed by normal geotechnical investigation and design processes. The majority of the LSP area is considered to be very low risk.

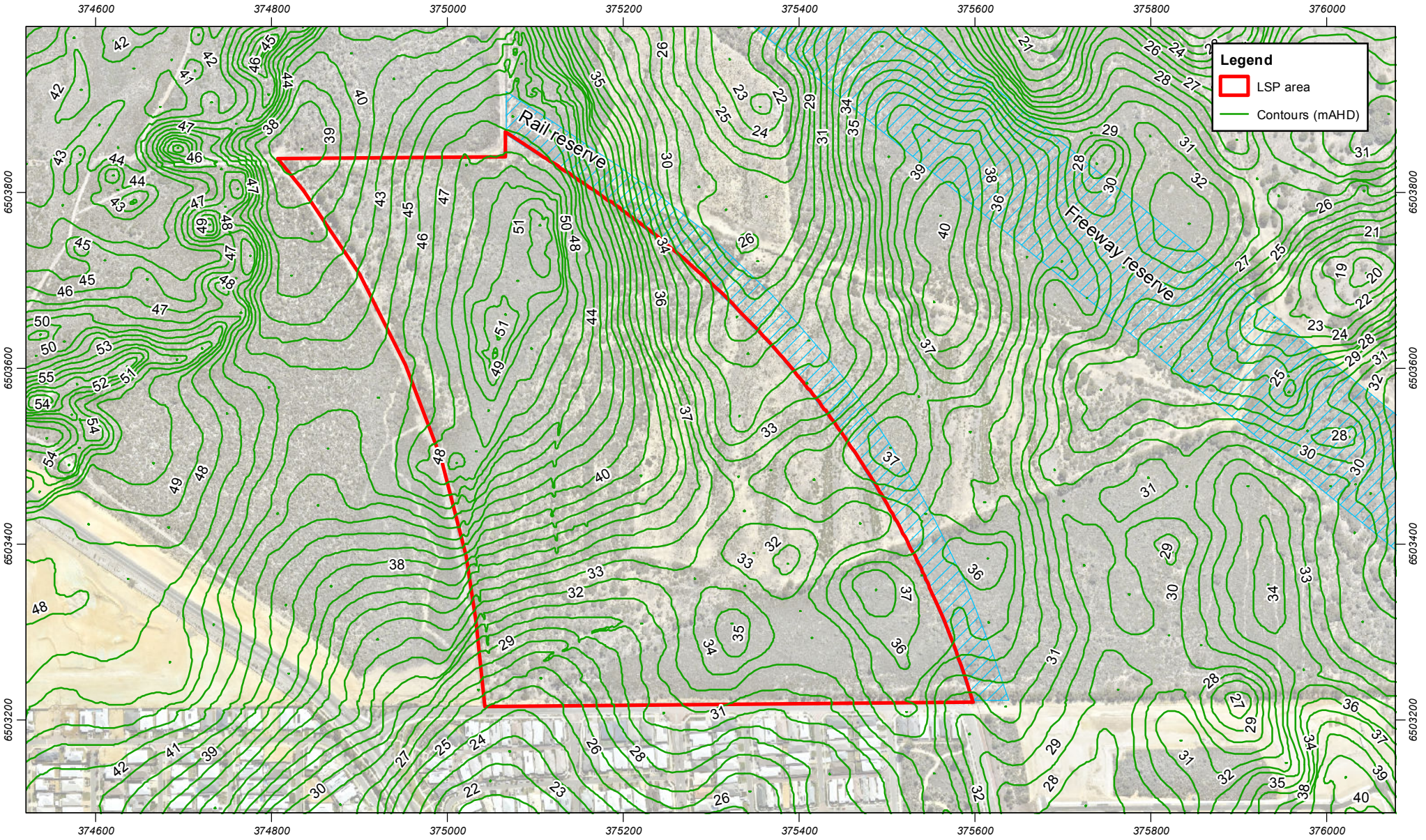

Figure 1: Topography and landforms

Scale 1:6,000 at A4

0 50 100 150 200 250 m

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Coordinate System: GDA 1994 MGA Zone 50
Note that positional errors may occur in some areas
Date: 17/01/2017
Author: JCrute
Source: Aerial image: Nearmap, flown 04/2016.

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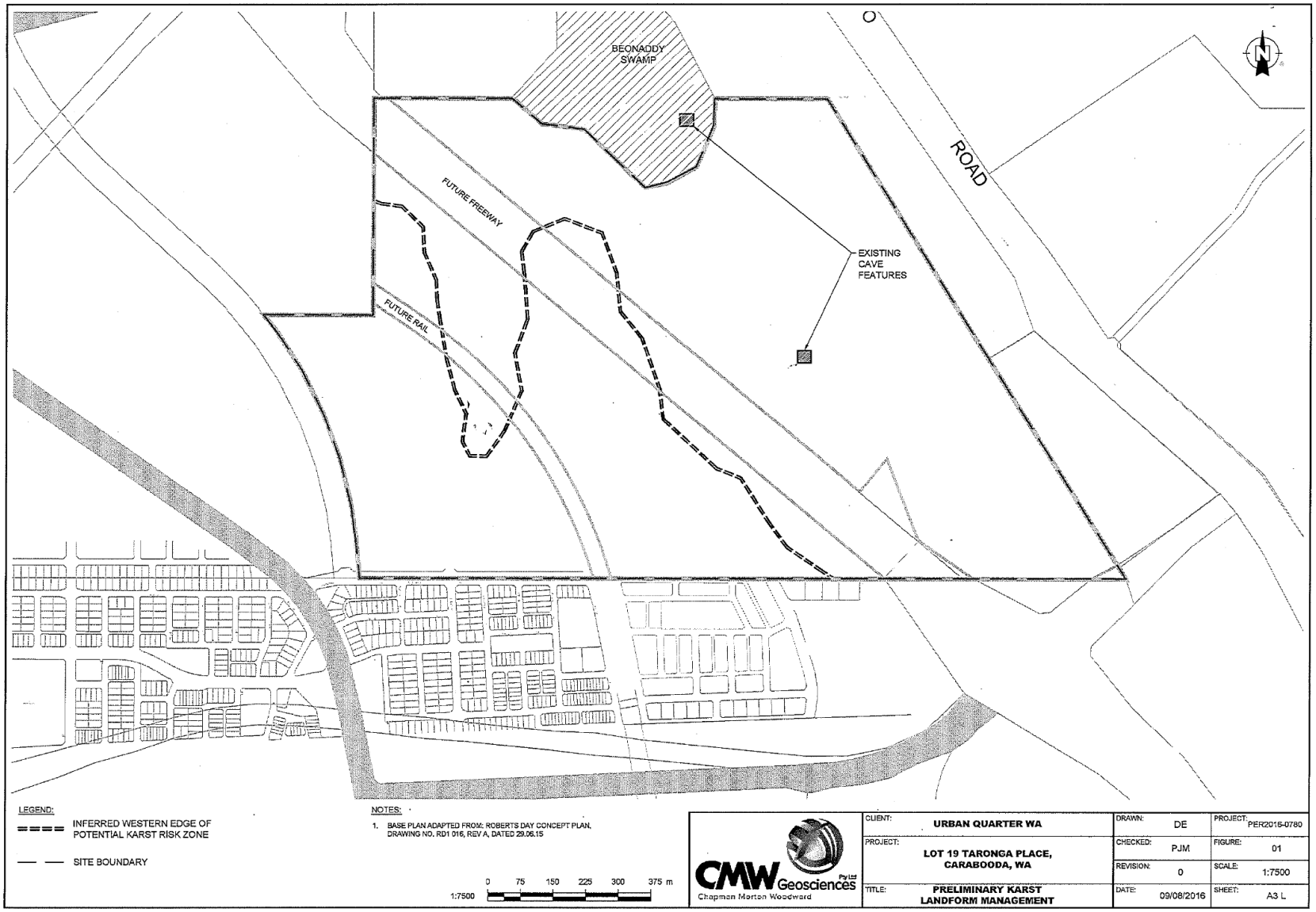

Source: CMW Geosciences

Figure 2: Preliminary Karst management

Acid Sulphate Soils

A search of the Swan Coastal Plain ASS risk mapping (Landgate 2016) identified no known risk of Acid Sulphate Soils (ASS) occurring within 3 m of the natural soil surface of the LSP area (Figure 3). As such and in consideration of the known geology, ASS investigations are not considered necessary for the LSP area.

Contamination

The Department of Environmental Regulation Contaminated Sites Database does not list the site as being a known or suspected contaminated site. A review of historical aerial photography from 1965 to present day shows that a portion of the site has been used for broad acre agricultural purposes with the majority of the site supporting native vegetation since 1965 (Landgate 2016).

1.2.2 Groundwater and surface water

Groundwater

Maximum groundwater level ranges from 2 m to 4 m AHD within Lot 6 Taronga Place and groundwater flows across the LSP area from east to west (DoW 2016, Figure 4). The depth to groundwater is over 20 m across the entire lot (DoW 2016).

The LSP area is located in a Priority 3 Public Drinking Water Source Area (PDWSA) as depicted in Figure 4. Residential and commercial developments are considered compatible with Priority 3 areas, although some commercial land uses such as service stations and warehouses may have specific conditions applied to manage water quality.

The southwest corner of the LSP area is located within a Wellhead Protection Zone (WHPZ), which are 300 m zones around wells in Priority 3 PDWSAs. The Department of Water (DoW) advises that contaminating land uses such as service stations and dry cleaners should be avoided in WHPZ in Priority 3 areas. The proposed residential development is a permitted use within the Wellhead Protection Zone (WHPZ) and therefore is not a constraint to development.

Surface water

There are no surface water bodies within the LSP area. The nearest wetland is a Sumpland Resource Enhancement Wetland (UFI 8016) adjacent to the northern boundary of Lot 6 Taronga Place (Figure 4).

The EPBC Protected Matters Search Tool indicates that there are no declared Ramsar wetlands present within 5 km of the LSP area and no Wetlands of International Importance present within 2 km of the LSP area (DEE 2016a). A Conservation Category Sumpland Wetland (UFI 8012) is located approximately 1 km north of the LSP area.

Figure 3: Acid Sulphate Soils risk

Scale 1:6,000 at A4

0 50 100 150 200 250 m

Coordinate System: GDA 1994 MGA Zone 50
Note that positional errors may occur in some areas
Date: 21/02/2017
Author: JCrute
Source: Aerial image: Nearmap, flown 04/2016.

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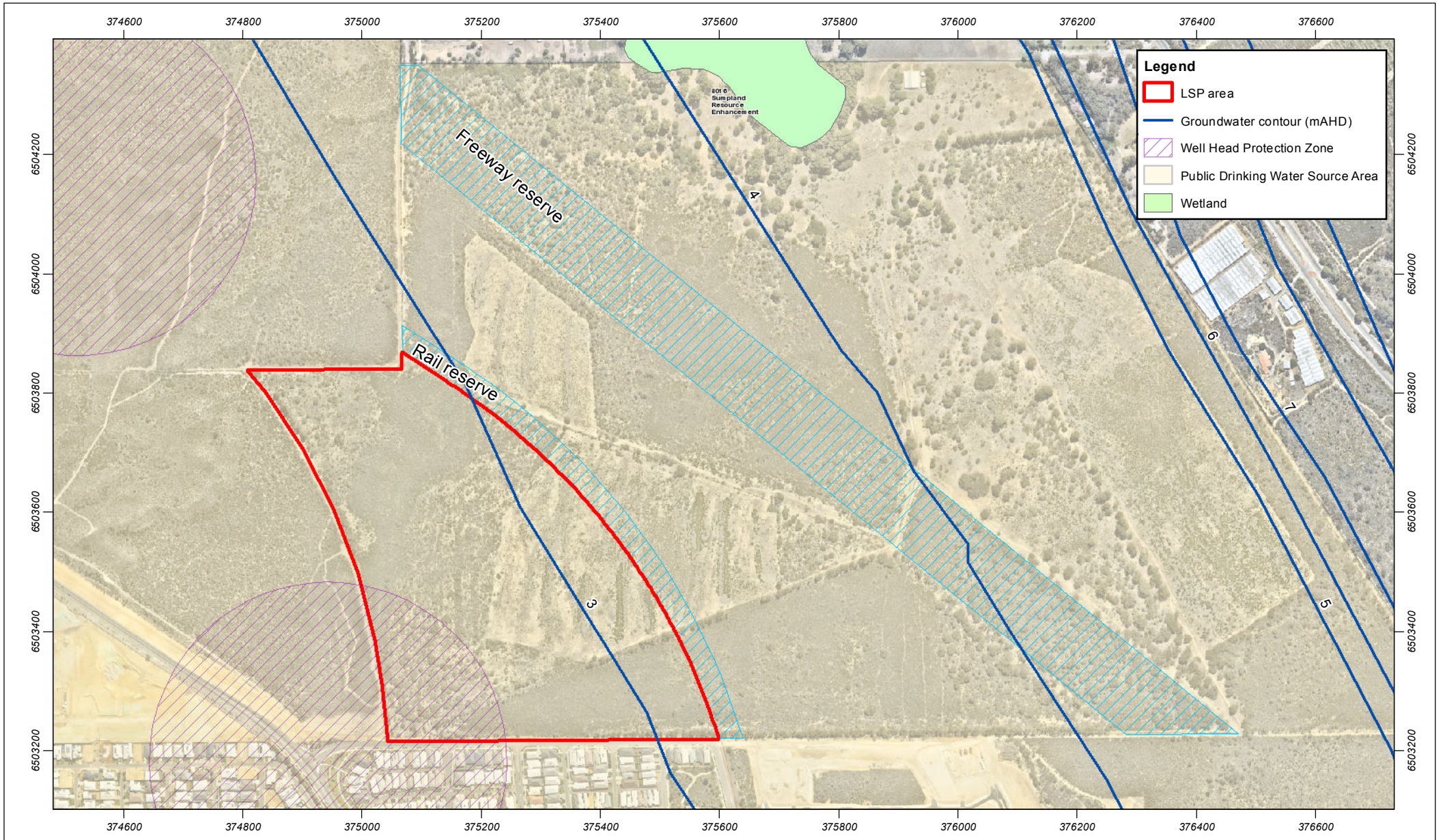

Figure 4: Groundwater and surface water

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Note that positional errors may occur in some areas
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Source: Aerial image: Nearmap, flown 04/2016. WHPZ, PDWSA: DOW 2016.

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1.2.3 Biodiversity and natural assets

The LSP area comprises remnant vegetation and cleared areas, reflecting the site's previous rural use. Semi cleared rural properties and low density residential development are located on the northern and southern bounds of Lot 6 Taronga Place, respectively. The surrounding area comprises large conservation areas including Yanchep National Park to the north, The Foreshore (coastal reserve), Alkimos masterplan conservation areas, Bush Forever sites to the north and east and Neerabup Nature Reserve to the south. These surrounding conservation parks and reserves provide extensive areas for retention of native vegetation.

Flora and vegetation

A flora and vegetation assessment was undertaken over the LSP area over two events; in late October and early November 2016 (Strategen 2016). The results of the surveys and information on the flora and vegetation within the LSP area are summarised below.

Vegetation Complex

The patterning of plant and animal distributions on the Swan Coastal Plain (SCP) is closely related to the geology, geomorphology and soils of the SCP. The LSP area is located on the Spearwood dunes, characterised by the Cottesloe Complex – Central and South. The Cottesloe Complex – Central and South has 35% of its pre-clearing extent remaining, with 18.5% proposed for protection through Bush Forever. This complex consists of mosaics of woodland of *Eucalyptus gomphocephala* and open forest of *Eucalyptus gomphocephala- Eucalyptus marginata-Corymbia calophylla*; closed heath on the limestone outcrops.

Vegetation types

The flora and vegetation survey identified nine vegetation types (VTs) within Lot 6 Taronga Place as listed below (Figure 5):

- BaBmEt – *Banksia attenuata, Banksia menziesii* and *Eucalyptus todtiana* Low Woodland over Open Heath of *Allocasuarina humilis* and *Xanthorrhoea preissii* over Low Open Shrubland of *Hibbertia hypericoides* over mixed Herbland
- BaBmBp – Banksia attenuata, Banksia menziesii, Banksia prionotes Open Low Woodland over Open Low Shrubland of Xanthorrhoea preissii and Hibbertia hypericoides over mixed Herbland including *Pelargonium capitatum and exotic grasses
- Bs – Tall Open Scrub of *Banksia sessilis* and occasional *Melaleuca huegelii* over Low Shrubland of *Melaleuca systena, Grevillea preissii* and *Calothamnus quadrifidus* over Open Sedgeland of *Lomandra maritima, Desmocladus asper, Mesomelaena pseudostygia* and *Lepidosperma squamatum*
- Ed – Woodland of *Eucalyptus decipiens* with scattered *E. todtiana* and *Allocasuarina fraseriana*, over Open Heath to Open Shrubland of *Hibbertia hypericoides* and *Calothamnus quadrifidus*
- EdBs – Woodland of *Eucalyptus decipiens* over Tall Open Scrub to Shrubland of *Banksia sessilis* and *Jacksonia sternbergiana* over Open Heath to Open Shrubland of *Hibbertia hypericoides* and *Calothamnus quadrifidus*
- EdBa – Woodland to Low Open Woodland of *Eucalyptus decipiens* and *Banksia attenuata* with Scattered *Eucalyptus todtiana* and *Allocasuarina fraseriana*, over Tall Open Scrub to Shrubland of *Banksia sessilis* and *Jacksonia sternbergiana* over Open Heath to Open Shrubland of *Allocasuarina humilis, Acacia saligna* and *Xanthorrhoea preissii* over Low Shrubland of *Hibbertia hypericoides* and *Calothamnus quadrifidus*
- Pasture – Scattered remnant *Eucalyptus* spp. and *Banksia* spp. over pasture weeds
- Planted trees – Planted *Eucalyptus* spp. over pasture weeds
- Regrowth - Recently cleared with re-emergent understory species including *Hibbertia hypericoides, Acacia pulchella, Allocasuarina humilis, Calothamnus quadrifidus* and *Conostylis aculeata.*

Of these vegetation types, five occur within the LSP area including:

- BaBmEt (8.61 ha)
- BaBmBp (1.63 ha)
- Bs (9.01 ha)
- planted trees (0.37 ha)
- regrowth (8.54 ha).

Vegetation condition

The LSP area contains approximately 28.16 ha of vegetation in varying condition, ranging from Excellent through to Completely Degraded as per the condition scale outlined in Keighery 1994 (Figure 6). Historical land use (e.g. agriculture) has impacted the vegetation condition via the introduction and spread of weeds and other human disturbance (e.g. fly tipping, vehicle use).

Conservation significant vegetation

A desktop assessment was conducted using Florabase, Parks and Wildlife, and Department of the Environment (DEE) databases to identify the possible occurrence of Threatened Ecological Communities (TECs), Priority Ecological Communities (PECs) and Threatened and Priority flora potentially occurring within the survey area. Reports that document regional flora, vegetation and fauna within the surrounds of the survey area were also reviewed prior to the field assessment. A database search request was also submitted to the Threatened Communities Branch of Parks and Wildlife to identify any potential TECs or PECs within 5 km of the survey area.

A TEC is defined under the *Environmental Protection Act 1986* (EP Act) as an ecological community listed, designated or declared under a written law or a law of the Australian Government as Threatened, Endangered or Vulnerable. There are four State categories of TECs (DEC 2010)[1]:

- presumed totally destroyed (PD)
- critically endangered (CR)
- endangered (EN)
- vulnerable (VU).

Ecological communities identified as Threatened, but not listed as TECs, are classified as PECs. These communities are under threat, but there is insufficient information available concerning their distribution to make a proper evaluation of their conservation status. Parks and Wildlife categorises PECs according to their conservation priority, using five categories, P1 (highest conservation significance) to P5 (lowest conservation significance), to denote the conservation priority status of such ecological communities (DEC 2010). A list of current PECs can be viewed at the Parks and Wildlife (2015b) website.

Four TECs and two PECs were identified within 5 km of the LSP area;

- *Banksia woodlands of the Swan Coastal Plain* (Endangered – EPBC Act)
- SCP 01: *Aquatic Root Mat Community Number 1 of Caves of the Swan Coastal Plain* (Endangered – EPBC Act, Critically Endangered – WC Act)
- FCT 26a; *Melaleuca huegelii - Melaleuca acerosa (currently M. systena) shrublands on limestone ridges* (Endangered – WC Act)
- FCT 19b: *Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain* (Endangered – EPBC Act, Critically Endangered – WC Act)
- FCT 24: *Northern Spearwood shrublands and woodlands* (Priority 3)
- FCT 30b: *Quindalup Eucalyptus gomphocephala and/or Agonis flexuosa woodlands* (Priority 3).

[1] The Department of Environment and Conservation is still listed as the author of all TEC and PEC databases and have been referred to as such in this document instead of the Department of Parks and Wildlife (Parks and Wildlife).

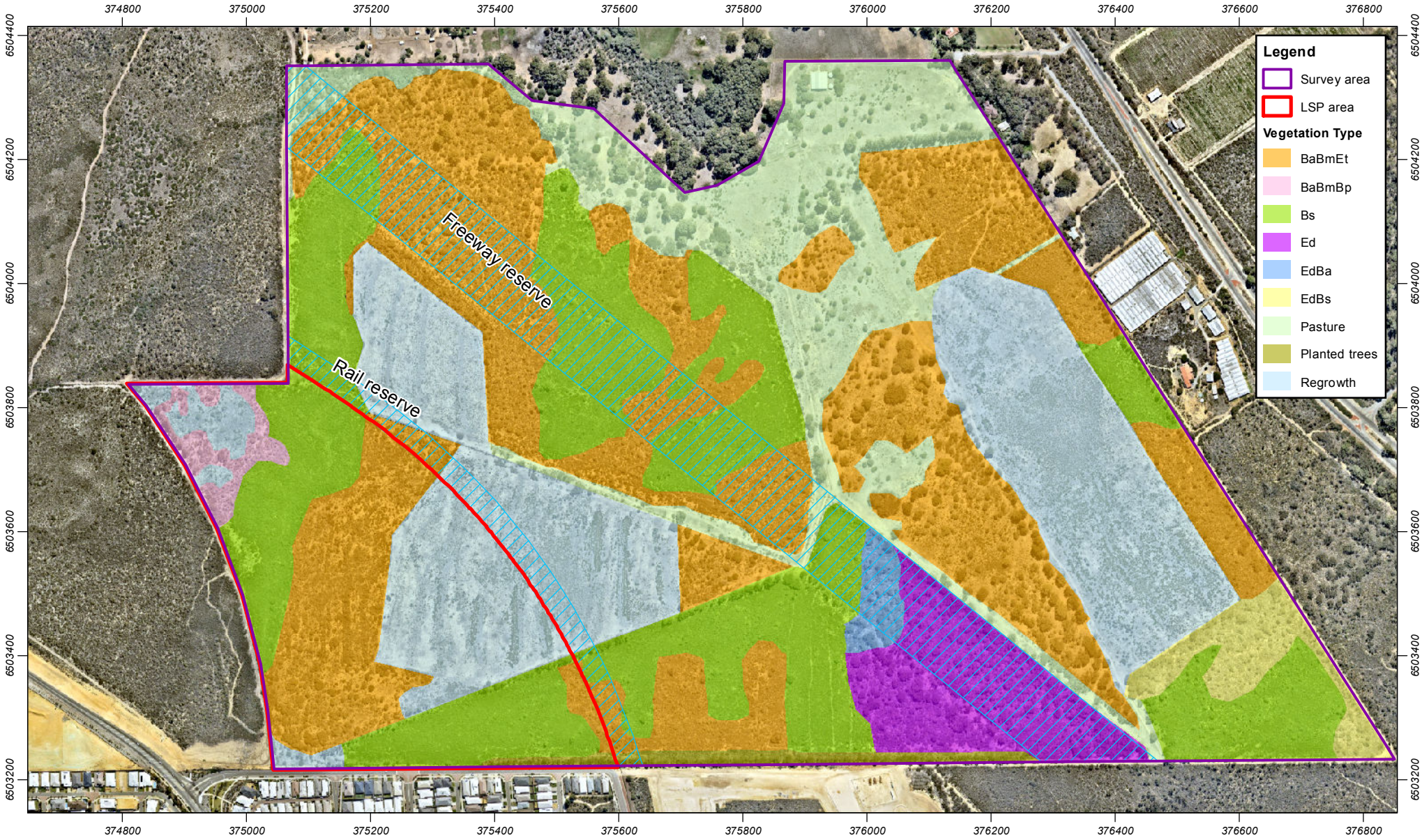

Figure 5: Vegetation types

Scale 1:8,500 at A4

0 50 100 150 200 250 m

Coordinate System: GDA 1994 MGA Zone 50
Note that positional errors may occur in some areas
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Author: JCrute
Source: Aerial image: Nearmap, flown 04/2016.

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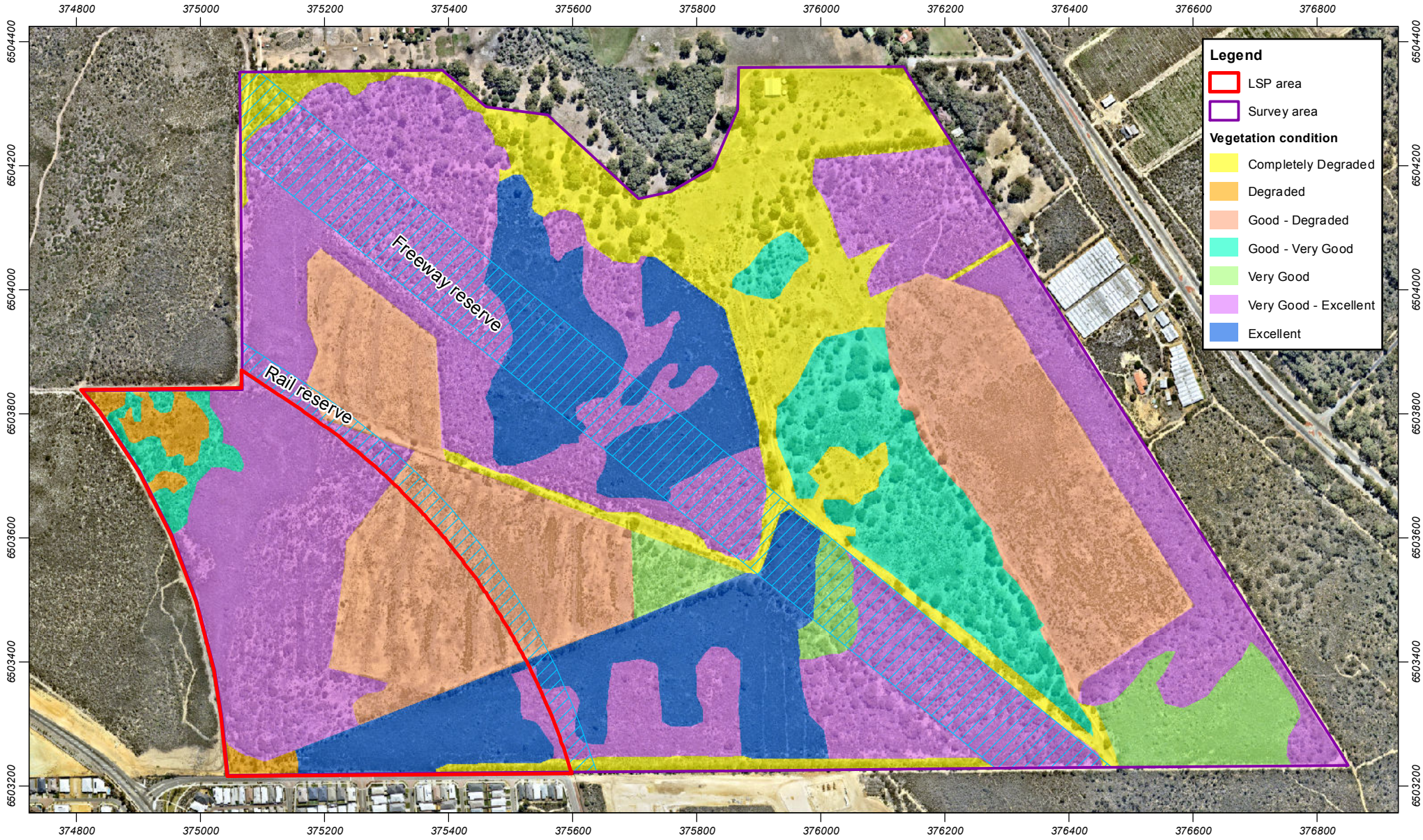

Figure 6: Vegetation condition

Scale 1:8,500 at A4

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Coordinate System: GDA 1994 MGA Zone 50
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Based on an analysis of vegetation mapping undertaken by Strategen (2016); approximately 10.24 ha of the LSP area contains the *Banksia woodlands of the Swan Coastal Plain* TEC, corresponding to VT BaBmEt and VT BaBmBp (Figure 7).

The Banksia Woodland TEC identified within the proposed action area resembles Floristic Community Type (FCT) 24: *Northern Spearwood shrublands and woodlands*, a Priority 3 PEC. This community occurs as heaths with scattered *Eucalyptus gomphocephala* on deeper soils. The community is found on the western Swan Coastal Plain, mostly on the Cottesloe unit of the Spearwood system and extends from Yanchep south to Singleton. The banksias found in this community include *Banksia attenuata* and *B. menziesii.* Typical flora species of FCT24 may include *Banksia sessilis, Calothamnus quadrifidus, Melaleuca systena, Xanthorrhoea preissii, Lepidosperma squamatum, Hardenbergia comptoniana*, and P*hyllanthus calycinus* with herbs, sedges and grasses including *Conostylis aculeata, Dianella revoluta, Lomandra maritima, Schoenus grandiflorus, Desmocladus flexuosa* and *Austrostipa flavescens*.

FCT24 has an average species richness (ASR) of 38.9 species (TSSC 2016). The ASR recorded within VT BaBmEt, VT BaBmBp and VTEdBa (i.e. vegetation types representing the Banksia TEC) was 24.0, approximately 61.7% of the ASR of FCT24. The comparatively low ASR recorded within the proposed action area reflects the historical clearing and subsequent regeneration of Banksia woodland within the area. The majority of the vegetation of the site is therefore not a high quality representation of the FCT.

Vegetation Type Bs within the LSP area bears resemblance to FCT 24 due to the presence of typical flora (e.g. *B. sessilis*), however it does not represent the *Banksia woodlands of the Swan Coastal Plain* TEC as it does not contain indicator species or a woodland structure as per the TSSC (2016). VT BaBmEt, BaBmBp and VT Bs are well represented in the surrounding vegetation and nearby conservation reserves; therefore the proposed development is not expected to impact the overall conservation status of these community types within the LSP area.

The LSP area has the potential to contain the EPBC Act listed TEC, *Aquatic Root Mat Community of Caves of the Swan Coastal Plain*. This TEC is known from caves at Yanchep which contain permanent streams/pools which provide habitat for a species rich assemblage of microflora and invertebrates. A cave has been recorded within Lot 6 Taronga Place (CMW 2016); however the cave is not within the LSP area therefore will not be impacted as a result of the development and the significant depth to groundwater on site makes the presence of this community highly unlikely.

FCT 26a and FCT 24 also have the potential to be present based on locations of such communities in the broader locality. The results of the Strategen surveys show that vegetation within the LSP area has less than 1% similarity to FCT 26a and is missing a key indicator species of the community; *Melaleuca huegelii.* It is also worth noting that the closest recording of FCT 26a to Lot 6 Taronga Place is located approximately 2 km west, in a coastal vegetation type which is more representative of the typical habitat for the TEC than what is contained within the LSP area (PGV 2012).

Vegetation within the LSP area did not resemble FCT 30b or FCT 19b.

Bush Forever

Bush Forever Sites are considered regionally significant urban bushland areas and appropriate management of them is outlined in the draft Bushland Policy for the Perth Metropolitan Region Statement of Planning Policy No 2.8 (Western Australian Planning Commission, 2010) and more specifically in Planning Bulletin No. 69 (Western Australian Planning Commission, 2004b).

No Bush Forever (BF) sites occur within the LSP area; however BF Sites 288 (Yanchep National Park and Adjacent Bushland, Yanchep), 129 (Bernard Rd, Carabooda) and 130 (link between Yanchep and Neerabup National Parks, Carabooda) occur within 1 km of the site (Figure 8). A number of conservation significant FCTs are inferred within these BF sites including FCT 19, FCT 23b, FCT 26a and FCT 28. The vegetation within the LSP area is well represented within the surrounding BF sites.

Flora

A total of 199 native vascular plant taxa from 56 plant families have the potential to occur within the LSP area (Parks and Wildlife 2007-; DEE 2015). The majority of taxa were from within the Fabaceae (19 taxa) and Proteaceae (18) families. Five Priority species have the potential to occur within the LSP area; *Leucopogon maritimus* (P1), *Hibbertia spicata* subsp*. Leptotheca* (P3)*, Stylidium maritimum* (P3), *Conostylis pauciflora* subsp*. euryrhipis* (P4) and *Conostylis pauciflora subsp. pauciflora* (P4).

A total of 103 taxa were recorded within Lot 6 Taronga Place, 18 of which were introduced species (weeds). No Threatened flora species as listed under section 178 of the EPBC Act or pursuant to Schedule 1 of the WC Act and as listed by Parks and Wildlife (2015) were recorded within the Lot. No Priority flora species as listed by Western Australian Herbarium (1998-) were recorded within the Lot. The LSP is considered to contain a small fraction of the species recorded over the entire Lot.

Introduced species

A total of 18 introduced species were recorded within Lot 6 Taronga Place. None of these species are Declared Plant species in Western Australia pursuant to section 22 of the *Biosecurity and Agriculture Management Act 2007* (BAM Act) according to the Western Australian Department of Agriculture and Food (DAFWA 2016).

Figure 7: Banksia Woodland TEC

Scale 1:6,000 at A4

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Coordinate System: GDA 1994 MGA Zone 50
Note that positional errors may occur in some areas
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Author: JCrute
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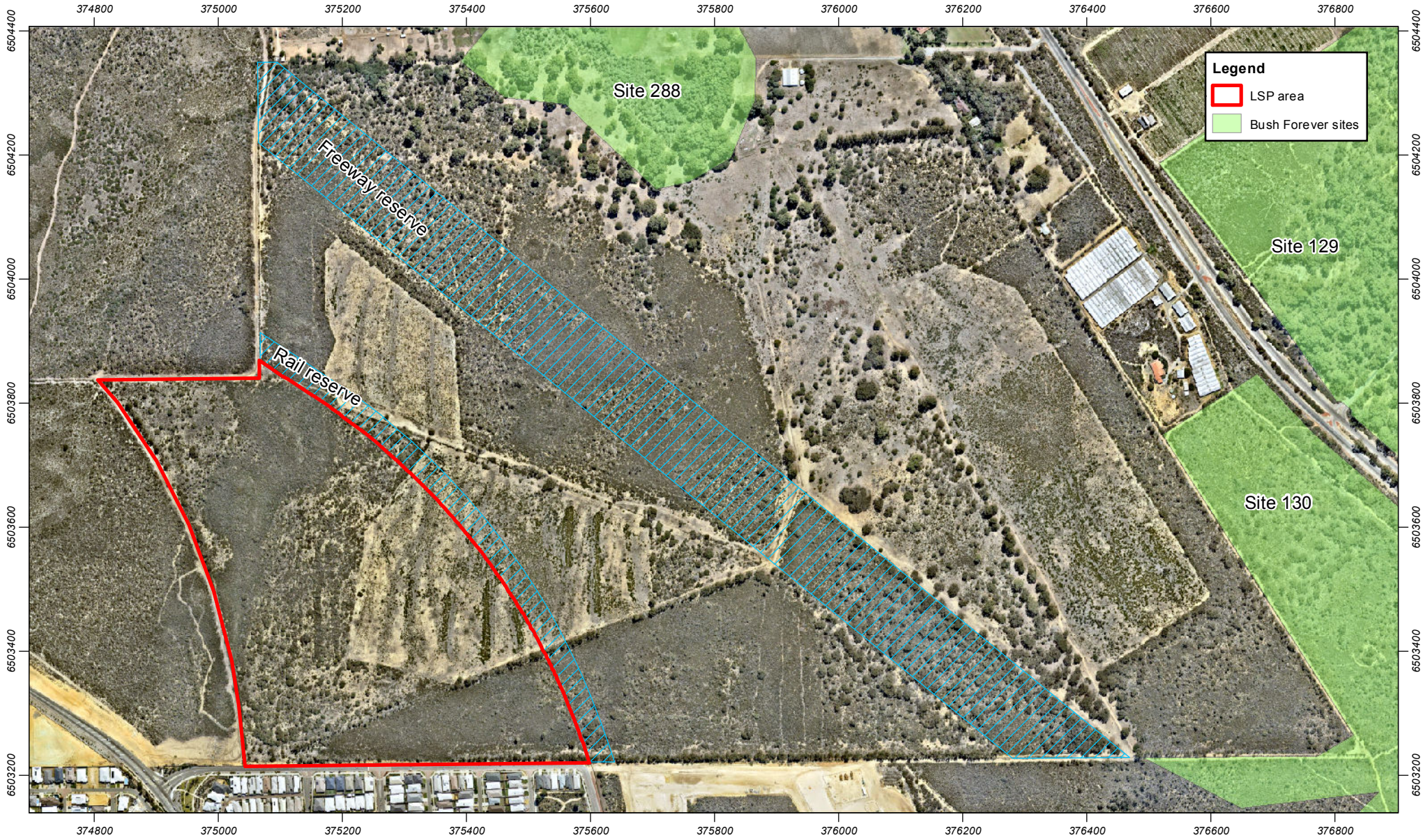

Figure 8: Bush Forever sites

Scale 1:8,500 at A4

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Coordinate System: GDA 1994 MGA Zone 50
Note that positional errors may occur in some areas
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Author: JCrute
Source: Aerial image: Nearmap, flown 04/2016.

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Fauna

Conservation significant fauna

A desktop survey identified 19 conservation significant fauna comprising 15 bird species, three mammal species and one insect species that have a potential to occur within the LSP area. This included four Threatened species (EPBC Act), 11 migratory species (EPBC Act) and four priority species (WC Act). Based on habitat requirements, the following species were considered likely to occur within the LSP area:

- *Calyptorhynchus latirostris* (Carnaby's Black Cockatoo [CBC]) – Threatened
- *Isoodon obesulus* (Southern Brown Bandicoot) – P5.

Evidence of foraging by CBC was observed during the 2016 surveys. No evidence of Southern Brown Bandicoots was recorded within the LSP area. The majority of the Migratory species are likely to be vagrant visitors to the site therefore potential impacts to these species are likely to be minimal as a result of the proposed development.

Black cockatoo habitat

Lot 6 Taronga Place was inspected for black cockatoo habitat during the 2016 supplementary surveys by three Strategen personnel with relevant experience as specified by the *EPBC Act Referral guidelines for three threatened black cockatoo species* (DSEWPaC 2012). The inspection included:

- a vegetation assessment to identify vegetation communities and potential black cockatoo foraging species
- a significant tree assessment to identify any trees with the potential to be utilised by black cockatoos for roosting or breeding.

The Lot occurs in the known habitat range of Carnaby's Black Cockatoo (CBC), based on the Carnaby's Cockatoo Recovery Plan (Parks and Wildlife 2013). CBC is listed as Threatened under the State WC Act and as Endangered under the EPBC Act. According to the *EPBC Act Referral guidelines for three threatened black cockatoo species* (DSEWPaC 2012), the Lot is not situated within the range of Forest Red-Tailed Black Cockatoos or Baudin's Black Cockatoos.

The Lot was divided into nine different VTs, five of which fall within the LSP area. Three VTs within the LSP area (BaBmEt, Bs, regrowth) contain flora species which are considered to be utilised by CBC for foraging; therefore approximately 27.8 ha of potential foraging habitat for CBC exists within the LSP area (Groom 2011, Johnstone 2010) (Figure 9). No potentially significant trees (Diameter at Breast Height [DBH] >50 cm) were recorded during the surveys therefore no potential black cockatoo breeding or roosting habitat occurs within the LSP area.

Foraging habitat for black cockatoos is generally defined as the availability of plant food sources within an area (Finn 2012). Food availability for black-cockatoos is a function of the diversity, abundance, distribution, energetic and nutritional qualities, and seasonality (phenology) of the food sources within a particular area. Table 1 summarises the value of each VT in terms of the quality of foraging habitat provided for black cockatoos. Table 2 provides a justification for how foraging values were defined.

The highest quality foraging habitat for black cockatoos was noted within BaBmEt which contained high densities of black cockatoo food species including *Banksia attenuata, Banksia menziesii, Eucalyptus todtiana* and *Banksia sessilis* at canopy and midstorey levels as well as *Mesomelaena pseudostygia* and other suitable food species in the understorey. The lowest quality foraging habitat for black cockatoos (not including cleared areas) was noted within Ed, which contained scattered *E. todtiana* and patches of *Allocasuarina fraseriana* and Pasture containing *Lupinus* sp. and scattered *Banksia* spp. and *Eucalyptus* spp., which provide limited food resources for CBC only.

Based on the results of the foraging assessment, the LSP area is considered to contain 10.2 ha of Excellent quality foraging habitat, 9.0 ha of Good quality foraging habitat, 8.5 ha of Very Poor quality foraging habitat and 0.4 ha of Nil foraging habitat for CBC.

Based on the vegetation types and condition recorded within the proposed action area, the overall habitat value for black cockatoos (i.e. foraging, breeding and roosting habitat) has been assessed and is presented in Figure 9. Overall black cockatoo habitat value within the proposed action area ranged from Nil to Good, which incorporates ratings regarding the quality foraging habitat present as well as the lack of breeding and roosting habitat within the proposed action area. The overall habitat for CBC included 10.2 ha Good quality habitat, 9.0 ha Moderate quality habitat, 8.5 ha Poor quality and 0.4 ha Nil habitat.

Figure 9: Black Cockatoo habitat

Scale 1:5,492 at A4

0 50 100 150 200 250 m

N

Coordinate System: GDA 1994 MGA Zone 50
Note that positional errors may occur in some areas
Date: 18/01/2017
Author: JCrute
Source: Aerial image: Nearmap, flown 04/2016.

Path: Q:\Consult\2016\URQ\URQ16477\ArcMap_documents\R003\RevA\URQ16477_01_R003_RevA_F009.mxd

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Table 1: Vegetation types and black cockatoo foraging species within the survey area

Vegetation type	CBC foraging species	Foraging quality	Area (ha)
BaBmEt	*Banksia attenuata, B. menziesii, Eucalyptus todtiana, B. sessilis, Xanthorrhoea preissii, Mesomelaena pseudostygia.*	Excellent	10.2
Bs	*B. sessilis.*	Good	9.0
Regrowth	*X. Preissii.*	Very Poor	8.5
Planted	Nil.	Nil	0.4

Table 2: Definition of black cockatoo foraging habitat within the survey area

Foraging quality	Justification
Excellent	High density of species suitable for foraging by black cockatoos (i.e. foliage cover of suitable species >60%) and presence of food sources at several strata (i.e. canopy, midstorey and understorey).
Good	High density of species suitable for foraging by black cockatoos (i.e. foliage cover of suitable species >60%) but food sources only present at one or two strata (i.e. canopy and midstorey).
Moderate	Moderate foraging value density of species suitable for foraging by black cockatoos (i.e. foliage cover of suitable species 20-40%) and food sources only present at one or two strata (i.e. canopy and midstorey).
Poor	Low density of species suitable for foraging by black cockatoos (i.e. foliage cover of suitable species 10-20%) and presence of food sources at only one stratum (i.e. canopy).
Very poor	Very low density of species suitable for foraging by black cockatoos (i.e. foliage cover of suitable species <10%) and presence of food sources at only one stratum (i.e. canopy).
Nil	Cleared areas - no suitable vegetation present.

1.2.4 Bushfire management

The LSP area is located in a designate bushfire prone area as per the Western Australia State Map of Bush Fire Prone Areas (DFES 2016). As a result, Strategen has prepared a Bushfire Management Plan (BMP) to support the Structure Plan in accordance with *State Planning Policy 3.7: Planning in Bushfire Prone Areas*. The BMP will be updated concurrently with future planning stages, including at Structure Plan and subdivision stage.

Vegetation surrounding the LSP area will have the greatest impacts on bushfire management outcomes for the site. This vegetation has led to the designation of bushfire prone land on most boundaries of the LSP area. Vegetation with a 'Moderate' or 'Extreme' bushfire hazard level is considered bushfire prone and any proposed development within 100 m of the bushfire prone vegetation extent will require application of Australian Standard AS 3959-2009 *Construction of Buildings in Bushfire-prone Areas* (SA 2009) via implementation of increased building construction standards in response to the assessed Bushfire Attack Level (BAL). Once the project area is cleared of vegetation in preparation of development there will only be a small proportion of the project area which will be located within bushfire prone land, which will require a BAL response in accordance with AS 3959-2009. This is largely consistent with findings of the *WA State Map of Bush Fire Prone Areas*.

Retained vegetation or revegetated areas within the LSP area will potentially trigger the application of BAL ratings on lots within 100 m of the vegetated areas. Clearing will occur throughout the LSP area on a staged basis and in advance where necessary to ensure building construction levels are not conflicted by temporary vegetation extent located within adjacent development stages yet to be cleared. This can be achieved by ensuring each approved stage subject to construction is surrounded by an on-site cleared or low threat buffer prior to development (not including vegetation proposed to be retained). Once the buffers are created, they will need to be maintained on a regular and ongoing basis at a fuel load less than 2 t/ha to achieve a low threat minimal fuel condition all year round until such time that the buffer area is developed as part of the next development stage. This will also assist in managing the current on-site woodland bushfire hazards in proximity to proposed development.

Individual lots adjacent to vegetation outside of the LSP area will be located outside of the BAL FZ and BAL 40 contours therefore meeting the intent of State Planning Policy 3.7 *Planning in Bushfire Prone Areas*. The width of hazard separation has been determined on the basis of compliance with a BAL 12.5, BAL 19 and BAL 29 rating under AS 3959–2009. Hazard separation zones will be maintained between all proposed lots and classified vegetation in the form of road reserves, landscaped buffers and cleared land. Full 80 m wide Hazard Separation Zones (HSZs) are not required in this instance, since proposed construction for each proposed dwelling meets the standard appropriate to the BAL for that location and does not exceed BAL 29 (WAPC 2015b).

1.3 Cultural heritage

Aboriginal heritage

The Department of Aboriginal Affairs Aboriginal Heritage Inquiry System (AHIS) did not identify any Registered Sites or Other Heritage Places within the LSP area (DAA 2016). Similarly, there are no listings of Heritage areas under the Municipal Heritage Inventory or the Heritage List as per the City of Wanneroo District Planning Scheme No. 2.

Two Aboriginal heritage sites occur within 1 km of Lot 6 Taronga Place, site 17451 occurs 0.5 km to the north of the site and site 1018 occurs 1 km to the east (DAA 2016). These sites will not be impacted by the development. The Aboriginal Heritage Inquiry System identified no other Heritage Places present in or within 2 km of the Lot (DAA 2016).

European heritage

There are no places listed in the Commonwealth Heritage Places Register within the LSP area (DEE2016b).

2. Conclusions and Potential constraints

The environmental values and attributes of Lot 6 Taronga Place and the LSP area have been investigated to support the preparation of an LSP for the proposed Urban Quarter development.

The key findings and conclusions of the environmental assessment are as follows:

- no ASS risk was identified therefore no further investigations are required
- the identified Karst poses low risk and can be adequately managed
- five vegetation types are found within the LSP area including 0.37 ha of planted trees and 8.54 ha of regrowth
- historical land use (e.g. agricultural use and other human disturbance) has impacted the vegetation condition via the introduction and spread of weeds
- there are no Bush Forever sites occurring with the structure plan area
- no Threatened flora species were recorded within the LSP area
- no potentially significant trees were recorded during the surveys and therefore no potential black cockatoo breeding or roosting habitat occurs within the LSP area
- no conservation significant wetlands occur within the LSP area
- no registered Aboriginal sites or European heritage sites occur within the LSP area
- bushfire risk can be managed within the site to achieve compliance with State Planning Policy 3.7.

Environmental considerations are limited to those associated with vegetation clearing on the site. Based on the assessment undertaken within the LSP area, the proposed development will potentially impact the following:

- up to 28.2 ha of native vegetation
- up to 10.2 ha of Good and 9.0 ha of Moderate black cockatoo habitat
- up to 10.2 ha of Banksia Woodland TEC.

Based on the constraints listed above, Urban Quarter has referred the proposed development under the EPBC Act for approval. This approvals process is separate to the LSP approval. An environmental offset package has also been developed as part of this approval process. Where possible, vegetation will be retained within Public Open Space areas. Further measures to manage and mitigate potential impacts will be proposed during the detailed design of the project.

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APPENDIX 3

Bushfire Management Plan (Strategen)

FPA AUSTRALIA | Fire Protection Association Australia | Life. Property. Environment.

BPAD Bushfire Planning & Design

Bushfire Management Plan Coversheet

This Coversheet and accompanying Bushfire Management Plan has been prepared and issued by a person accredited by Fire Protection Association Australia under the Bushfire Planning and Design (BPAD) Accreditation Scheme.

Bushfire Management Plan and Site Details

Site Address / Plan Reference: Lot 6 Taronga Place

Suburb: Eglinton **State:** WA **P/code:** 6034

Local government area: City of Wanneroo

Description of the planning proposal: Structure Plan for a portion of Lot 6

BMP Plan / Reference Number: URQ16447 R002 **Version:** Rev 2 **Date of Issue:** 10/03/2017

Client / Business Name: Urban Quarter

Reason for referral to DFES	Yes	No
Has the BAL been calculated by a method other than method 1 as outlined in AS3959 (tick no if AS3959 method 1 has been used to calculate the BAL)?	☐	☒
Have any of the bushfire protection criteria elements been addressed through the use of a performance principle (tick no if only acceptable solutions have been used to address all of the BPC elements)?	☐	☒

Is the proposal any of the following special development types (see SPP 3.7 for definitions)?

Unavoidable development (in BAL-40 or BAL-FZ)	☐	☒
Strategic planning proposal (including rezoning applications)	☒	☐
Minor development (in BAL-40 or BAL-FZ)	☐	☒
High risk land-use	☐	☒
Vulnerable land-use	☐	☒

If the development is a special development type as listed above, explain why the proposal is considered to be one of the above listed classifications (E.g. considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

Strategic Planning Proposal - Structure Plan

Note: The decision maker (e.g. local government or the WAPC) should only refer the proposal to DFES for comment if one (or more) of the above answers are ticked "Yes".

BPAD Accredited Practitioner Details and Declaration

Name	Accreditation Level	Accreditation No.	Accreditation Expiry
Daniel Panickar	Level 2	BPAD 37802	31/12/2017
Company		**Contact No.**	
Strategen Environmental		9380 3100	

I declare that the information provided within this bushfire management plan is to the best of my knowledge true and correct

Signature of Practitioner  **Date** 10/03/2017

intelligent outcomes | respected experience

Bushfire Management Plan

Lot 6 Taronga Place, Eglinton

Prepared for
Urban Quarter
by Strategen

March 2017

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Bushfire Management Plan

Lot 6 Taronga Place, Eglinton

Strategen is a trading name of
Strategen Environmental Consultants Pty Ltd
Level 1, 50 Subiaco Square Road Subiaco WA 6008
ACN: 056 190 419

March 2017

Limitations

Scope of services

This report ("the report") has been prepared by Strategen Environmental Consultants Pty Ltd (Strategen) in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Strategen. In some circumstances, a range of factors such as time, budget, access and/or site disturbance constraints may have limited the scope of services. This report is strictly limited to the matters stated in it and is not to be read as extending, by implication, to any other matter in connection with the matters addressed in it.

Reliance on data

In preparing the report, Strategen has relied upon data and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise expressly stated in the report, Strategen has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Strategen has also not attempted to determine whether any material matter has been omitted from the data. Strategen will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Strategen. The making of any assumption does not imply that Strategen has made any enquiry to verify the correctness of that assumption.

The report is based on conditions encountered and information received at the time of preparation of this report or the time that site investigations were carried out. Strategen disclaims responsibility for any changes that may have occurred after this time. This report and any legal issues arising from it are governed by and construed in accordance with the law of Western Australia as at the date of this report.

Environmental conclusions

Within the limitations imposed by the scope of services, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted environmental consulting practices. No other warranty, whether express or implied, is made.

Client: Urban Quarter

Report Version	Revision No.	Purpose	Strategen author/reviewer	Submitted to Client	
				Form	Date
Draft Report	Rev A	For review by Client	L Ramlee / D Panickar (BPAD 37802)/ R Banks (BPAD 36857)	Electronic	15 Dec 2016
Final Report	Rev 0	For submission to CoW	D Panickar (BPAD 37802) / R Banks (BPAD 36857)	Electronic	4 Jan 2017
Final Report	Rev 1	For submission to CoW	D Panickar (BPAD 37802) / R Banks (BPAD 36857)	Electronic	31 Jan 2017
Final Report	**Rev 2**	**For submission to CoW**	**D Panickar (BPAD 37802)**	**Electronic**	**10 Mar 2017**

Filename: URQ16447_01_R002_Rev 2 - 10 March 2017

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1. Introduction

Urban Quarter is proposing to develop Lot 6 Taronga Place, Eglinton, in the City of Wanneroo (the subject site) for residential and commercial development. A Structure Plan has been prepared for a portion of the subject site (the project area) which includes residential lots, roads and areas of active and managed public open space (POS).

Due to the current extent of on-site and adjacent vegetation, the subject site and project area are designated as bushfire prone, as outlined on the Western Australian *Map of Bush Fire Prone Areas* (DFES 2016). As a result, Strategen has prepared this BMP to support the Structure Plan in accordance with *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7; WAPC 2015a).

This BMP has been prepared in accordance with the Guidelines and addresses all of the information requirements to satisfy SPP 3.7 specific to the Structure Plan stage for this project.

This BMP provides a compliant bushfire management response for proposed development based on the proposed post-development state of the on-site and surrounding fire environment.

This Bushfire Management Plan (BMP) will be updated concurrently with future planning stages, including at Structure Plan and subdivision stage.

1.1 Purpose and application of the plan

The purpose of the BMP is to provide guidance on how to plan for and manage the potential bushfire risk to future assets of the project through implementation of a range of bushfire risk mitigation measures. The BMP outlines how future on-site assets can be protected during the summer months when the threat from bushfire is at its peak. This is particularly relevant when existing fire appliances in the area may be unable to offer an immediate emergency suppression response; therefore, development planning and design should aim to provide mitigation strategies that protect future life and property from bushfire as a priority.

2. Spatial consideration of bushfire threat

2.1 Existing site characteristics

2.1.1 Location

The project area comprises approximately 28.03 ha of land within Lot 6 Taronga Place, Eglinton. The subject site is bound by the following, as depicted in Figure 1:

- Bushland and cleared land to the north and east
- Residential development to the south
- Marmion Avenue and remainder of Lot 6 to the west.

2.1.2 Zoning and land use

The subject site is currently zoned 'Urban' under the Metropolitan Regional Scheme (MRS) and 'Urban Development' under provisions of the City of Wanneroo Local Planning Scheme No. 2.

Land surrounding the subject site is zoned 'Urban Development' under the City of Wanneroo Local Planning Scheme. Land surrounding the subject site is zoned 'Urban' under the MRS.

The subject site is currently undeveloped and contains woodland vegetation.

2.1.3 Assets

The subject site currently contains no property assets due to the undeveloped nature of the site. Proposed development will significantly increase these critical assets in that the number of residents, visitors and built assets will be intensified across the subject land.

The subject site contains environmental assets in the form of intact *Banksia woodlands of the Swan Coastal Plain* Threatened Ecological Community (TEC) which also potentially contains habitat for black cockatoos.

The presence of and potential impacts on environmental assets have been considered as part of standard referral requirements for strategic planning proposals under the *Environmental Protection Act 1986* and *Environment Protection and Biodiversity Conservation Act 1999.* A banksia woodland retention plan has been proposed, which allows for 10.3 ha of banksia woodland to be retained within the subject site (more than 100 m from the project area).

2.1.4 Access

The subject site is currently accessed via Bluewater Drive from the south (Figure 1). There are no formal access ways currently constructed within the subject site, only a network of informal tracks and boundary firebreaks.

2.1.5 Water and power supply

The subject site is currently un-serviced.

Created by ENVIRONMAPS | e. simoncrofts@environmaps.com.au | p. 0406 590 006

Legend

- Project Area
- 100m Wide Assessment Area
- Cadastre
- Freeway Reserve
- Railway Reserve

Scale: 1:4,000 @ A3

0 15 30 60 90 120 150 Meters

N

Coordinate System: GDA 1994 MGA Zone 50
Note: Position errors may occur in some areas
Date: 13/12/2016
Author: ENVIRONMAPS
Source: Cadastre - Landgate, 2016
Orthophoto - Nearmaps, 04.11.16

5003
15
5003
17
6
9019
MARMION AV
BLUEWATER DR
MERIDIAN AV
SHIPMASTER AV
SHIPMASTER AV
FLARE WY
LATITUDE L
GUNWALE L
DRAFT WY
CHINE WY
TOPSAIL LOOP
CAMBER LINK
LEEWAY LOOP
CHESSTREE AV
LEEWAY LOOP
1578
9024
1579

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Lot 6 Taronga Place, Eglinton

Site Overview

Figure 1

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2.2 Existing fire environment

2.2.1 Vegetation

Strategen has assessed vegetation class within the project area and adjacent 100 m through on-ground verification.

Vegetation was assessed in accordance with the *Visual guide for bushfire risk assessment in* Western Australia (DoP 2016) and *Australian Standard 3959-2009 Construction of Buildings in Bushfire Prone Areas* (AS 3959-2009: SA 2009). The following provides a summary of the vegetation classes within 100 m of the project area, as depicted in Figure 2a:

- subject site consists of:
  - Class B woodland (Plate 1; Plate 2, Plate 3; Plate 4; Plate 5; Plate 6)
  - Class C shrubland (Plate 7; Plate 8; Plate 9; Plate 10)
  - Class D scrub (Plate 11; Plate 12)

Vegetation that is currently managed in a low threat, minimal fuel condition is excluded from classification under Clause 2.2.3.2 (f) of AS 3959. Any non-vegetated areas occupied by waterways, rocky outcrops, roads, dwellings or other infrastructure are excluded from classification under Clause 2.2.3.2 (e) of AS 3959.

Strategen emphasises that the vegetation extent discussed above and mapped in Figure 2a displays current site conditions and does not take into account vegetation clearing proposed as part of development. Therefore, the mapped extent of Clause 2.2.3.2 exclusions within the project area will increase as development progresses throughout the site as shown in Figure 2b.

Vegetation to the east of the project area (with the exception of a small pocket of conservation POS) will be cleared as part of the development (Figure 2b). Urban Quarter owns this land as per the Certificate of Title in Appendix 3 and will maintain this area as per Clause 2.2.3.2 exclusions in perpetuity.

The above information has been used to inform a pre-development and post-development bushfire hazard level assessment for the project area.

2.2.2 Site topography and effective slope

Strategen has assessed site topography and effective slope under classified vegetation within the project area and adjacent 100 m through on-ground verification in accordance with AS 3959 methodology (Figure 2a; Figure 2b).

Site observations indicate that vegetation within the project area and adjacent 100 m is situated on either flat ground or on land with an effective slope of 0-5 degrees.

Plate 1: Class B woodland (Note narrow strip of *Eucalypt globulus* along boundary)

Plate 2: Class B woodland

Plate 3: Class B woodland with Planting of *E globulus*

Plate 4: Class B woodland

Plate 5: Class B woodland

Plate 6: Class B woodland

Plate 7: Class C shrubland

Plate 8: Class C shrubland

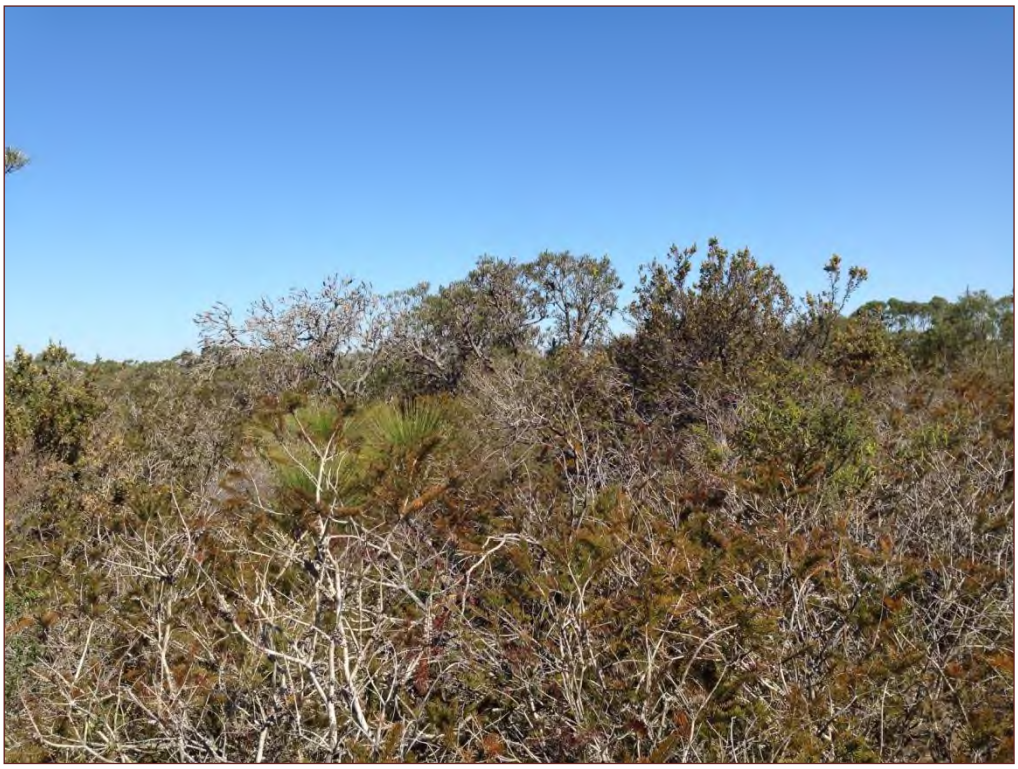

Plate 9: Class C shrubland (<2 m tall)

Plate 10: Class C shrubland (<2 m tall)

Plate 11: Class D scrub (>2 m tall)

Plate 12: Class D scrub

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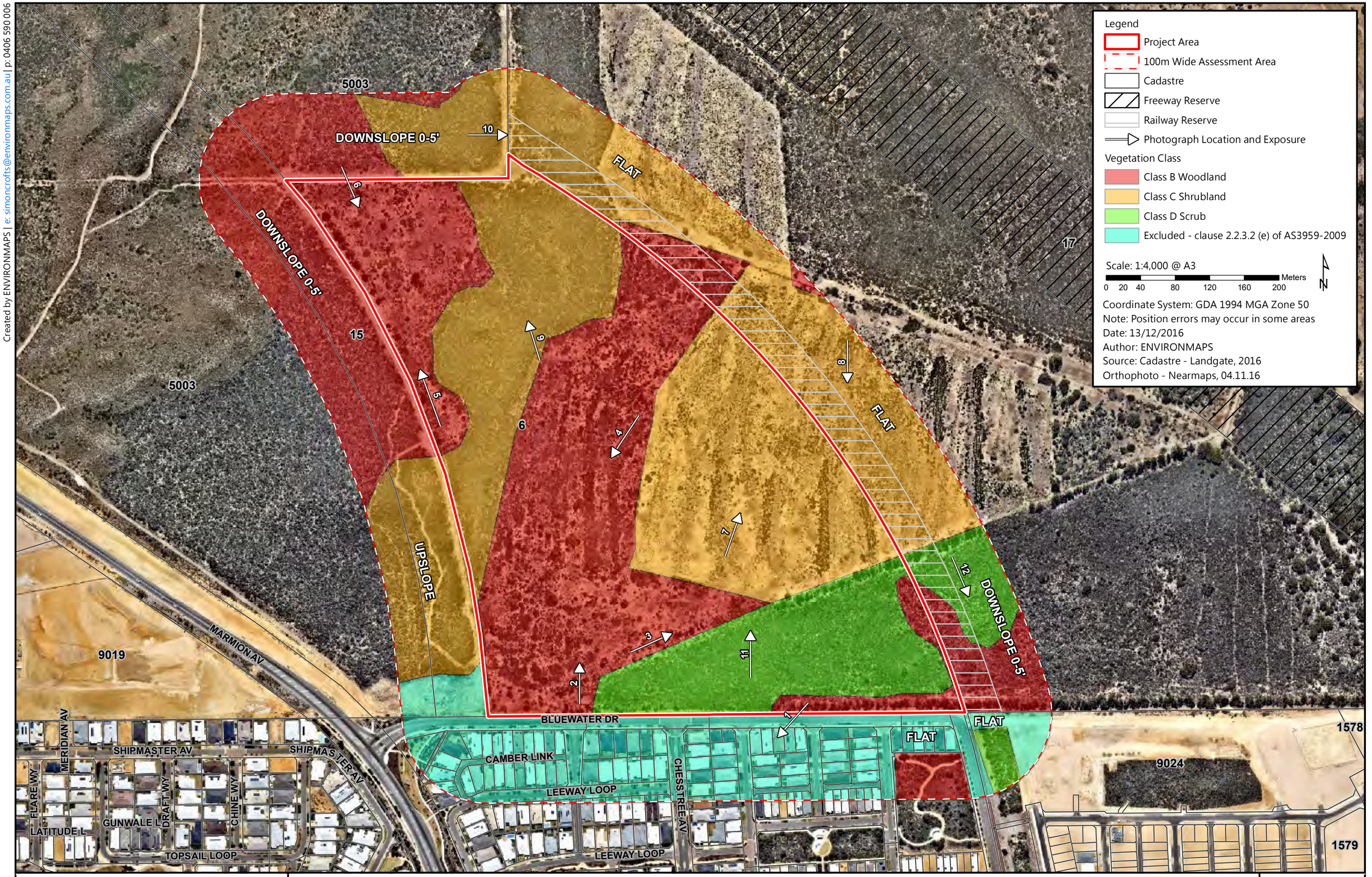

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Lot 6 Taronga Place, Eglinton

Vegetation Class (Pre-development)

Figure 2a

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Legend

- Project Area
- 100m Wide Assessment Area
- Cadastre
- Freeway Reserve
- Railway Reserve
- Photograph Location and Exposure

Vegetation Class

- Class B Woodland
- Class C Shrubland
- Class D Scrub
- Excluded - clause 2.2.3.2 (e) of AS3959-2009
- Excluded - clause 2.2.3.2 (e) and (f) of AS3959-2009

Scale: 1:4,000 @ A3

0 20 40 80 120 160 200 Meters

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Coordinate System: GDA 1994 MGA Zone 50
Note: Position errors may occur in some areas
Date: 29/01/2017
Author: ENVIRONMAPS
Source: Cadastre - Landgate, 2016
Orthophoto - Nearmaps, 04.11.16

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FLAT
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12
DOWNSLOPE 0-5'
UPSLOPE
3
11
2
1
BLUEWATER DR
FLAT
FLAT
1578
9024
1579
CAMBER LINK
LEEWAY LOOP
CHESSTREE AV
LEEWAY LOOP
MARMION AV
9019
MERIDIAN AV
SHIPMASTER AV
SHIPMASTER AV
FLARE WY
GUNWALE L
DRAFT WY
CHINE WY
LATITUDE L
TOPSAIL LOOP

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Lot 6 Taronga Place, Eglinton

Vegetation Class (Post-development)

Figure 2b

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2.2.3 Bushfire weather conditions

Climate statistics

The Eglinton locality experiences a Mediterranean climate characterised by mild, wet winters and warm to hot, dry summers. The nearest Bureau of Meteorology (BoM) weather station at Gingin Aero (Station No. 009178), located approximately 22 km from the subject site, provides average monthly climate statistics for the locality.

Average annual rainfall recorded at Gingin Aero is 620.2 mm (BoM 2016). Rainfall may occur at any time of year; however, most occurs in winter in association with cold fronts from the southwest. Highest temperatures occur between November and March, with average monthly maximums ranging from 28°C in November to 33.3°C in February (BoM 2016). Lowest temperatures occur between May and October, with average monthly minimums ranging from 6.2°C in July to 9.2°C in October (BoM 2016).

Worst case bushfire weather conditions

Southwest Western Australia generally experiences a cool to mild growing season in the months of August through to November of each year, followed by four months of summer drought conditions, which is when the potential for bushfire occurrence is at its peak.

Worst case (adverse) bushfire weather conditions can occur during this dry period when a low pressure trough forms off the west coast and strong winds develop from the north or northeast. These conditions are sometimes associated with 'Extreme' or 'Catastrophic' fire dangers, which are consistent with very high temperatures, low relative humidity and very strong winds. Based on the predominant summer climatic conditions of the local area, 'Extreme' and 'Catastrophic' fire dangers normally occur less than 5% of the time during the designated bushfire season, which equates to around six days between December and March (McCaw & Hanstrum 2003).

Predominant bushfire weather conditions

Predominant fire weather conditions are considered to occur 95% of the time during the designated bush fire season and these conditions generally align with average summer climatic conditions of the locality.

Average 9:00 am and 3:00 pm January wind profiles for Gingin Aero are contained in Appendix 2. These profiles illustrate that the predominant winds during the designated bush fire season are from the east and southeast in the morning averaging around 20.9 km/h; and from the southwest in the afternoon averaging around 25.5 km/h (BoM 2016).

The mean 9:00 am and 3:00 pm relative humidity for Gingin Aero during the designated bush fire season is around 48% and 33% respectively, with average monthly maximum temperatures peaking at around 33.3°C in February. These predominant fire weather conditions correlate with an average fire danger index of 'High', as determined using the Commonwealth Science and Industrial Research Organisation Fire Danger and Fire Spread Calculator (CSIRO 1999).

2.2.4 Bushfire history, fuel age, risk of ignition and potential ignition source

City of Wanneroo is rated as one of the high bushfire risk areas in Western Australia, which is indicative of a significant vegetation extent situated within or adjacent to urban or rural-urban developments in such localities as Yanchep, Alkimos and Jindalee.

The subject site has likely been subject to infrequent bushfires, however, no documented bushfire history is available. During the flora and vegetation assessment conducted by Strategen in October 2016, it was noted that fire age across most of the vegetation was over ten years, indicating the area has not been burnt for at least ten years.

On 16 January 2009, an uncontrolled bush fire burnt through approximately 8 000 ha of vegetation at Yanchep National Park, north of the subject site. Power lines and poles, parts of the Pinjar pine plantation were destroyed.

The current ignition risk within the project area is considered to be low to moderate due to the low levels of existing residency, public access and visitation throughout the location and surrounding land. Strategen considers that the ignition risk may increase following development intensification given that current levels of public access and resident occupancy at the bushland interface are low.

The potential sources of ignition in the area are expected to be from:

- deliberately lit fire (i.e. arson)
- lightning strike
- accidental causes, such as vehicle accidents and sparks from vehicle exhausts/machinery
- escapes from fuel hazard reduction burning
- incorrect disposal of cigarettes.

2.2.5 Potential bushfire scenarios

Strategen considers a fire front approaching the subject site from the east to west to be the worst case bushfire scenario, due to the bushfire run at a landscape scale within vegetation in these directions. However, given that likely afternoon summer prevailing winds are from the southwest this worst case scenario is not considered to pose a significant bushfire risk.

2.2.6 Bushfire suppression response capability

Local Bush Fire Brigades stationed at Two Rock and Quinns Rocks are expected to provide a best case emergency suppression response time of 30 minutes should a bushfire threaten lives or homes on or adjacent to the subject site.

2.3 Pre-development bushfire hazard level assessment

Strategen has mapped the pre-development bushfire hazard levels on and within 100 m of the subject site (Figure 3a). The bushfire hazard levels have been assessed on the basis of the vegetation classes identified in Section 2.2.1, the current pre-development extent of vegetation within the site and the effective slope under classified vegetation assessed in Section 2.2.2.

All woodland and scrub (Class B and D) vegetation has been assigned a bushfire hazard level of ‘Extreme’. All shrubland (Class C) vegetation has been assigned a hazard level of ‘Moderate’. Areas within 100 m of woodland (Class B), scrub (Class D) and shrubland (Class C) vegetation have been assigned a bushfire hazard level of ‘Moderate’.

Strategen emphasises that the vegetation extent discussed above and mapped in Figure 3a displays current site conditions and does not take into account vegetation clearance proposed as part of the development. Therefore, the mapped extent of AS 3959 Clause 2.2.3.2 exclusions within the subject site will increase as development progresses throughout the site.

2.4 Post-development bushfire hazard level assessment

The existing vegetation extent within the subject site will be cleared, due to the low fuel outcome of the proposed urban development. The proposed development will include 3.16 ha of POS which will constitute excluded vegetation as per clause 2.2.3.2 of AS 3959-2009. Strategen reiterates that this hazard level mapping will be revised at future planning stages to accurately reflect the on-ground status of vegetation at the time of future assessments.

Strategen has mapped the post development bushfire hazard levels on and within 100 m of the subject site on the basis of current vegetation extent within the subject site being cleared to accommodate proposed urban development. All woodland and scrub (Class B and D) vegetation has been assigned a bushfire hazard level of ‘Extreme’. All shrubland (Class C) vegetation has been assigned a hazard level of ‘Moderate’. Areas within 100 m of woodland (Class B), scrub (Class D) and shrubland (Class C) vegetation have been assigned a bushfire hazard level of ‘Moderate’.

Figure 3b demonstrates that post development vegetation extent will result in the entirety of the subject site being located within a 'Moderate' or 'Low' bushfire hazard level area.

2.5 Identification of any bushfire hazard issues

There is limited landscape scale bushfire risk or fire run through dense vegetation or steep terrain adjacent to the subject site. There will be no bushfire risk or fire run within the subject site post development.

The bushfire risk to proposed development poised by these hazards can be managed through standard application of acceptable solutions under the Guidelines, as well as through a direct bushfire suppression response if required.

On completion of the development, there will be a reduced bushfire risk to future assets of the site as a result of vegetation clearing that will be undertaken to facilitate development. Vegetation clearing throughout the project staging will play an important role in managing the bushfire risk posed by on-site temporary vegetation during roll out of individual development stages.

2.6 BAL assessment

Vegetation with a 'Moderate' or 'Extreme' bushfire hazard level is considered bushfire prone and any proposed development within 100 m of the bushfire prone vegetation extent will require application of Australian Standard AS 3959-2009 *Construction of Buildings in Bushfire-prone Areas* (SA 2009) via implementation of increased building construction standards in response to the assessed Bushfire Attack Level (BAL).

Once the project area is cleared of vegetation in preparation of development there will only be a small proportion of the project area which will be located within bushfire prone land, which will require a BAL response in accordance with AS 3959-2009 (Figure 4). This is largely consistent with findings of the *WA State Map of Bush Fire Prone Areas*.

Vegetation situated adjacent to the project area (west and northwest) will be cleared as part of adjacent developments. This clearing has not been incorporated into the BAL assessment contained within this BMP, however updated versions of this BMP prepared to support subdivision applications will reflect this clearing if applicable.

The Method 1 procedure for calculating the BAL (as outlined in AS 3959-2009) incorporates the following factors:

- state-adopted FDI rating
- vegetation
- slope under classified vegetation
- distance maintained between proposed development areas and the classified vegetation.

Based on the specified BAL, construction/separation requirements for proposed buildings can then be assigned.

2.6.1 Fire Danger Index

A blanket rating of FDI 80 is adopted for Western Australian environments, as outlined in AS 3959-2009 and endorsed by Australasian Fire and Emergency Service Authorities Council.

2.6.2 Vegetation class

Vegetation class is described in Section 2.2.1 and depicted in Figure 2b and consists of woodland (Class B), shrubland (Class C) and scrub (Class D). Where BAL contours differ based on the different BAL application distances associated with the vegetation classifications, the highest BAL has been applied (e.g. BAL 12.5 in Class B woodland vs. BAL 19 in Class C shrubland – BAL 19 would be the end result).

2.6.3 Slope under classified vegetation

Slope under classified vegetation is assessed in Section 2.2.2 and is depicted in Figure 2a and Figure 2b:

2.6.4 Distance between proposed development areas and the classified vegetation

Strategen has assessed and identified the separation distances between future buildings and the classified vegetation extent, as summarised in Table 1.

2.6.5 Method 1 BAL calculation

A Method 1 BAL calculation has been completed for the project area in accordance with AS 3959-2009 (Table 1).

The BAL rating gives an indication of the level of bushfire attack (i.e. the radiant heat flux) that may be received by the proposed dwelling and subsequently informs the standard of building construction required for that dwelling to withstand such impacts.

A portion of the project area will be located within 100 m of vegetation assessed as having an 'Extreme' and 'Moderate' bushfire hazard level (i.e. bushfire prone land), which will require implementation of AS 3959-2009 (refer to Figure 4). The 'Extreme' bushfire hazard applies to Class B Woodland vegetation and 'Moderate' bushfire hazard applies to Class C shrubland surrounding the project area. Vegetation under slope is summarised in Section 2.6.3.

BAL contours for proposed built assets within 100 m of this vegetation are outlined in Table 1.

Table 1: Method 1 BAL calculation (BAL contours)

Vegetation class	Slope under classified vegetation	Distance from classified vegetation				
		BAL FZ	BAL 40	BAL 29	BAL 19	BAL 12.5
Class B woodland	Vegetation at equal elevation to, or upslope from proposed assets	0-<10 m	10–<14 m	14-<20 m	20-<29 m	29-<100 m
	Vegetation downslope at an angle between 0 to 5 degrees from proposed assets	0-<13 m	13–<17 m	17-<25 m	25-<35 m	35-<100 m
Class C Shrubland	Vegetation at equal elevation to, or upslope from Site	0-<7 m	7–<9 m	9-<13 m	13-<19 m	19-<100 m
	Vegetation downslope at an angle between 0 to 5 degrees from proposed assets	0-<7 m	7–<10 m	10-<15 m	15-<22 m	22-<100 m
Class D scrub	Vegetation at equal elevation to, or upslope from Site	0-<10 m	10–<13 m	13-<19 m	19-<27 m	27-<100 m
	Vegetation downslope at an angle between 0 to 5 degrees from proposed assets	0-<11 m	11–<15 m	15-<22 m	22-<31 m	31-<100 m

Section 6.6.2 of SPP 3.7 states that subdivision and development applications in areas of BAL 40 or BAL FZ will not be supported without extraordinary planning approval. Therefore, all proposed buildings must be developed outside of areas subject to BAL FZ or BAL 40 to avoid applying for extraordinary planning approval (i.e. proposal for unavoidable or minor development). All proposed lots will be located outside of areas subject to BAL FZ and BAL 40 contours which will be displayed in a revised BMP provided at the subdivision stage of planning.

The following items are still able to be constructed within BAL FZ and BAL 40 areas (i.e. the APZ):

- driveways
- roads
- carparks
- laydown area
- Public Open Space managed in a low fuel state.

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Legend

- Project Area
- 100m Wide Assessment Area
- Cadastre
- Freeway Reserve
- Railway Reserve

Bushfire Hazard Level

- Extreme
- Moderate

Scale: 1:4,000 @ A3

0 20 40 80 120 160 200 Meters

N

Coordinate System: GDA 1994 MGA Zone 50
Note: Position errors may occur in some areas
Date: 13/12/2016
Author: ENVIRONMAPS
Source: Cadastre - Landgate, 2016
Orthophoto - Nearmaps, 04.11.16

5003
15
5003
6
17
9019
MARMION AV
BLUEWATER DR
MERIDIAN AV
SHIPMASTER AV
SHIPMASTER AV
CAMBER LINK
LEEWAY LOOP
CHESSTREE AV
FLARE WY
DRAFT WY
CHINE WY
GUNWALE L
LATITUDE L
TOPSAIL LOOP
LEEWAY LOOP
1578
9024
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Lot 6 Taronga Place, Eglinton

Bushfire Hazard Level Map (Pre-development)

Figure 3a

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This concept plan and BALs are indicative only and shall be accurately mapped and revised in updated BMPs which will be prepared to support future stages of planning.

5003

15

5003

9019

17

1578

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Legend

- Project Area
- 100m Wide Assessment Area
- Cadastre
- Freeway Reserve
- Railway Reserve

Bushfire Hazard Level

- Extreme
- Moderate
- Low

Scale: 1:4,000 @ A3

0 20 40 80 120 160 200 Meters

N

Coordinate System: GDA 1994 MGA Zone 50
Note: Position errors may occur in some areas
Date: 9/03/2017
Author: ENVIRONMAPS
Source: Cadastre - Landgate, 2016
Orthophoto - Nearmaps, 04.11.16
Proposed Development - CLE 05.12.16

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Lot 6 Taronga Place, Eglinton

Bushfire Hazard Level Map (Post-development)

Figure 3b

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This concept plan and BALs are indicative only and shall be accurately mapped and revised in updated BMPs which will be prepared to support future stages of planning.

5003

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5003

17

6

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9024

1578

1579

THE LAYOUT PROVIDED SHOWS LARGE CELLS WHICH WILL CONTAIN RESIDENTIAL LOTS. INDIVIDUAL LOTS WILL BE LOCATED OUTSIDE OF BAL FZ & BAL 40 CONTOURS

Legend

- Project Area
- 100m Wide Assessment Area
- Cadastre
- Freeway Reserve
- Railway Reserve
- Classified Vegetation

Indicative APZ

- Indicative APZ

BAL Rating

- BAL FZ
- BAL 40
- BAL 29
- BAL 19
- BAL 12.5

Scale: 1:4,000 @ A3

0 20 40 80 120 160 200 Meters

N

Coordinate System: GDA 1994 MGA Zone 50
Note: Position errors may occur in some areas
Date: 10/03/2017
Author: ENVIRONMAPS
Source: Cadastre - Landgate, 2016
Orthophoto - Nearmaps, 04.11.16
Proposed Layout - CLE 05.12.16

strategen ENVIRONMENTAL

Lot 6 Taronga Place, Eglinton

Bushfire Attack Level Contour Map

Figure 4

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3. Bushfire management measures

Strategen has identified a range of bushfire management measures to address compliance with the Guidelines. It should be noted that these measures are being provided at the strategic planning level in the absence of a detailed development plan and that future addendums to this BMP will need to be prepared to align with future planning stages on provision of greater levels of detail. This BMP demonstrates a commitment to ensure that all of the bushfire management measures identified will be implemented to achieve compliance with the Guidelines in subsequent planning stages.

3.1 Asset Protection Zone

The proposed development will maintain an Asset Protection Zone (APZ) between classified vegetation and proposed buildings which will allow all proposed buildings to be located in areas subject to a BAL rating of BAL 29 or lower. These APZs will comprise of perimeter roads and setbacks within the development area itself, as well as low fuel buffers on adjacent lands which will be maintained by Urban Quarter in perpetuity. Figure 4 displays indicative APZs which will be revised and updated when this BMP is revised at future stages of planning. The detail presented above is sufficient to show that APZs can be maintained between proposed lots and classified vegetation, therefore meeting the intent of SPP 3.7 at this high level of planning.

All APZs will be maintained on a regular and ongoing basis as low threat vegetation as per clause 2.2.3.2 (f) of AS 3959-2009. This meets the intent of the APZ specified in the Guidelines.

The BMP will be reviewed at subsequent planning stages, at which time any changes to development and clearing within surrounding areas can be considered and addressed in a revised BMP.

3.2 Increased building construction standards

Strategen has designated BAL requirements for the proposed development in accordance with AS 3959–2009. This has resulted in a combination BAL 29, BAL 19 and BAL 12.5 contours being recommended to areas of land within the Project area.

3.3 Vehicular access

The proposed vehicular access network will provide greater than two links to the surrounding public road network to the south as well as future links to adjacent development areas to the north, east and west.

The public roads created as part of the proposed development will be compliant with Guideline requirements as detailed in Table 2.

Table 2: Vehicular access technical requirements

Technical requirement	Public road	Cul-de-sac	Private driveway	Emergency access ways	Fire service access routes
Minimum trafficable surface (m)	6*	6	4	6*	6*
Horizontal distance (m)	6	6	6	6	6
Vertical clearance (m)	4.5	N/A	4.5	4.5	4.5
Maximum grade <50 m	1 in 10	1 in 10	1 in 10	1 in 10	1 in 10
Minimum weight capacity (t)	15	15	15	15	15

Technical requirement	Public road	Cul-de-sac	Private driveway	Emergency access ways	Fire service access routes
Maximum crossfall	1 in 33	1 in 33	1 in 33	1 in 33	1 in 33
Curves minimum inner radius	8.5	8.5	8.5	8.5	8.5

* Refer to E3.2 Public roads: Trafficable surface

Source: WAPC 2015b

3.4 Water supply

Water supply services will be extended throughout the project area from surrounding areas. The reticulated system will ensure an all year round supply of water is provided to meet minimum domestic and emergency water supply requirements.

At subsequent planning stages, the developer will also be required to prepare, have approved by the relevant water supply authority and Department of Fire and Emergency Services (DFES), and implement a detailed plan demonstrating the location and capacity of fire emergency infrastructure.

A network of hydrants will need to be provided along the internal road network at locations which meet relevant water supply authority and DFES requirements, in particular the Water Corporation Design Standard DS 63 'Water Reticulation Standard Design and Construction Requirements for Water Reticulation Systems up to DN250'. This standard will guide construction of the internal reticulated water supply system and fire hydrant network, including spacing and positioning of fire hydrants so that the maximum distance between a hydrant and the rear of a building envelope (or in the absence of a building envelope, the rear of the lot) shall be 120 m and the hydrants shall be no more than 200 m apart.

3.5 Fuel management within POS

POS areas located within the project area will be maintained such that they can be excluded from classified vegetation under clause 2.2.3.2 of AS 3959-2009 (e.g. less than 1 ha of retained vegetation more than 100 M away from areas of classified vegetation, low threat vegetation etc.)

Ongoing management of fuel loads within proposed POS areas will be addressed through landscaping plans provided as part of a revised BMP at future planning stages.

3.6 Additional measures

Strategen makes the following recommendations for additional bushfire management measures to inform ongoing planning stages of the development and increase the level of bushfire risk mitigation across the site:

1. Notification on Title: Strategen recommends notification to be placed on title for areas within the development that have a BAL-12.5 rating or higher as a condition of subdivision to ensure all landowners/proponents and prospective purchasers are aware that their lot is in a designated bushfire prone area and that increased building construction standards will apply to future buildings. The notification on title is also to include that the site is subject to a BMP.
2. Compliance with the City of Wanneroo Fire and Burning Notice 2015-2016 the developer/land manager and prospective land purchasers are to comply with the current City of Wanneroo Fire and Burning Information 2015-2016 (Appendix 1).

4. Proposal compliance and justification

Proposed development within the project area is required to comply with SPP 3.7 and the Guidelines, as required under the following policy measures:

6.2 Strategic planning proposals, subdivision and development applications

a) Strategic planning proposals, subdivision and development applications within designated bushfire prone areas relating to land that has or will have a Bushfire Hazard Level (BHL) above low and/or where a Bushfire Attack Level (BAL) rating above BAL-LOW apply, are to comply with these policy measures.

b) Any strategic planning proposal, subdivision or development application in an area to which policy measure 6.2 a) applies, that has or will, on completion, have a moderate BHL and/or where BAL-12.5 to BAL-29 applies, may be considered for approval where it can be undertaken in accordance with policy measures 6.3, 6.4 or 6.5.

c) This policy also applies where an area is not yet designated as a bushfire prone area but is proposed to be developed in a way that introduces a bushfire hazard, as outlined in the Guidelines.

6.3 Information to accompany strategic planning proposals

Any strategic planning proposal to which policy measure 6.2 applies is to be accompanied by the following information prepared in accordance with the Guidelines:

a) (i) the results of a BHL assessment determining the applicable hazard level(s) across the subject land, in accordance with the methodology set out in the Guidelines. BHL assessments should be prepared by an accredited Bushfire Planning Practitioner; or

a) (ii) where the lot layout of the proposal is known, a BAL Contour Map to determine the indicative acceptable BAL ratings across the subject site, in accordance with the Guidelines. The BAL Contour Map should be prepared by an accredited Bushfire Planning Practitioner; and

b) the identification of any bushfire hazard issues arising from the relevant assessment; and

c) clear demonstration that compliance with the bushfire protection criteria in the Guidelines can be achieved in subsequent planning stages.

This information can be provided in the form of a Bushfire Management Plan or an amended Bushfire Management Plan where one has been previously endorsed.

Implementation of this BMP is expected to meet the following objectives of SPP 3.7:

5.1 Avoid any increase in the threat of bushfire to people, property and infrastructure. The preservation of life and the management of bushfire impact are paramount.

5.2 Reduce vulnerability to bushfire through the identification and consideration of bushfire risks in decision-making at all stages of the planning and development process.

5.3 Ensure that higher order strategic planning documents, strategic planning proposals, subdivision and development applications take into account bushfire protection requirements and include specified bushfire protection measures.

5.4 Achieve an appropriate balance between bushfire risk management measures and, biodiversity conservation values, environmental protection and biodiversity management and landscape amenity, with consideration of the potential impacts of climate change.

In response to the above requirements of SPP 3.7 and the Guidelines, bushfire management measures, as outlined in Section 3, have been devised for the proposed development in accordance with Guideline acceptable solutions to meet compliance with bushfire protection criteria. An ‘acceptable solutions’ assessment at the strategic planning stage is provided in Table 3 to assess the proposed bushfire management measures against each bushfire protection criteria in accordance with the Guidelines and demonstrate that the measures proposed meet the intent of each element of the bushfire protection criteria.

Table 3: Acceptable solutions assessment against bushfire protection criteria

Bushfire protection criteria	Intent	Acceptable solutions	Proposed bushfire management measures	Compliance statement
Element 1: Location	To ensure that strategic planning proposals, subdivision and development applications are located in areas with the least possible risk of bushfire to facilitate the protection of people, property and infrastructure.	A1.1 Development location The strategic planning proposal, subdivision and development application is located in an area that is or will, on completion, be subject to either a moderate or low bushfire hazard level, or BAL–29 or below.	Refer to Section 3.2, Figure 3b and Figure 4, which demonstrates that proposed development to be identified as part of future planning stages will be located within a Moderate bushfire hazard level area and designed and located to ensure a rating of BAL 29 or below is achieved.	The measures proposed are considered to comply and meet the intent of Element 1 Location.
Element 2: Siting and design of development	To ensure that the siting and design of development minimises the level of bushfire impact.	A2.1 Asset Protection Zone Every building is surrounded by an APZ, depicted on submitted plans, which meets detailed requirements (refer to the Guidelines for detailed APZ requirements).	Refer to Section 3.1, which demonstrates that APZs will be adopted to meet the standard appropriate to the BAL for that location, whilst not exceeding BAL–29. The requirement for APZs will need to be reviewed when proposed development layout is identified at future planning stages..	The measures proposed are considered to comply and meet the intent of Element 2 siting and design of development.
Element 3: Vehicular access	To ensure that the vehicular access serving a subdivision/development is available and safe during a bushfire event.	A3.1 Two access routes Two different vehicular access routes are provided, both of which connect to the public road network, provide safe access and egress to two different destinations and are available to all residents/the public at all times and under all weather conditions.	Refer to Section 3.3, which demonstrates that the public road network proposed as part of the development will provide a minimum of two access routes for all proposed lots through a combination of existing roads and proposed internal roads.	The measures proposed are considered to comply and meet the intent of Element 3 Vehicular access.
		A3.2 Public road A public road is to meet the requirements in Table 2, Column 1.	Refer to Section 3.3, which demonstrates that any proposed public roads will be designed to meet minimum requirements outlined in Table 2.	
		A3.3 Cul-de-sac (including a dead-end-road) A cul-de-sac and/or a dead end road should be avoided in bushfire prone areas. Where no alternative exists (i.e. the lot layout already exists and/or will need to be demonstrated by the proponent), detailed requirements will need to be achieved (refer to the Guidelines for detailed cul-de-sac requirements).	Refer to Section 3.3, which demonstrates that any proposed cul-de-sacs will be designed to meet minimum requirements outlined in Table 2.	
		A3.4 Battle-axe Battle-axe access leg should be avoided in bushfire prone areas. Where no alternative exists, (this will need to be demonstrated by the proponent) detailed requirements will need to be achieved (refer to the Guidelines for detailed battle-axe requirements).	Refer to Section 3.3, which demonstrates that proposed development will avoid inclusion of any battle-axe access legs.	
		A3.5 Private driveway longer than 50 m A private driveway is to meet detailed requirements (refer to the Guidelines for detailed private driveway requirements).	N/A. No private driveways longer than 50 m proposed.	

		A3.6 Emergency access way An access way that does not provide through access to a public road is to be avoided in bushfire prone areas. Where no alternative exists (this will need to be demonstrated by the proponent), an emergency access way is to be provided as an alternative link to a public road during emergencies. An emergency access way is to meet detailed requirements (refer to the Guidelines for detailed EAW requirements).	N/A. No Emergency Access Ways proposed.	
		A3.7 Fire service access routes (perimeter roads) Fire service access routes are to be established to provide access within and around the edge of the subdivision and related development to provide direct access to bushfire prone areas for fire fighters and link between public road networks for fire fighting purposes. Fire service access routes are to meet detailed requirements (refer to the Guidelines for detailed fire service access route requirements).	N/A. No Fire service access roads proposed.	
		A3.8 Firebreak width Lots greater than 0.5 hectares must have an internal perimeter firebreak of a minimum width of three metres or to the level as prescribed in the local firebreak notice issued by the local government.	N/A. No firebreaks proposed.	
Element 4: Water	To ensure that water is available to the subdivision, development or land use to enable people, property and infrastructure to be defended from bushfire.	A4.1 Reticulated areas The subdivision, development or land use is provided with a reticulated water supply in accordance with the specifications of the relevant water supply authority and Department of Fire and Emergency Services.	Refer to Section 3.4, which demonstrates that reticulated water supply will be provided for the proposed development.	The measures proposed are considered to comply and meet the intent of Element 4 Water
		A4.2 Non-reticulated areas Water tanks for fire fighting purposes with a hydrant or standpipe are provided and meet detailed requirements (refer to the Guidelines for detailed requirements for non-reticulated areas).	N/A Reticulated water supply will be provided for the proposed development.	
		A4.3 Individual lots within non-reticulated areas (Only for use if creating 1 additional lot and cannot be applied cumulatively). Single lots above 500 square metres need a dedicated static water supply on the lot that has the effective capacity of 10 000 litres.	N/A Reticulated water supply will be provided for the proposed development.	

5. Implementation and enforcement

Implementation of the BMP and future revisions of the BMP apply to the developer, prospective landowners and local government to ensure bushfire management measures are adopted and implemented on an ongoing basis. A summary of the bushfire management measures described in Section 3, as well as an indicative works program to guide future planning, is provided in Table 4.

This indicative works program will need to be revised and updated as part of requirements for preparation of a revised BMP as planning stages progress.

Table 4: Indicative works program

Bushfire management measure	Timing for application	Responsibility
Creation of APZs	Prior to construction of proposed dwellings	Developer during development, prospective landowners thereafter
Maintenance of APZs	Following creation of APZ and as required to achieve 2 t/ha fuel threshold all year round	Developer during development, prospective landowners thereafter
Implementation of increased building construction standards	During construction of proposed dwellings	Local government, builder, prospective landowners
Construction of public roads, emergency access ways, fire service access routes or firebreaks	Following subdivision approval and prior to construction of proposed dwellings	Developer
Implementation and maintenance of firebreaks	As required in accordance with City of Armadale Firebreak Notice	Prospective landowners
Provision of reticulated water supply	Prior to construction of proposed dwellings	Developer
Fuel management within POS	Prior to construction of proposed dwellings	Developer for specified/agreed period, Shire thereafter
Notification on Title	Following subdivision approval	Developer
Revised BMP and BAL assessment at future planning stages	Prior to subdivision approval	Developer

5.1 Document review

This BMP will need to be updated as part of future planning stages to ensure:

1. Proposed management measures are based on a final detailed development plan, including lot boundaries, road layout, building envelopes and locations
2. Final development details and management measures are re-assessed for compliance with bushfire protection criteria.

The developer will be responsible for updating and revising the BMP until such time that the development is complete, after which the Shire will be the authority responsible for updating and revising the BMP.

5.2 Stakeholder consultation

Strategen has undertaken consultation with the client to ensure the aims and objectives of the BMP are in accordance with stakeholder expectations and the BMP maintains compliance with the BMP.

6. References

Bureau of Meteorology (BoM) 2016, *Climate statistics for Australian locations: Monthly climate statistics for Bickley*, [Online], Commonwealth of Australia, available from: *http://www.bom.gov.au/climate/averages/tables/cw_009240.shtml*, [6/9/2016].

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Appendix 1
City of Wanneroo Fire and Burning Notice 2015-2016

City of Wanneroo

CITY OF WANNEROO

FIRE AND BURNING INFORMATION

2015-2016

- BURNING PERIODS & FDRS
- BUILDING PROTECTION ZONES
- BURNING GARDEN REFUSE
- ALTERNATIVES TO BURNING
- FIRE BANS / BRIGADE CONTACTS
- BUSHFIRE SURVIVAL PLAN
- FIREBREAKS & EXAMPLES

TO REPORT ALL FIRES RING 000

BURNING PERIOD DATES & FIRE DANGER RATINGS (FDRs)

1 DECEMBER TO 31 MARCH (INCLUSIVE)

ALL burning, including garden refuse is prohibited during this period.

Dates may be varied due to climate or weather conditions. Period variations will be advertised in local papers, the City website and Facebook page.

BURNING PERMITS ARE REQUIRED 1 APRIL - 30 NOVEMBER

Permits to burn may be obtained from the City of Wanneroo at the following locations:

Wanneroo Animal Care Centre
1204 Wanneroo Road, Ashby // 4pm-6pm everyday

City of Wanneroo Civic Centre
23 Dundebar Road, Wanneroo // 9am-4pm weekdays

Two Rocks Volunteer Fire Brigade
Carraway Loop, Two Rocks. Call **0427 026 000** before attending. For Two Rocks residents only (Seatrees Estate and Breakwater estate)

ALL BURNING IS PROHIBITED ON DAYS OF **VERY HIGH** OR ABOVE FIRE DANGER RATINGS AND IF A TOTAL FIRE BAN OR A HARVEST AND VEHICLE MOVEMENT BAN IS DECLARED.

FIRE DANGER RATINGS (FDR)

If you are in a bushfire risk location you need to know what the Fire Danger Rating (FDR) is for your area, monitor local conditions and keep informed.

The FDR is based on the forecast weather conditions and gives you advice about the level of bushfire threat on a particular day. When the rating is high, the threat of a bushfire increases.

FIRE DANGER RATING INFORMATION BOARDS

These boards cleary display the daily fire danger rating and are featured at eight locations across the City of Wanneroo.

- Corner of Joondalup Drive and Wanneroo Road
- Wanneroo Road, south of the Yanchep Beach Road turn off
- Wanneroo Road, Carabooda
- Marmion Avenue, Jindalee
- Neaves Road, Mariginiup
- Old Yanchep Road, Pinjar
- Gnangara Road, Landsdale
- Countryside Drive, Two Rocks

STAY INFORMED

An RSS feed is available to receive email alerts when the City's Harvest and Vehicle Movement Bans are declared. To sign up, visit the City website.

Harvest and Vehicle Movement Bans are also published on the website and broadcast on the ABC local radio station.

The City of Wanneroo's fire weather district is - Lower West Coast.

You can find out the daily FDR online at:

- www.dfes.wa.gov.au
- www.bom.gov.au

or by phoning the Telstra Weather Service on 1196.

BUILDING PROTECTION ZONES

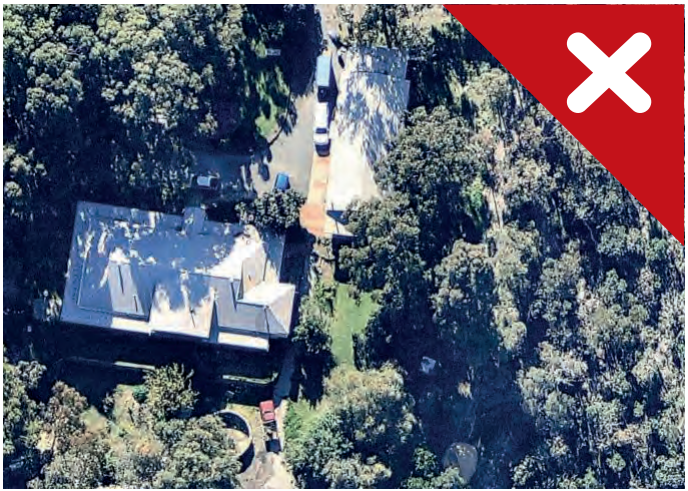
A building protection zone (BPZ) is an area extending for at least 20 metres around a building on all sides where there is little or nothing to burn.

Reducing vegetation, rubbish and anything that can burn from around your home will increase its chances of surviving a bushfire.

If there is little or nothing to burn then the fire's impact will be reduced. This can be achieved by:

- Maintaining a minimum 2m gap between trees and the building. Make sure that no trees overhang the house.
- Ensuring tree crowns are a minimum of 10m apart.
- Ensuring there is a gap between shrubs and buildings of three times their mature height.
- Ensuring shrubs aren't planted in clumps.

- Keeping the grass short and prune the scrub so that it is not dense, nor does it have fine, dead aerated material in the crown of the scrub.
- Raking up leaves, twigs and removing tree trailing bark.
- Pruning lower branches (up to 2m off the ground) to stop a surface fire spreading to the canopy of the trees.
- Creating a mineral earth firebreak.
- Having your paths adjacent to the building and have your driveway placed so that it maximises the protection to the house.
- Keeping your gutters free of leaves and other flammable material



✓ EXAMPLE ABOVE:
extensive fire protection zone created around building.

✗ EXAMPLE LEFT:
no fire protection zone created around building.

BURNING GARDEN REFUSE

There are many methods of hazard reduction available to residents. Reduction of fuel does not have to be as drastic as removing all vegetation. Burning garden refuse is one option available at certain times of the year.

GARDEN REFUSE MAY BE BURNT WITHOUT A PERMIT AFTER 6PM, SUBJECT TO:

- the pile of refuse being burnt not exceeding 1sqm
- a 2 metre wide area clear of flammable material surrounding the pile
- the fire only being lit between 6pm and 11pm
- only one heap being burnt at any one time
- the fire being completely extinguished by midnight
- a person in control of the fire staying with the fire until it is completely extinguished
- there being a means of extinguishing the fire available at all times (eg garden hose, knapsack spray or fire unit)
- neighbours are informed of your intention to burn
- the smoke does not cause a nuisance to neighbours
- the smoke does not create a traffic hazard
- household or commercial waste, or any noxious materials are not burned.

MITIGATION BURNS

For assistance regarding mitigation burns, contact the City of Wanneroo Fire Protection Officers where properties can be assessed. Volunteer Fire Brigades in conjunction with the City's Fire Protection Officers may be able to assist with undertaking the burns. For more information please call 9405 5000.

Mild intensity prescribed burn for fuel reduction.

Eight months post burn at Ashbrook Park.

GARDEN REFUSE CANNOT BE BURNT:

- At any time during the Prohibited Burning Period
- If a Total Fire Ban or Harvest and Vehicle Movement Ban has been declared
- If the Fire Danger Rating is Very High or above.

NOTE: DO NOT BURN DAMP, WET OR GREEN MATERIAL AT ANY TIME AS THIS WILL CAUSE EXCESSIVE SMOKE.

ALTERNATIVES TO BURNING

There are a range of alternatives to burning waste which can also be used as a method of hazard reduction.

In many circumstances, hand and mechanical clearing methods should be considered the best way to protect assets. These methods can be safer than burning, and easier to organise and maintain.

Raking or manual removal of fine fuels

Remove fuels such as fallen leaves, twigs and bark.

Mowing grass

Keep grass short, green and well watered. Mowed / slashed firebreaks need to be kept below 20mm.

Spraying

Grass can be sprayed with herbicide to reduce fuel loads. This may be a practical alternative particularly if erosion is a concern or if areas are difficult to access.

Slashing and mulching

This is an economical method of fuel reduction. To be effective, the cut material must be removed or allowed to rot before summer starts. Slashing and mowing may leave grass in rows, increasing fuel in some places. Mulching, or turbo mowing, also mulches the vegetation leaving the fuel where it is cut.

Ploughing and grading

These methods can produce effective firebreaks, however, the areas need constant maintenance. Loose soil may erode in steep areas, particularly where there is high rainfall and strong winds.

For further information on preventing erosion please contact the Fire Protection Officer.

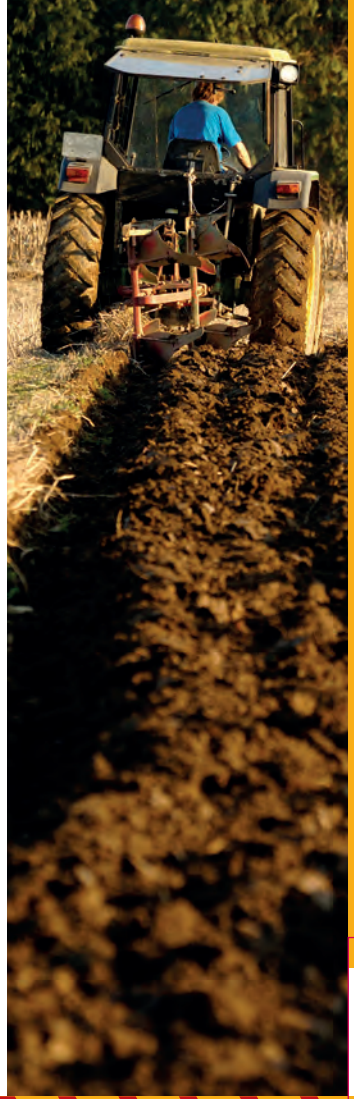
DISPOSAL OF GREEN WASTE

City residents and ratepayers are able to dispose of green waste and garden refuse at the Greens recycling Facility (70 Motivation Drive, Wangara. 8am – 4.45pm weekends and public holidays).

Access to the site is free with a 'Greens voucher'. Four Greens vouchers are included with the annual Rates notice. Each voucher allows the disposal of a standard 6x4 trailer-load of clean greens at no charge. Entry fees apply without a valid voucher

Garden refuse can also be used as a mulch or compost to improve soils and the growth of plants. If you have large quantities of green waste (branches, tree trunks) you can arrange for mobile mulching services to mulch the material onsite.

Mulch piles should be no larger than 5 cubic metres to reduce the risk of spontaneous combustion and should be surrounded by a firebreak.



VERGES - A SHARED RESPONSIBILITY

The City of Wanneroo urges all residents to include their property's verge in their fire preparation activities.

The City cannot do it alone, given its size and number of bush verges requiring maintenance.

FIRE BANS / BRIGADE CONTACTS

TOTAL FIRE BAN

A Total Fire Ban is declared by Department of Fire and Emergency Services (DFES) on days when fires are most likely to threaten lives and property.

WHEN A BAN IS DECLARED IT WILL BE FEATURED ON:

- the DFES website **www.dfes.wa.gov.au**
- DFES Twitter account **@dfes_wa**
- published to subscribers through DFES's automated RSS feeds
- broadcast on **ABC local radio**
- via DFES information line **1800 709 355**

VOLUNTEER BUSH FIRE BRIGADES

Volunteer Bush Fire Brigades are called to fires via a paging and radio communications system. The 000 emergency number will put you in contact with DFES who will dispatch the nearest Brigade.

Brigades should not be contacted directly to report a fire; call 000 to report a fire.

HARVEST AND VEHICLE MOVEMENT BAN

Harvest and Vehicle Movement Bans must be imposed by a local government when the bush fire danger index exceeds 35 during a Total Fire Ban.

They are also imposed when the Chief Bush Fire Control Officer is of the opinion that the use of engines, vehicles, plant or machinery during the prohibited burning times or the restricted burning times or both is likely to cause a fire or contribute to the spread of a bush fire.

If a Harvest and Vehicle Movement and Hot works Ban is declared it is published on the City's website and broadcast on radio 720 AM.

During a Total Fire Ban or Harvest and Vehicle Movement Ban you are not allowed to light, maintain or use a fire in the open air, or to carry out any activity in the open air that causes, or is likely to cause, a fire.

This includes a prohibition on the use of engines, vehicles, plant or machinery likely to cause or be conducive to the spread of a bush fire.

YOU COULD BE FINED UP TO $25,000 AND/OR JAILED FOR 12 MONTHS IF YOU BREACH A BAN.

BRIGADE CONTACT INFORMATION

Quinns Rocks Brigade
T: 0428 498 779
www.quinnsrocksbfb.org.au

Wanneroo Fire Support Brigade
T: 0427 026 006
www.wanneroosupportbfb.org.au

Quinns Rocks Fire Station
14 Hidden Valley Retreat,
Clarkson

Two Rocks Brigade
Caraway Loop, Two Rocks
T: 0427 026 000
www.tworocksbfb.org.au

Wanneroo Brigade
Bldg 1, Ashby Operations Centre
1204 Wanneroo Road, Ashby
T: 0427 026 521
www.wanneroobfb.org.au

PREPARE ACT SURVIVE

ARE YOU BUSHFIRE READY?
areyouready.wa.gov.au

IT COULD SAVE YOUR LIFE!

If you live in or near bush, developing and using a **bushfire survival plan** is critical. Your plan will help you avoid making last minute decisions that could prove deadly during a bushfire.

Your plan MUST include

1. **Your triggers to leave or start defending.**
2. **An informed decision about whether you will leave for a safer place or stay and actively defend.**

Bushfire Survival Plan TIPS

- ☐ Your plan must work for you and your family. Everyone's bush fire survival plan will be different and depend on individual circumstances.
- ☐ If you live alone develop a plan with your neighbours.
- ☐ Write your plan down and don't doubt it when the time comes to put it into action.
- ☐ Prepare and practice your plan with all the members of your family before the start of the bushfire season.
- ☐ Review your plan when your family circumstances change.

3 **A back-up plan.** Conditions can change very quickly in a bushfire, often without warning. Your plan must be flexible and cover a range of situations you may face before, during or after the fire.

4 **Where you will go** and how you will get there if you plan to leave for a safer place?

Research has shown that leaving late can be deadly. Over the last 100 years 60% of people who died in bushfires were found within 100 metres of their own residence.

Act immediately. Never 'wait and see' what might happen. Relocating at the last minute can be deadly. **Never second guess your plan.**

☐ Don't forget to include your pets and livestock in your bushfire survival plan.

Download a bushfire survival plan template today at **www.dfes.wa.gov.au**

For more information visit **www.dfes.wa.gov.au** or contact **DFES Community Engagement** 9395 9861

Government of **Western Australia**
Department of **Fire & Emergency Services**

DFES
Department of Fire & Emergency Services

BUSHFIRE SURVIVAL PLAN

FIREBREAKS / FUEL HAZARD REDUCTION / FIREBREAK EXAMPLES

Under the Bush Fires Act (1954), all owners and occupiers of land in Western Australia must establish and maintain firebreaks.

Fire breaks and protection measures are vital in assisting the prevention of fires spreading and to allow safer access for bush fire fighters and vehicles.

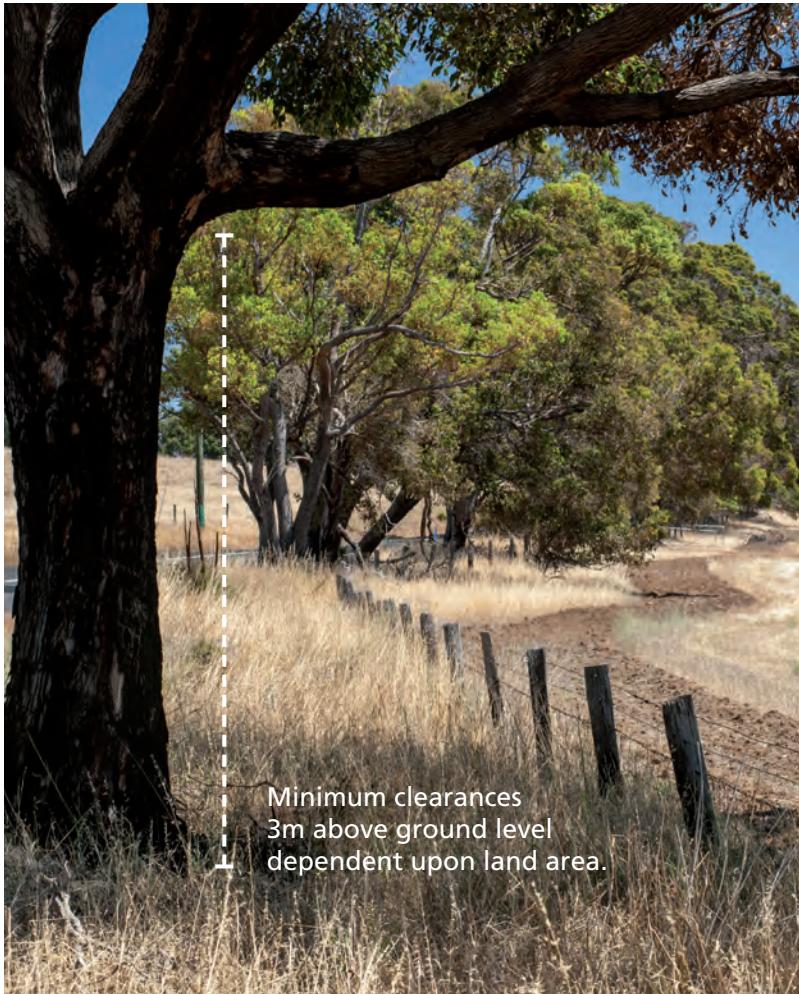
ALL LAND OWNERS WITHIN THE CITY OF WANNEROO BE ADVISED

Fire break installation must be completed by 15 November each year. Property inspections will commence the following day.

Failure to comply with these requirements may incur fines and further action by the City of Wanneroo.

Land with an area of less than 2,000m^2

- A firebreak, not less than two (2) metres wide must be cleared immediately inside (or as close as possible) and around all external boundaries of the land.
- All tree branches that over-hang a firebreak must be trimmed back to a minimum height of three (3) metres above ground level.



Land with an area of 2,000m² or more

- A firebreak, not less than three (3) metres wide, must be cleared immediately inside (or as close as possible) around all external boundaries of the land.
- All tree branches that over-hang a firebreak must be trimmed back to a minimum height of three (3) metres above ground level.

Buildings

- A firebreak not less than three (3) metres wide immediately around all external walls of every building must be cleared.

APPLICATION TO VARY THE ABOVE REQUIREMENTS

If it is considered impracticable for any reason to implement any of these requirements, an application may be made not later than the 1st day of November annually to the Council or its authorised officer for permission to provide alternative fire protection measures. If permission is not granted the stated requirements must be complied with.

ADDITIONAL WORKS

In addition to these requirements, you may be required to carry out further works which are considered necessary by an Authorised Officer and specified by way of a separate written notice forwarded to the address of the owner/s as shown on the City of Wanneroo rates record for the relevant land.

Non-compliant: no firebreak installed inside boundary fence

Compliant: grass slashed to ground level

Non-compliant: mineral earth fire break showing grass/weed regrowth

Compliant: mineral earth fire break

Non-compliant: thick scrub creates a fire hazard around power poles

Compliant: cleared buffer zone around power poles

FIREBREAKS & EXAMPLES

23 Dundebar Road, Wanneroo, WA 6065
Locked Bag 1, Wanneroo, WA 6946
T : (08) 9405 5000 F : (08) 9405 5499

wanneroo.wa.gov.au

Appendix 2
January wind profiles for Gingin Aero

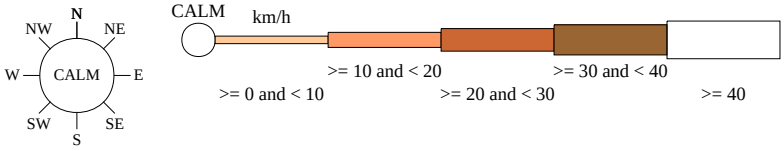
Rose of Wind direction versus Wind speed in km/h (01 May 1996 to 30 Sep 2010)

Custom times selected, refer to attached note for details

GINGIN AERO

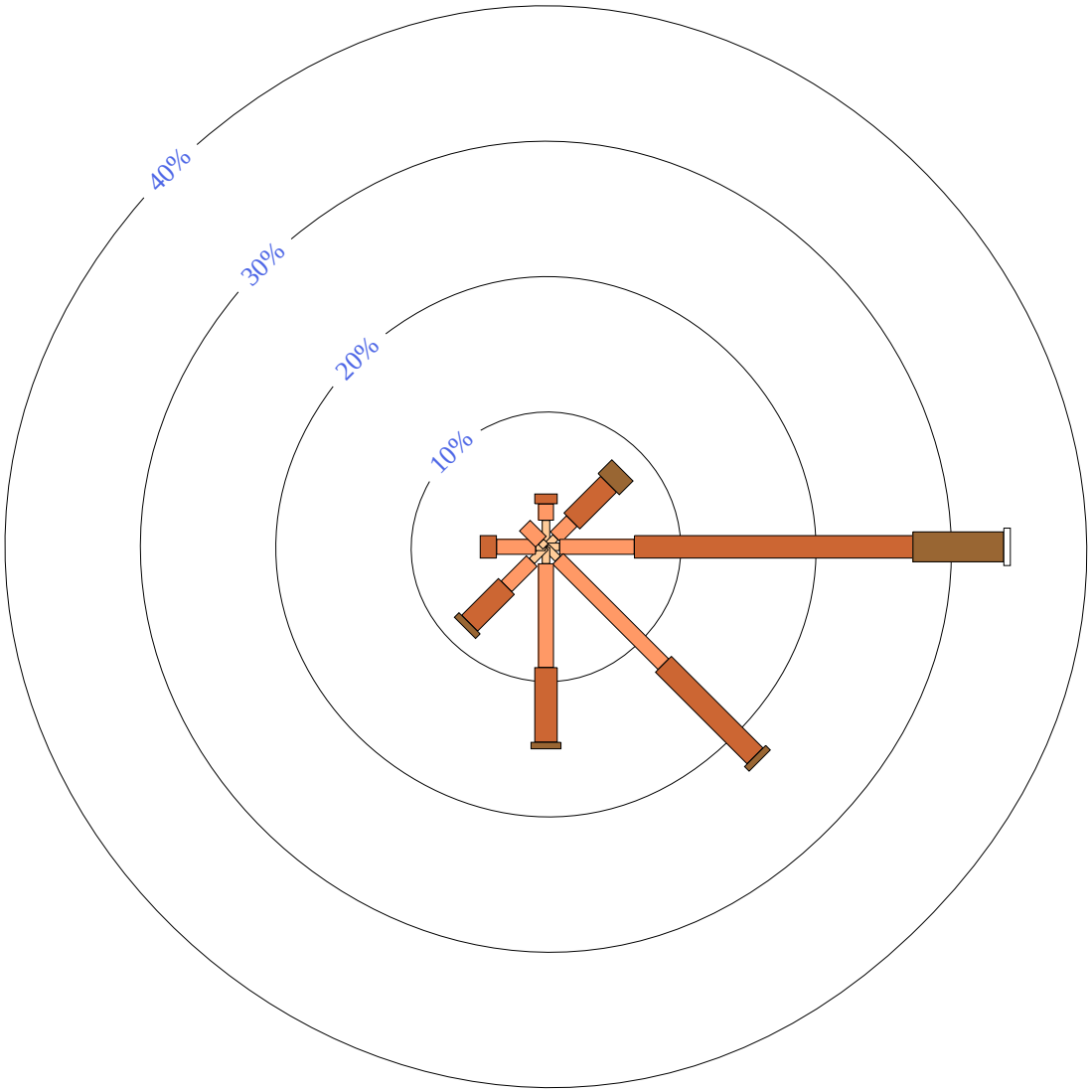
Site No: 009178 • Opened Jan 1968 • Still Open • Latitude: -31.4628° • Longitude: 115.8642° • Elevation 73m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



9 am Jan
411 Total Observations

Calm *



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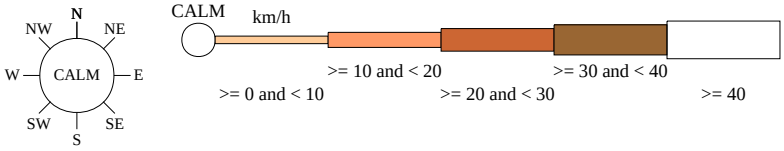
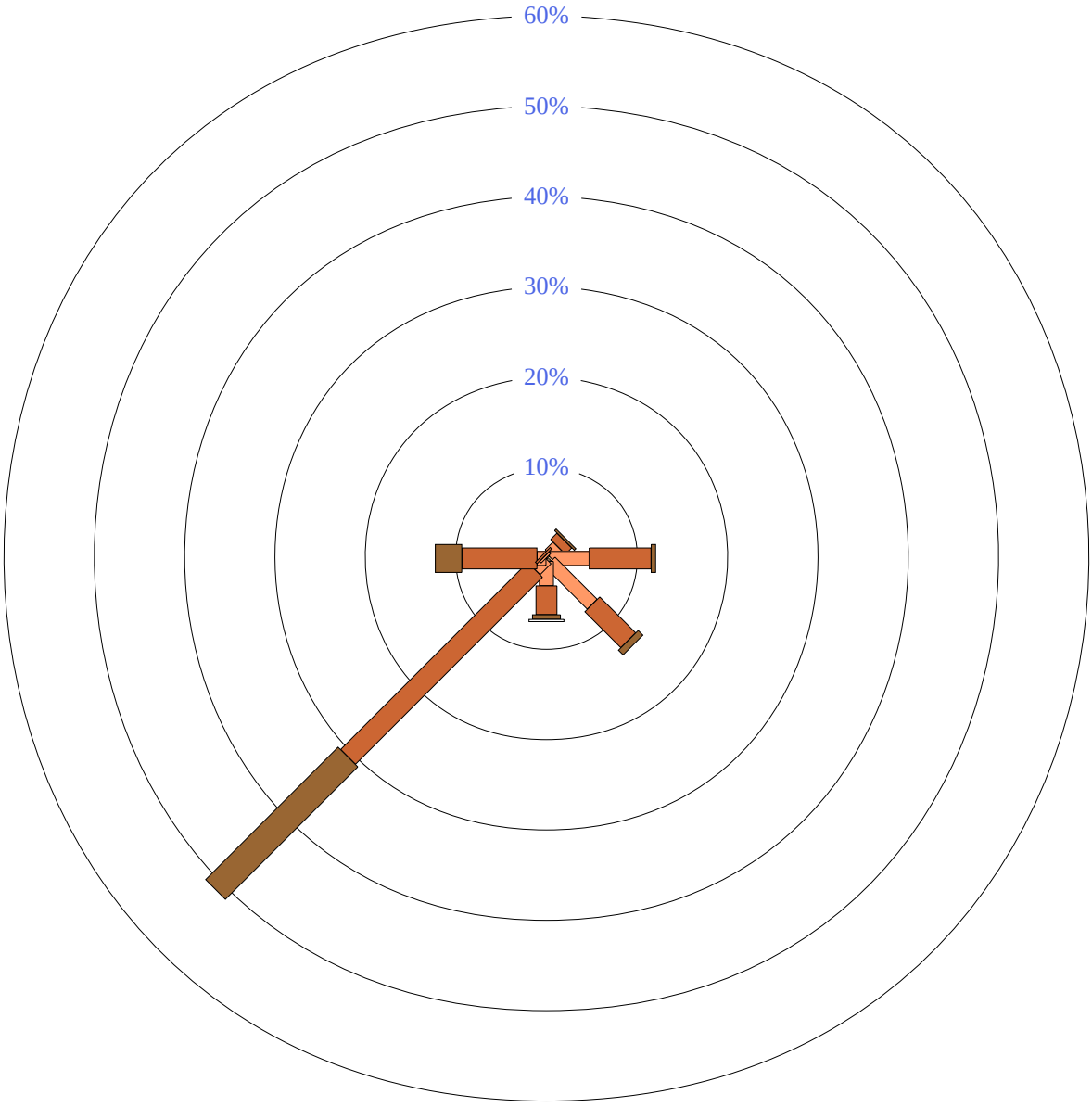


3 pm Jan
410 Total Observations

Calm *



Appendix 3
Certificate of Title

214D

REGISTER NUMBER	
6/D26989	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
2	25/10/2016

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

VOLUME 1909 FOLIO 63

UNDER THE TRANSFER OF LAND ACT 1893

The person described in the first schedule is the registered proprietor of an estate in fee simple in the land described below subject to the reservations, conditions and depth limit contained in the original grant (if a grant issued) and to the limitations, interests, encumbrances and notifications shown in the second schedule.

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 6 ON DIAGRAM 26989

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

DAWS & SON PTY LTD OF LEVEL 4 72 KINGS PARK ROAD WEST PERTH WA 6005
(T N466075) REGISTERED 24 OCTOBER 2016

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:
(SECOND SCHEDULE)

1. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 594/1933.
2. THE LAND THE SUBJECT OF THIS CERTIFICATE OF TITLE EXCLUDES ALL PORTIONS OF THE LOT DESCRIBED ABOVE EXCEPT THAT PORTION SHOWN IN THE SKETCH OF THE SUPERSEDED PAPER VERSION OF THIS TITLE. VOL 1909 FOL 063.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
* Any entries preceded by an asterisk may not appear on the current edition of the duplicate certificate of title.
Lot as described in the land description may be a lot or location.

----------END OF CERTIFICATE OF TITLE----------

STATEMENTS:

The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND: 1909-63 (6/D26989).
PREVIOUS TITLE: 1285-913.
PROPERTY STREET ADDRESS: 19 TARONGA PL, CARABOODA.
LOCAL GOVERNMENT AREA: CITY OF WANNEROO.

APPENDIX 4

Transport Assessment (GTA)

GTAconsultants

Lot 6, Taronga Place, Eglinton
Local Structure Plan
Transport Assessment

Client // Urban Quarter
Office // WA
Reference // W115940
Date // 03/03/17

Lot 6, Taronga Place, Eglinton

Local Structure Plan

Transport Assessment

Issue: Final 03/03/17

Client: Urban Quarter
Reference: W115940
GTA Consultants Office: WA

Quality Record

Issue	Date	Description	Prepared By	Checked By	Approved By	Signed
A-Dr	15/12/16	Draft	MF	TM	TM	
Final	03/03/17	Final	MF	TM	TM	

GTAconsultants
Melbourne | Sydney | Brisbane
Canberra | Adelaide | Perth
Gold Coast | Townsville

Table of Contents

Figures

Tables

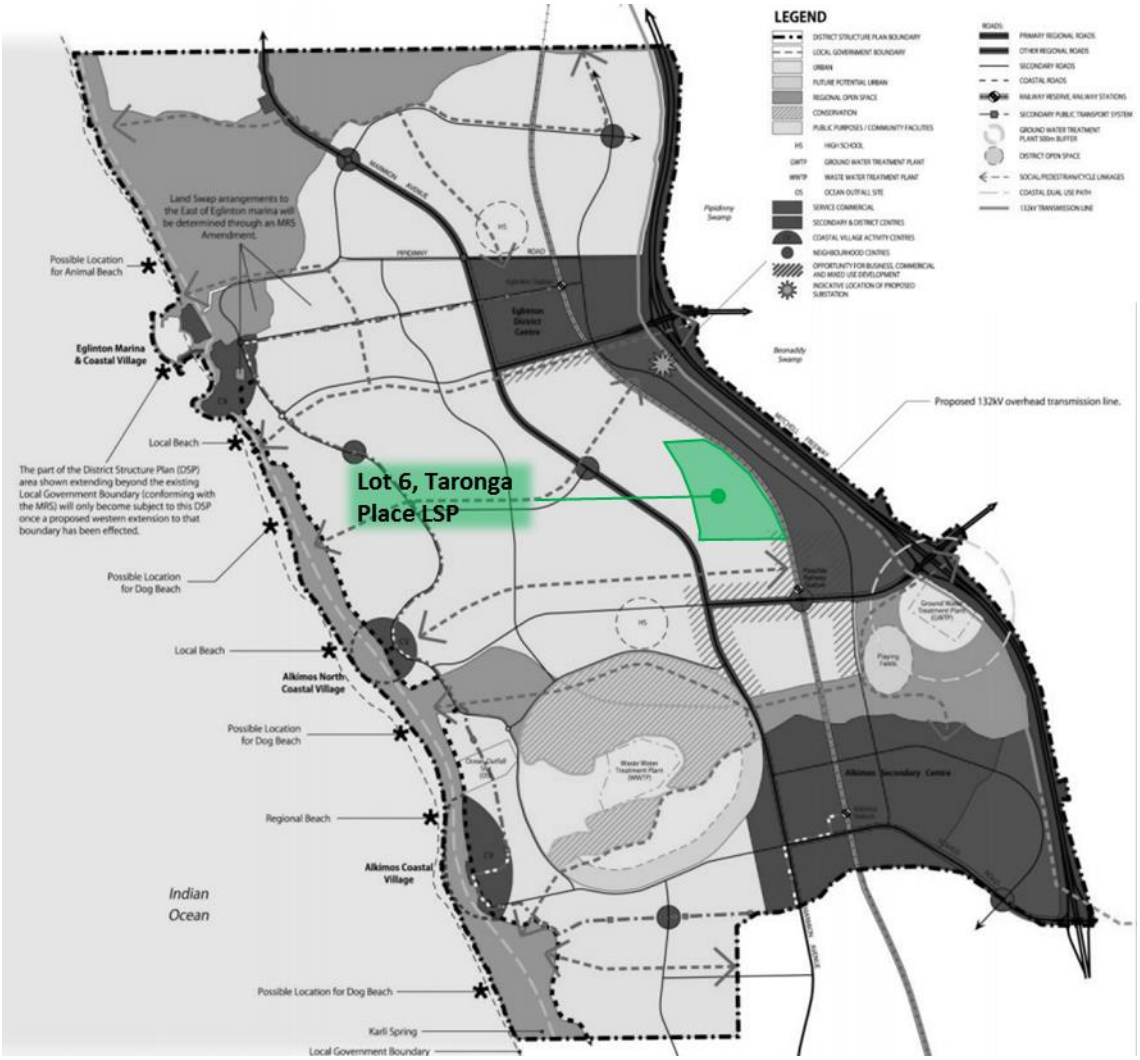
1. Introduction

1.1 Background & Proposal

A Local Structure Plan (LSP) is being prepared for a proposed residential development within the western portion of Lot 6, Taronga Place, Eglinton in the City of Wanneroo (CoW). GTA Consultants (GTA) has been commissioned by Urban Quarter to prepare a Transport Assessment to support the LSP, which is designated within the Alkimos Eglinton District Structure Plan (DSP) area as "Urban" land, as shown in Figure 1.1.

The proposed LSP is for the parcel of land bound by the rail reserve to the east, the Shorehaven Estate to the south and Eglinton Estates Local Structure Plan area to the west and north. Upon full development, the LSP is expected to contain approximately 470 residential dwellings with associated Public Open Space (POS), and necessary infrastructure.

Figure 1.1: LSP Location within Alkimos Eglinton DSP



(Source: Alkimos Eglinton DSP, dated September 2006)

1.2 Report Purpose

This report details the methodology and findings of the Traffic Impact Assessment (TIA), which was prepared in line with the guidelines set out in the Western Australian Planning Commission publication '*Transport Impact Assessment Guidelines*' (WAPC Guidelines)[1] and takes account of the CoW planning policies. This TIA considers the sites integration with the existing transport networks including walking, cycling, public transport and vehicular travel and considers the potential impact of the proposed development on these, including consideration of the following:

i existing and future transport conditions surrounding the site
ii the proposed transport network internal to the site
iii the proposed access arrangements from the site to the external road network
iv the traffic generating characteristics of the proposed LSP
v the estimated transport impact of the proposed LSP on the surrounding road network.

1.3 References and Consultation

In preparing this report, reference has been made to the following:

- CoW *District Planning Scheme No. 2* (gazetted 6 July 2001)
- CoW *Local Planning Policy 3.8: Marmion Avenue Arterial Road Access* (adopted 7 February 2012, reviewed 2017)
- the Western Australian Planning Commission (WAPC) *Liveable Neighbourhoods – Updated 02*, dated January 2009
- WAPC *Transport Impact Assessment Guidelines*, dated August 2016
- *Lot1005/1006 Alkimos, Traffic and Transport Planning, Final Report*, prepared by Bruce Aulabaugh in May 2009
- *Alkimos Eglinton District Structure Plan, Appendix 4, Traffic and Transport* Report, dated December 2010
- *Cycle Wanneroo*, CoW Bike Plan
- plans for the proposed LSP prepared by CLE
- other documents as referenced in this report.

In addition, members of the wider LSP project team met with CoW and Department of Planning representatives on site on 1 December 2016 to discuss the proposal.

The above information was used to inform the content of this report where relevant.

[1] Transport Impact Assessment Guidelines, Volumes 1 to 5, published by WAPC August 2016.

2. Existing Situation

2.1 LSP Area Use and Location

The LSP area covers an approximate 28 ha within the Alkimos Eglinton area of the CoW, as shown in Figure 2.1. At present the site is vacant land.

The site is bounded to the east by the northern suburbs rail line reserve, and on all other boundaries abut adjacent (current and future) residential subdivisions. To the south the Shorehaven Estate is established and road infrastructure is in place. To the west and north of the site there is an interface with the Eglinton Estates LSP, which is yet to be developed.

Figure 2.1: LSP Area and its Environs

(Source: Nearmap)

2.2 Existing Movement Networks

Given the largely undeveloped nature of the area and subsequent lack of travel demand, current movement infrastructure provisions are limited as it relates directly for travel to, from and within the LSP area. Notwithstanding, there is some infrastructure provision which is described below. It is also worth noting that as the area matures, through this and adjacent LSP's, the movement networks will be provided generally in accordance with the DSP. Specific future infrastructure relevant to the site is considered in Section 3 of this report.

2.2.1 Walking and Cycling

Pedestrian paths are currently provided on Marmion Avenue where current development has occurred abutting this road. There also exists terminated paths and crossings on Marmion Avenue which will be connected as part of a wider network as development in the area proceeds.

Shared use paths are currently provided along the southern boundary of the LSP area, on the southern side of Bluewater Drive as part of the Shorehaven Estate. These shared use paths on Bluewater Drive connect to a network of further footpaths throughout the Shorehaven Estate .

Similarly, formal cycling infrastructure in the area is limited, however a wide sealed shoulder is provided on both sides of Marmion Avenue to enable cyclists to use the route in the relative safety of the shoulder. Within the Shorehaven Estate on-road cycle lanes are provided on both sides of Bluewater Drive providing an east-west cycle connection. North-south connections are provided by way of on-road cycle lanes on Chesstree Avenue and Maroon Avenue within the Shorehaven Estate. Ultimately these routes will extend south to Alkimos Drive in line with the DSP.

2.2.2 Public Transport

Two Transperth bus routes currently operate along Marmion Avenue as detailed in Table 2.1.

Table 2.1: Existing Public Transport Provision

Service	Route #	Route Description	Location of / Distance to Nearest Stop	Frequency On/Off Peak
Bus	490	Butler Station – Two Rocks	Marmion Ave before Bluewater Drive (500m from centre of site)	20 minutes peak 60 minutes off peak
	491	Butler Station - Yanchep		

These routes run north-south on Marmion Avenue between Yanchep / Two Rocks and Butler Station, stopping on Marmion Avenue, generally adjacent to new residential developments. Whilst the exact location of any future bus stops cannot be determined at this stage, the DSP *Transport and Access* report illustrates an intent to at least maintain the operation of these existing services on Marmion Avenue.

The closest bus stop is located around 500m from the centre of the LSP area. Considering the general 400m catchment for public transport, around one third of the LSP is located within this distance of the existing bus stop which is a strong starting point for development of a currently vacant site.

2.2.3 Vehicular Access

The existing primary vehicle access routes for the LSP are highlighted in Figure 2.1 and discussed below.

There are a number of future connections to be provided and routes to be developed as the area matures, these are discussed relative to the LSP area in Section 3.

Marmion Avenue

Marmion Avenue is a Distributor A road managed by the CoW. It is a two-lane, two-way undivided road running in a northwest-southeast direction. Marmion Avenue is set within a road reserve of 45m width (minimum) proximate to the subject site, and has a speed limit of 80km/h in this area.

Marmion Avenue plays a strategic role in the movement of traffic in the northwest development corridor of Perth, which is one of the highest population growth areas in WA and exists along the coast north of Burns Beach to Yanchep. As per the DSP and CoW's *Marmion Avenue Arterial Road Access Policy*, Marmion Avenue is to be upgraded in the future to become a four-lane divided Integrator Arterial 'A' road. The exact timing of this upgrade is yet to be confirmed, and is expected to be triggered by increases in traffic volumes warranting the upgrade as development in the corridor progresses. The intended future role of Marmion Avenue is to be a major north-south connector but of a lower classification than the proposed extended Mitchell Freeway (see below).

Bluewater Drive

Bluewater Drive is a Neighbourhood Connector road running east-west within the northern boundary of the Shorehaven Estate and the southern boundary of the LSP area. It is a two-lane, two-way undivided road with a 6.6m wide vehicle carriageway, and 1.2m wide cycle lanes on either side of the road. The road reserve is currently 16m wide, although will be widened to 20m as part of the LSP proposal. Bluewater Drive has an unposted 50km/h speed limit for its entire length.

It is proposed to access the LSP area from Bluewater Drive.

Chesstree Avenue

Chesstree Avenue is a Neighbourhood Connector road running north-south within Shorehaven Estate, providing a link between the LSP area and Alkimos Drive as identified within the DSP. It is proposed to continue Chesstree Avenue as a key north-south route within the LSP. It is a two-lane, two-way divided boulevard type road with 3.3m wide traffic lanes, 1.2m wide cycle lanes and a 2.0m wide median. A shared use path is provided on the western side of the road and a footpath on the eastern side. Chesstree Avenue has an unposted 50km/h speed limit for its entire length.

Maroon Avenue

Maroon Avenue is a Neighbourhood Connector road running north-south within Shorehaven Estate, providing a second key link between the LSP area and Alkimos Drive as identified within the DSP. It is a two-lane, two-way divided boulevard type road with 3.3m wide traffic lanes, 1.2m wide cycle lanes and a 2.0m wide painted median. A shared use path is also provided along its eastern edge, with a footpath on its western side. Maroon Avenue has an unposted 50km/h speed limit for its entire length.

Mitchell Freeway

As detailed in the DSP, long-term planning indicates that the Mitchell Freeway is proposed to be extended north from its current terminus at Burns Beach Road in Currambine (with construction already underway extending it to Hester Avenue in Clarkson). Ultimately the Mitchell Freeway will form the major north-south distributor for the northwest corridor, with the freeway reserve located closely to the east of the site.

It is noted that the closest proposed freeway interchange to the site is to be located at Alkimos Drive, approximately 1km south-east of the subject site. As identified above, access to Alkimos Drive can be gained via Chesstree Avenue, Maroon Avenue and Marmion Avenue.

3. Development Proposal

3.1 Context

As noted in Section 1, the relatively small LSP area is located within the wider Alkimos Eglinton DSP area. This DSP area covers some 2,600 hectares of land in Perth's northwest and is ultimately envisaged to contain over 22,000 dwellings, as well as schools, shops and commercial uses. The overall DSP is expected to contribute to the increase of housing supply for the CoW and Greater Perth over the coming 10-15 years.

This LSP applies to a portion of Lot 6 Taronga Place, Eglinton. The subject site is approximately 28 ha in area and located immediately west of the northern suburbs rail reserve and north of the existing Shorehaven Estate.

The site is zoned 'Urban Development' under the *City of Wanneroo District Planning Scheme No. 2* (the Scheme). This LSP intends to fulfil the requirements of the Scheme and the DSP for the preparation and approval of a LSP prior to the subdivision and/or development of land.

The LSP proposes development of the land for:

- Residential purposes comprising a range of residential densities
- Public open space (POS)
- An integrated movement network for vehicular, cyclist and pedestrian traffic.

The central portion of Lot 6 located immediately east of the proposed LSP area (and west of the freeway reserve) is shown in the DSP as service commercial. As part of a separate exercise, this central portion is being investigated for use as residential, as a response to the unsuitability of the site for service commercial given the sites constrained access points, undulating topography and conservation considerations.

Furthermore, the originally planned rail station at North-Alkimos will no longer proceed and land use immediately to the south of the site is now being progressed as mixed use (with initial development proposed as residential) and not service commercial. CoW is currently progressing a review of the DSP. Further discussions (outside of this LSP proposal) will be undertaken with regard to the appropriate use of this central portion of Lot 6.

Accordingly, the investigation associated with this central portion of Lot 6 informs key assumptions for the traffic assessment. If this land is progressed for residential development it is assumed that a bridge will be provided across the rail reserve to link the western LSP (this proposal) and central portion communities. If the land proceeds as currently planned, no bridge will be provided. For the purposes of this report, to cater for the higher traffic volume scenario it has been assumed this residential development will occur and a bridge will be provided.

3.2 Proposed Land Uses

The proposed Lot 6 Taronga Place LSP is shown in Figure 3.1. The LSP incorporates approximately 470 residential dwellings and associated open space (to be provided in accordance with Liveable Neighbourhoods).

Figure 3.1: Lot 6 Taronga Place LSP Layout Proposal

The vast majority of land within the LSP is proposed to be utilised for residential dwellings. This proposed use is consistent with the land use outcomes envisaged in the DSP, which shows the entire LSP as 'Urban'.

3.3 Movement Network

The LSP layout has been developed to provide an integrated movement network which is legible and useable by all modes of transport for travel, to, from and within the area. As the LSP area is bound to the east by the rail reserve, access and movement related to the LSP is generally focussed to the north, south and west.

Further, given the relatively small scale of the LSP area, it is not possible to necessarily provide new key long distance links for travel through the DSP area but a key principle in developing the networks was to ensure consistency and contribute to adjacent LSP and DSP area planning.

3.3.1 Future External Movement Network and Land Development

The wider DSP area is largely undeveloped at present and therefore there will be a number of changes to the movement networks around the LSP area. The provision of infrastructure within the LSP is done so in mind of the DSP to ensure legible, district-wide networks are provided that do not compromise the intent of the wider network planning.

Walking and Cycling

In order to determine the wider proposed networks, reference was made to the LSP documents for Shorehaven and Eglinton Estates. These illustrate a proposed network of shared paths and on-road cycle lanes (relative to road type), which can be continued into and through the LSP area.

The external routes identified are provided graphically in Section 3.3.2 relative to the proposed networks within the LSP.

Public Transport

In terms of future public transport provisions, the Department of Transport's *Public Transport for Perth in 2031* sets out the State Government's long-term plan for the public transport system in and around Perth. This plan details an ultimate network plan in which the existing railway to Butler is extended north to Yanchep, via Alkimos and Eglinton, by 2031. It is understood that no funding has yet been allocated by State Government for the extension of the railway beyond its current terminus at Butler located approximately 4.5km south of the LSP area.

The DSP includes the abovementioned railway extension, with rail stations proposed at Eglinton approximately 1.5km north of the LSP and at Alkimos City Centre, approximately 2.5km to the south. The DSP also shows a station at North-Alkimos immediately south of the site within the Shorehaven Estate. Discussions with the PTA, DoP and CoW have indicated that this station will no longer be progressed. Assumptions associated with this traffic impact assessment presented in this report reflect the removal of this station.

Locally, the operation of bus services on Marmion Avenue in the vicinity of the LSP area will continue as demonstrated within the DSP, with further stops added as the area develops.

Vehicular Travel

Similar to the walking and cycling networks, the road network layout within the LSP area is influenced by the established Shorehaven Estate and the adjacent Eglinton Estates LSP proposal. These external connections are denoted on the proposed LSP layout shown in Figure 3.1. Key links for the LSP area include the Bluewater Drive connection to Marmion Avenue, the southern connections through Shorehaven Estate to Alkimos Drive (via Chesstree Avenue and Maroon Avenue) and the connection north to the Eglinton Estates LSP area.

3.3.2 LSP Movement Network

The LSP layout has been developed such that access to and from it is easily achievable without compromising the intent of the movement networks in the DSP and negatively impacting the amenity of the residential areas of the LSP. In general, there will be limited 'through' trips in the LSP area i.e. the significant majority of movement within the site will originate and terminate here.

Pedestrian and Cycle Networks

At its widest point (in an east/west direction) along the southern boundary, the LSP area is approximately 550m wide which equates to less than a 10 minute walk or 5 minute cycle. The distances from one area of the development to another are therefore relatively small and comfortably accessible by either walking or cycling. This is also relevant for access to the local schools and retail offerings provided in the adjacent LSP.

The internal movement networks have been developed in a way which provides greater amenity for pedestrians and cyclists through the provision of in-direct through vehicle routes and landscaped environments. These type of environments reduce vehicle speeds by design, thus creating a safer environment which will allow these more active modes to flourish as a method of making local trips to the recreation areas, local schools and retail. Furthermore, there are a large number of pedestrian and cycle routes proposed in the DSP which provide area wide linkages and networks for these modes. In this respect, the intent and principles of the wider movement networks within the DSP have also been maintained, and it is expected that any through vehicles will remain on the higher order roads within the LSP area.

To further improve pedestrian amenity, footpaths shall be provided at a minimum on one side of all roads, and where appropriate and reflecting the type and location of the road, a footpath on both sides shall be provided.

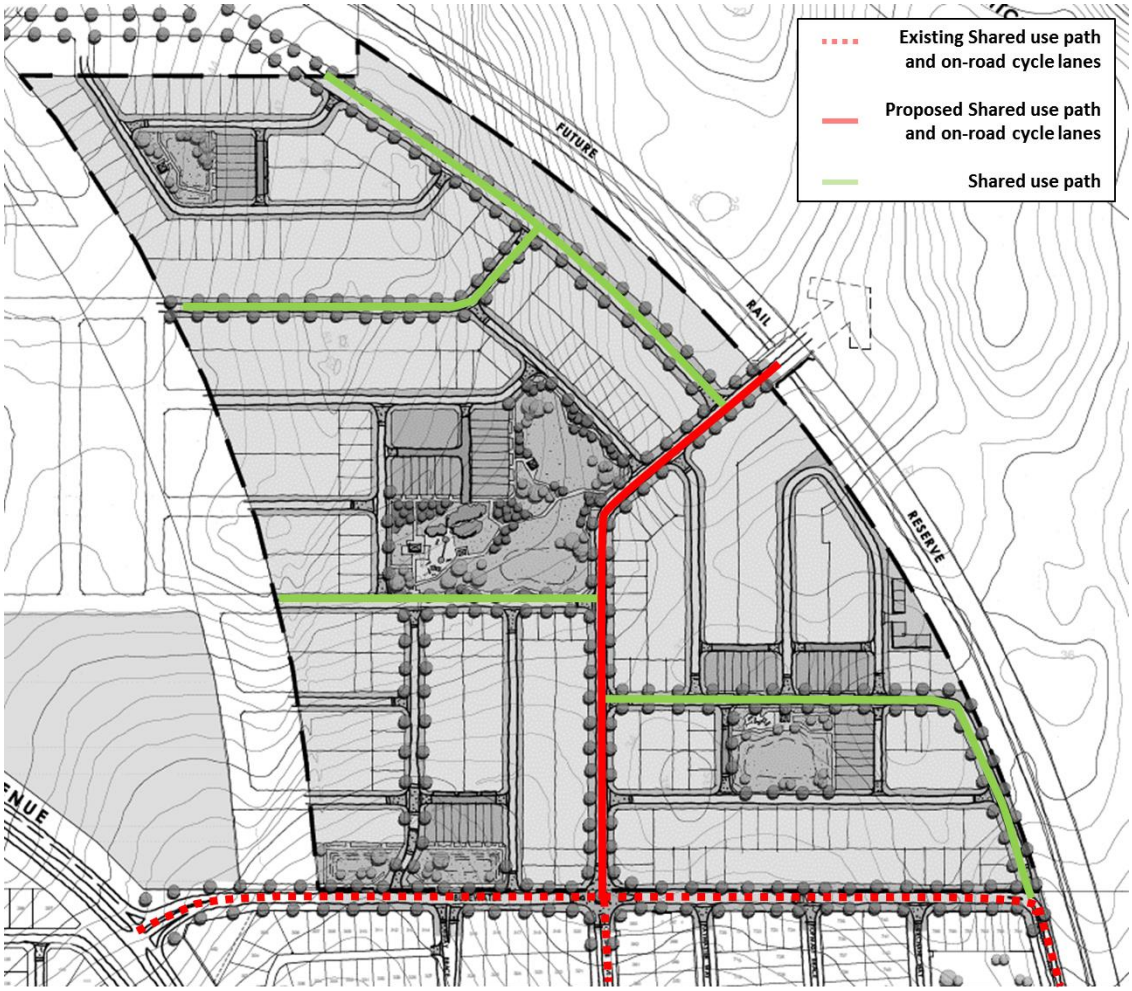
Future pedestrian and cycle infrastructure requirements for the wider area are set out in the DSP. The provision of infrastructure within the LSP area will contribute to completing these networks with local infrastructure to be provided as per the requirements of *Liveable Neighbourhoods* for each given level of road hierarchy. As a minimum, these would therefore include:

- a minimum of a shared path on all Neighbourhood Connector roads, with on-road cycle lanes also provided where relevant
- a minimum of one pedestrian path on all access roads with a path on both sides for key roads.

The introduction of these facilities within the LSP will support the CoW recently published Bike Plan document, "*Cycle Wanneroo*". This document aims to establish cycling in the CoW area by providing infrastructure, legible routes and policy to support its growth with a focus on infrastructure and path provision in public open spaces.

The proposed key cycle routes through the LSP area, relative to the external cycle routes is illustrated in Figure 3.2.

Figure 3.2: LSP proposed key cycle routes



3.3.3 Proposed Vehicular Access

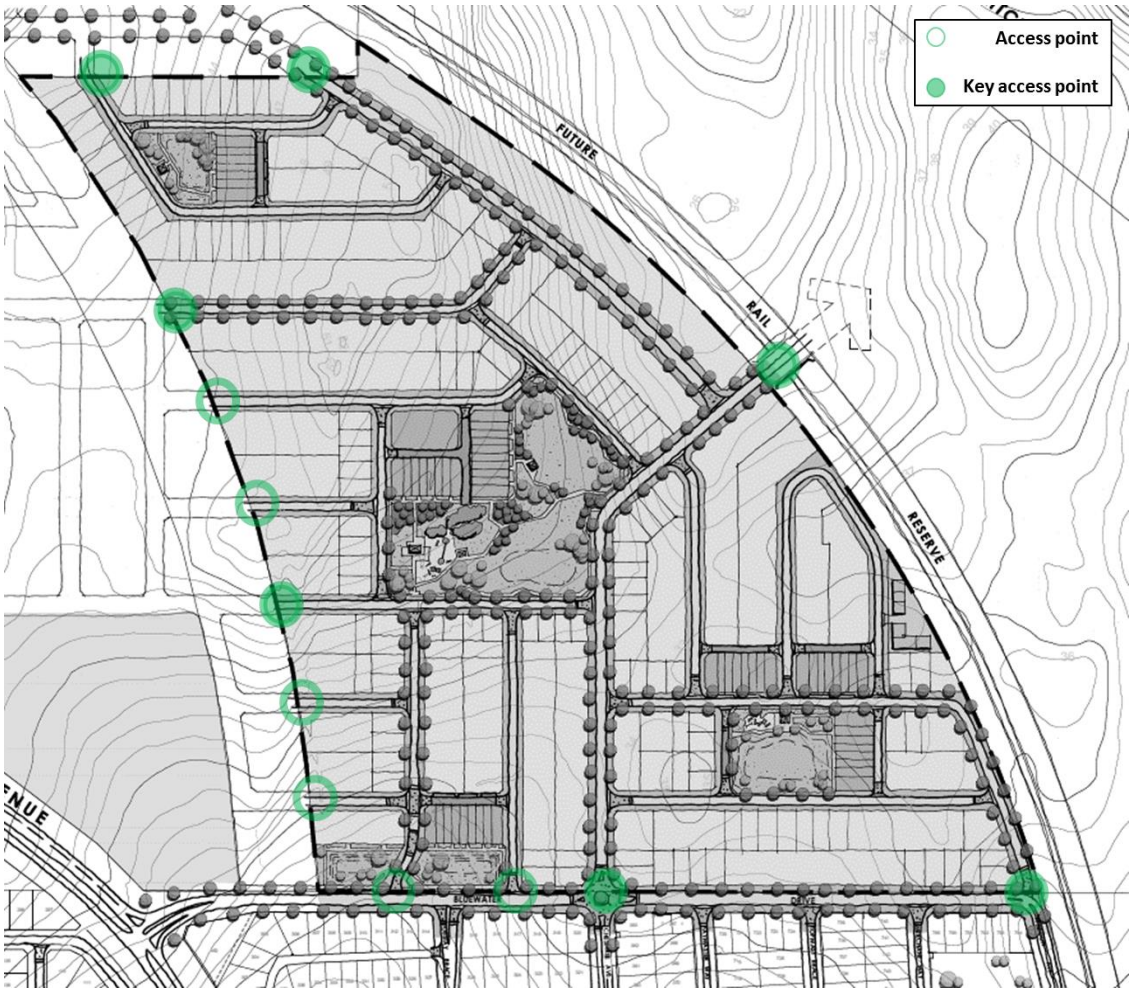
Given the sites location in relation to the surrounding LSP's, it does not have direct frontage to strategic roads in the area, nor is it required or intended to. Rather secondary access to the LSP area is gained via the higher order road network developed within the DSP, together with connections to and through the adjacent LSP areas.

Since the Eglinton Estates LSP is still in planning, reference has been made to the most up to date structure plan layout, which it is understood is currently with CoW for approval. This, together with the road layout constructed within the Shorehaven Estate has been used to guide the key routes to and from the LSP area and the key access points. The LSP therefore has been designed with regard to the adjoining structure plans in the area which are more advanced, at least from a traffic and transport perspective.

The LSP area has frontage to Bluewater Drive. At present Bluewater Drive has a 16m road reserve, but as part of this LSP development, this will be increased to 20m in accordance with its status as a Neighbourhood Connector road. To facilitate the primary vehicle access to the proposed development, it is proposed to add a 4th arm to the intersection between Bluewater Drive and Chesstree Avenue and create a roundabout, as envisaged in the Shorehaven Estate LSP layout. Additional access will be gained via priority controlled intersections on Bluewater Drive, which are in accordance with the minimum spacing as set out in *Liveable Neighbourhoods* from the existing Shorehaven Estate intersections. This arrangement is illustrated in the wider LSP layout in Figure 3.1.

As it relates to connectivity to the surrounding LSP's, there are a total of 13 points at which access can be gained to/from the LSP area. A number of these are minor access points provided to ensure the road networks in the adjacent LSP are not compromised and remain legible, and that the LSP area is well connected. Of these 13 accesses, it is considered there are seven key access points with respect to vehicle distribution and routes between the LSP area and key points on the external road network for onward travel (to Marmion Avenue or Alkimos Drive, for example). These access points are highlighted in Figure 3.3.

Figure 3.3: LSP Vehicle Access Points



All of the proposed access points are priority controlled intersections, with one roundabout. Some intersections give priority to LSP area traffic and some give priority to passing traffic.

The access points provide good connections to Marmion Avenue which provides a strong north-south link on the strategic road network. The access points on the southern boundary of the LSP will ultimately provide access to Alkimos Drive (once constructed), which in turn will provide access to the Mitchell Freeway (once extended). Marmion Avenue will ultimately become a dual carriageway with two lanes in each direction, upgraded when development and vehicular demands in the North West corridor increase. This direct access to the strategic road network is of great benefit for both vehicular access and access to a public transport corridor, for what is a relatively small scale development.

4. Traffic Impact Assessment

4.1 Introduction

The traffic impact assessment for the LSP has been completed for the 2031 design year, consistent with the planning and transport modelling completed by Main Roads Western Australia (MRWA) for the region, as well as the design year adopted in the transport study for the DSP (being 2031).

It is assumed the entire LSP will be fully operational at 2031 (i.e. ultimate development scenario).

4.2 Background Traffic Volumes

As previously discussed, given the location and scale of the LSP in the context of the DSP movement networks, it is expected there will be limited through traffic. Accordingly, the LSP traffic generation is the main consideration within this traffic impact assessment.

4.2.1 DSP and Adjacent LSPs

The DSP documents and LSP documents for Shorehaven and Eglinton Estates have been reviewed to determine any relevant traffic volumes for consideration. It is important to note in this respect that traffic generation associated with the LSP area has been considered within the DSP and the movement networks originally defined on this basis. The current LSP proposal is consistent with the intent of the DSP and so it is not expected that any major changes to the previous outcomes would occur.

The LSP report prepared for the Shorehaven Estate to the south states that Bluewater Drive is expected to carry in the region of 4,700 vehicles per day at its western end (Marmion Avenue) and 4,000 vehicles per day at its eastern end. The Shorehaven Estate LSP traffic report indicates 1,900 vehicles per day are expected to travel on Chesstree Avenue, with around 4,300 vehicles per day on Maroon Avenue. Note however, that these volumes are particularly high since they include around 650 vehicles per day associated with the proposed LSP area and also assume the inclusion of the Alkimos-North rail station. As discussed previously, this rail station will no longer be provided and so the traffic flows included in the Shorehaven Estate LSP report are deemed inappropriate for use and planning of the road network for the LSP area.

Following this, a first-principles trip generation exercise has been conducted to conservatively estimate the potential traffic generation associated with the Shorehaven Estate development to the immediate south of the LSP area. This portion of Shorehaven Estate includes around 305 residential lots west of the railway reserve, which has been used to estimate the actual vehicle trip generation. The vehicle trip generation has then been distributed between Marmion Avenue and Alkimos Drive. For the purpose of generating a conservative estimate of traffic on key links, it has been assumed that all vehicles heading to Marmion Avenue will do so on Bluewater Drive, and all vehicles heading to Alkimos Drive will do so on Chesstree Avenue. The trip generation and distribution is set out below in Table 4.1.

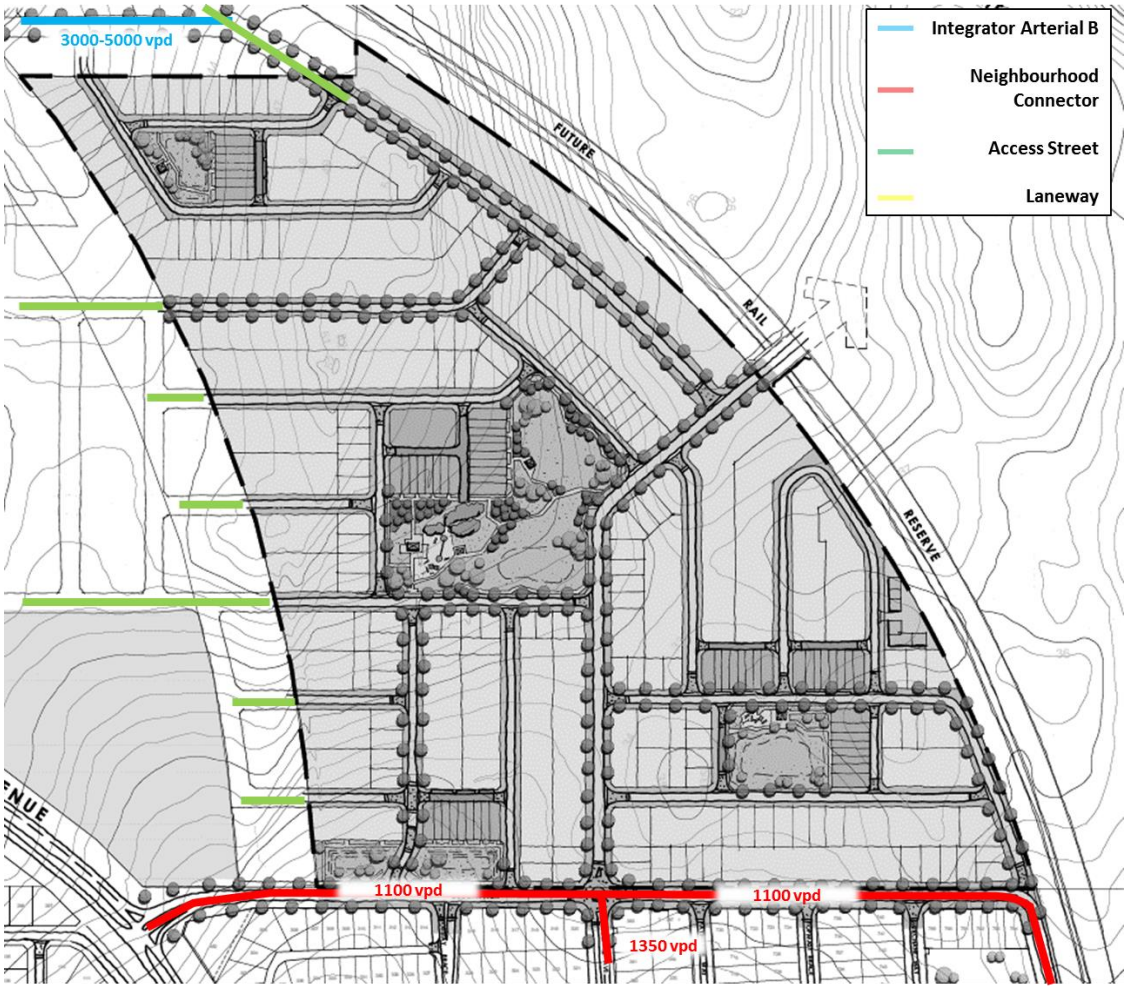
Table 4.1: Estimated Shorehaven Estate Traffic Generation

Land Use	Size	Trip Generation		Trip Distribution	
		Daily Rate	Daily Trips	Bluewater Drive	Chesstree Avenue
Residential	305 lots	8 trips / dwelling / day	2,440 trips / day	45% 1,098 trips / day	55% 1,342 trips / day

The LSP report for Eglinton Estates to the north and west is less prescriptive with respect to traffic flows, while presenting a range of potential volumes for the purpose of defining road categories. These defined road categories do provide an indication of the capacity of each of these road links.

Figure 4.1 provides a summary of these road categories and forecast volumes on the surrounding road networks as described above and extracted from the adjacent LSP reports.

Figure 4.1: Surrounding Road Types and Traffic Volumes



4.2.2 Potential Rezoning of Land to East of Rail Reserve

It has been assumed for the preparation of this report that a bridge will be provided on the eastern boundary of the LSP to link to potential future residential development on the east of the rail reserve (subject to assessment and planning approvals to rezone to residential use).

it is therefore important to consider the impact of any traffic travelling through the LSP area using the bridge. It is noted however that the area to the east of the rail reserve is also well served by the road network included in the DSP, with a key integrator arterial road running north-south east of the rail reserve, connecting to Alkimos Drive and north to Pipidinny Road and the Eglinton District Centre. There are therefore other, more direct, opportunities for this development to access the strategic road network and this is reflected in GTA's determination of traffic volumes which may enter the LSP area from it. The bridge therefore is expected to serve more local traffic as opposed to opening up a through-route.

It is anticipated that the development of the land to the east of the rail reserve may yield around 450 lots, resulting in a total of around 3,600 vehicle trips per day (assuming 8 trips per dwelling per day). Considering the key travel nodes for vehicle traffic in the area; Marmion Avenue, Alkimos Drive and the Mitchell Freeway, and the options for vehicles for this area to get to these, it is estimated that up to 30% of daily trips could enter the LSP area. This 30% has been assumed to primarily travel along the main spine road through the centre of the LSP area and the road against the eastern site boundary to gain access to Marmion Avenue. These volumes have been estimated and distributed, and are presented in Figure 4.2.

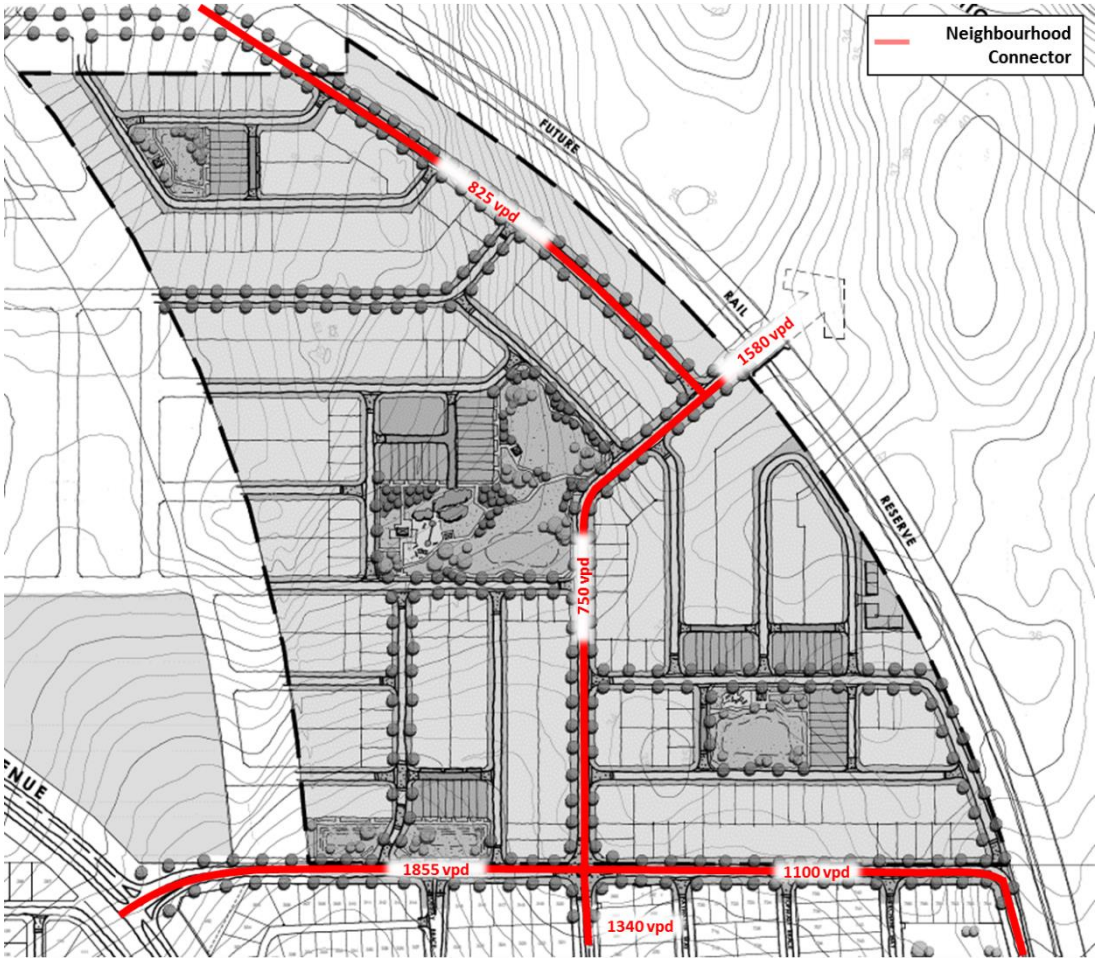
Figure 4.2: Rezoned Land to East, Vehicle Trips in LSP area

It is also likely that the introduction of the bridge will attract vehicle movements from Eglinton Estates, through the LSP area to gain access to Alkimos Drive to the east of the rail reserve. A

proportion of the trips identified on the Integrator Arterial B road shown in the Eglinton Estates LSP (refer Figure 4.1) will therefore travel through the LSP area.

As such, for the purposes of this report, the background traffic has been adopted as shown in Figure 4.3.

Figure 4.3: Total Background Traffic



Due to its inherent location, a number of the roads on which background traffic has been estimated are outside of the LSP area. These roads and the volumes on them have been determined during the respective planning exercises for these LSP areas, or in the case of Shorehaven Estate re-estimated for consideration in this LSP proposal. This report will illustrate the expected traffic volumes (including those associated with this LSP) on the external roads against the theoretical road capacity to identify if the future volumes are expected to exceed these.

4.3 LSP Traffic Generation

As per the WAPC Guidelines, a conservative trip generation rate of 8 trips per day and 0.8 trips per peak hour for each dwelling has been applied to estimate trip generation of the residential lots proposed within the LSP.

The ultimate yield is around 470 residential dwellings. On this basis, the traffic generation associated with the LSP is presented in Table 4.2.

Table 4.2: Estimated LSP Traffic Generation

Land Use	Size	Trip Generation Rates		Traffic Generation Estimates	
		Peak hour	Daily	Peak hour	Daily
Residential	470 lots	0.8 trips / dwelling / hour	8 trips / dwelling / day	376 trips / hour	3,760 trips / day

Table 4.2 indicates that the LSP proposal could be expected to generate some 3,760 vehicle trips over a given weekday.

These traffic generation estimates represent a total of the traffic likely to be generated by the LSP. These estimates do not take into account any potential discount due to trips internal to the LSP, and as such are expected to provide a conservative estimate of traffic generated by the LSP.

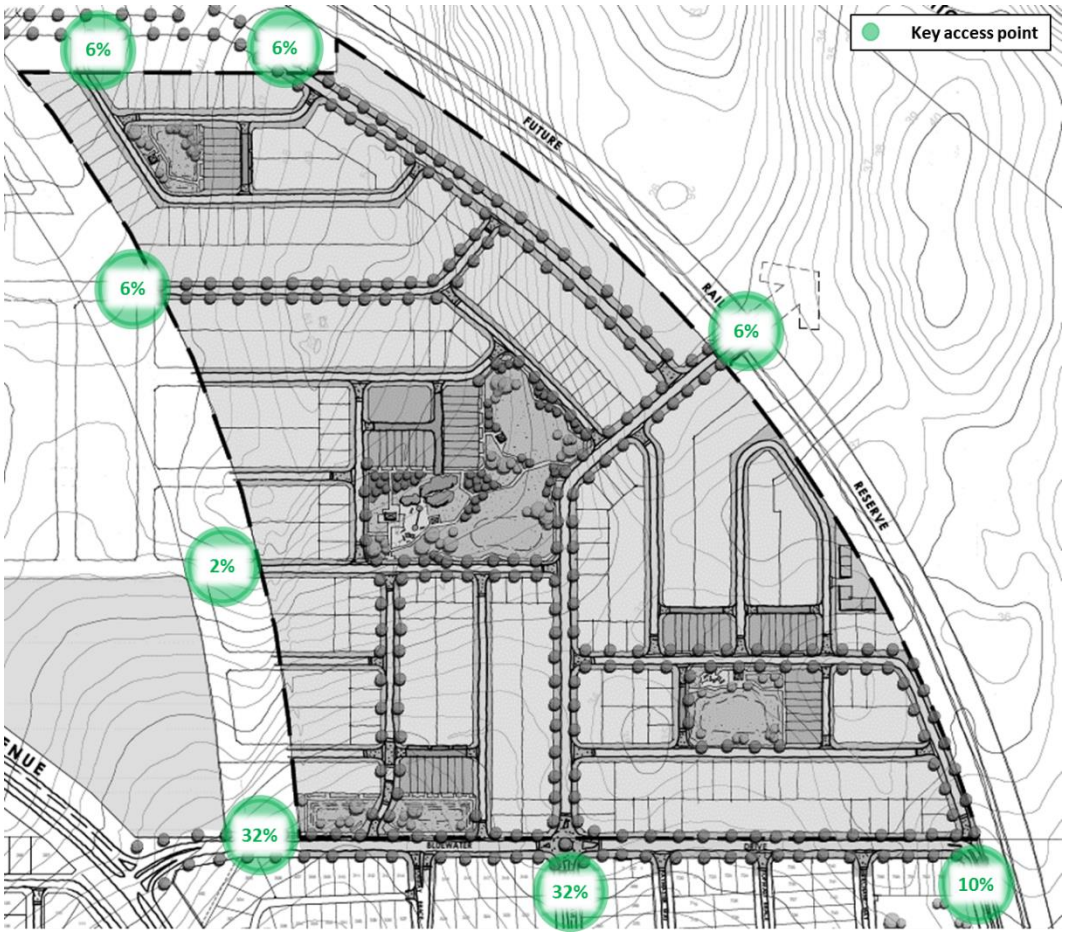
4.4 Distribution and Assignment

The directional distribution and assignment of traffic generated by the LSP is influenced by a number of key factors, including:

- configuration of the surrounding road network, intersection locations and permitted movements at intersections
- anticipated future operations of roads and intersections in the area
- surrounding land uses, employment and commercial centres in relation to the site
- the proposed site access arrangements and turning movements permitted at these access locations.

Having consideration for these factors, the external traffic distribution proportions between the eight key access intersections have been assumed as shown in Figure 4.4.

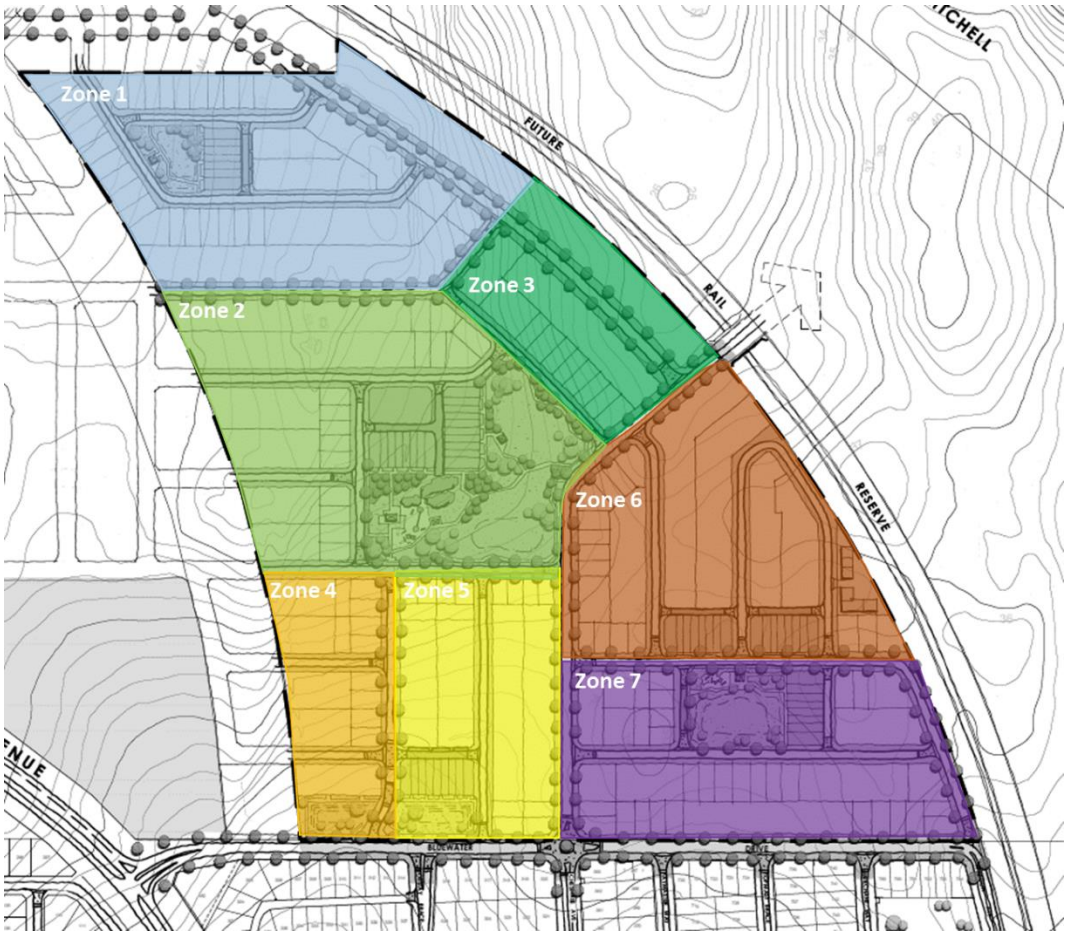
Figure 4.4: Utilisation of Access Points



4.5 Internal Road Hierarchy

In order to determine traffic distribution on individual roads within the LSP, a series of traffic generating zones were devised within the LSP, as illustrated in Figure 4.5.

Figure 4.5: Traffic Generation Zones

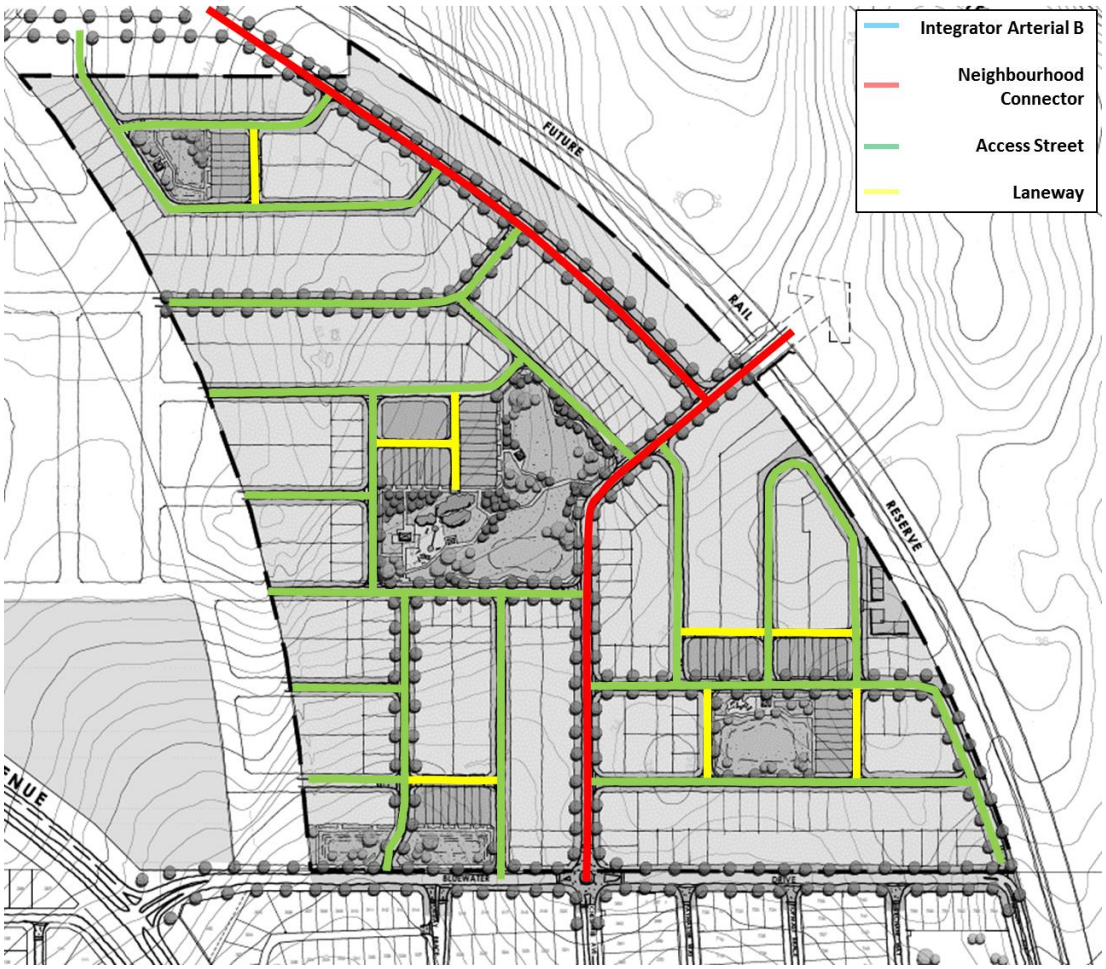


Traffic from these zones were then assigned onto the internal road network based on their attraction to the key access points shown in Figure 4.4. The daily demands expected on the proposed road network, including background traffic, are set out in Figure 4.6.

Figure 4.6: Estimated daily vehicle demands

From this, the proposed internal road hierarchy for the LSP was developed, which is shown in Figure 4.7. This road hierarchy has been developed using the guidelines and indicative daily traffic volume limits set out in *Liveable Neighbourhoods*, together with the overall design principles and aims for the LSP.

Figure 4.7: Proposed Road Hierarchy



The road reserve widths proposed for each class of road are in line with the guidance set out in *Liveable Neighbourhoods*, as set out below:

- Neighbourhood Connector = 19.4 – 24.4m
- Access Street D = 14.2 - 15m
- Laneway = 6 – 6.4m.

The addition of traffic associated with the LSP area, once distributed through the adjacent road network, does not compromise or exceed the capacity of the proposed road types within the other LSP areas.

4.6 Intersection Types

Given the sole residential land use within the LSP area, and the expected weighted one-directional peak hour flows within the internal road network, it is not expected any capacity issues will occur and that uncontrolled priority and roundabout intersections will be sufficient to accommodate expected demand.

The intersections throughout the LSP area are all therefore proposed as priority controlled intersections, with the exception of one on the main Neighbourhood Connecter road through the centre of the LSP. The intersection of Chesstree Avenue and Bluewater Drive is proposed as a

roundabout to facilitate primary access to the LSP area. These intersection forms should be further tested and analysed during subdivision stage.

5. Conclusion

Based on the analysis and discussions presented within this report, the following conclusions are made:

i The proposed LSP is located in the Alkimos Eglinton DSP, just north of the Shorehaven Estate.

ii The proposed LSP area covers approximately 28 ha in area and located immediately west of the railway reserve. The LSP proposes development of the land for:

- Approximately 470 residential dwellings
- Associated open space (to be provided in accordance with *Liveable Neighbourhoods*).

iii This site is located in the DSP area for which the future transport networks have been mapped out. The site layout has been developed in this regard and intends to enhance the movement networks in the area.

- It is proposed to provide footpaths on both sides of all proposed Neighbourhood Connectors and a minimum of one side of all Access Roads (with key access roads provided with a footpath on both sides).
- Shared use paths and on-road cycle lanes are to be provided on key links.

iv Vehicular access to/from the LSP has regard to the adjacent structure plan layouts. In total 13 access points are provided, with seven of these expected to be key.

v The intersection of Chesstree Avenue and Bluewater Drive is proposed as a roundabout to facilitate primary access to the LSP area. All other proposed access points are priority controlled intersections.

vi The LSP is expected to generate up to 3,760 vehicle trips on a daily basis.

vii The road network within the LSP has been determined on the basis of daily flows and in accordance with *Liveable Neighbourhoods*.

viii It is expected the external traffic generation associated with the LSP can be accommodated on the future planned external road network.

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APPENDIX 5

Local Water Management Strategy (Cossill & Webley)

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APPENDIX B – Preliminary Karst Landform Management Report (Prepared by CMW)

APPENDIX C - Catchment Areas and Drainage Calculations (Prepared by Cossill & Webley)

APPENDIX D – Lot 6 Taronga Place, Eglinton Conceptual POS Designs (Prepared by Plan E)

APPENDIX E - PC Sump Calculations (Prepared by Cossill & Webley)

APPENDIX F - Department of Water Checklist

ABBREVIATIONS

AHD	Australian Height Datum
ARI	Australian Rainfall Intensity
ASSMP	Acid Sulphate Soils Management Plan
BMP	Best Management Practices
DoW	Department of Water
EPA	Environmental Protection Authority
LOT 6 LSP1	Eglinton Lot 6 Taronga Place Local Structure Plan 1
LSP	Local Structure Plan
LWMS	Local Water Management Strategy
PDWSA	Public Drinking Water Source Area
POS	Public Open Space
WSUD	Water Sensitive Urban Design
UWMP	Urban Water Management Plan

EXECUTIVE SUMMARY

This document, prepared for Urban Quarter WA, aims to define the strategy for water management at a local level for the Eglinton Lot 6 Taronga Place Local Structure Plan (Lot 6 LSP1) area.

Background

The Lot 6 LSP1 is presented in APPENDIX A. This area is currently zoned Urban under the current Metropolitan Region Scheme (MRS).

Local Water Management Strategy

A LWMS is required to address the following:

- Principles, objectives and requirements for total water cycle management
- Interim water related design objectives for the LSP area
- Existing site characteristics
- Site constraints and opportunities, and identification of the critical management issues
- Discussion of potential water sources for drinking water and other uses
- Conceptual stormwater management system
- Recommended monitoring framework
- Issues to be addressed at subdivision stage (UWMP)
- Implementation framework

These components are summarised below and discussed in further detail within the main body of this LWMS for Lot 6 Taronga Place, Eglinton.

Water Balance and Conservation

The objective of water source planning is to identify possible water sources particularly for non-potable uses in order to reduce potable water consumption. Pre and post-development water balances at the development plan scale inform the assessment of environmental water requirements and options for use of potable and non-potable water.

The results of the preliminary water balance for the Lot 6 LSP1 indicate that an average property without water efficiency measures will meet the 100kL/person/year water consumption targets set by the Water Corporation.

A significant reduction in water use can be achieved by limiting the use of potable water outside the home. Water conservation initiatives may include:

- Xeriscaping;
- Waterwise POS designs that promote the installation of native coastal or Mediterranean species;
- Rehabilitation or revegetation areas that will remain un-irrigated post establishment;
- Areas of lawn/vegetation that require significant watering to be reduced;
- Garden and lawn care education;
- Encouraging residents to install rainwater tanks.

Stormwater Management Objectives

The water management strategy will incorporate:

Water sensitive urban design - The following structural Best Management Practices (BMPs) will be used to address water quality for the Lot 6 LSP1:

- Soakwells within lots and for use as gully pits
- Vegetated swales
- Retention/detention basins

Flood management – Surface water will be directed to POS, conveyed by a combination of overland flow paths and pipes within road reserves. Roadways will be used as flood path to each of the POS/infiltration areas located throughout the LOT 6 LSP1.

Conceptual stormwater management system - A system to maintain post-development flows consisting of the following components:

- Maximising infiltration at-source to recharge the unconfined aquifer. At source infiltration is to be achieved through the use of lot-level soak-wells, street-level drainage pits, tree pits and road-side swales,
- Use of BMPs such as bio-retention swales to manage water quality (nutrient loads),
- Retention of runoff from storm events of up to 100 year ARI within the catchment using retention/infiltration systems in line with WSUD principles,
- Conveyance of flood events to a designated infiltration basin,
- Consideration of water conservation options, such as stormwater reuse, rainwater tanks, waterwise landscaping and waterwise POS area design,
- Use of non-structural practices (e.g. ongoing maintenance programs, xeriscaping) to ensure the stormwater management system functions as designed,

Groundwater management – there is significant separation to groundwater, and hence through careful management of nutrients within the future development, it is not anticipated that development of the Lot 6 LSP1 will adversely impact groundwater quality.

Monitoring

No pre-development monitoring has been undertaken for the Lot 6 LSP1. The performance of swales and bio-filters should be monitored to confirm they are performing adequately.

1. INTRODUCTION

Cossill & Webley (CW) were commissioned by Urban Quarter WA to prepare a Local Water Management Strategy (LWMS) for the Eglinton Lot 6 Taronga Place Local Structure Plan 1 (Lot 6 LSP1) area.

This LWMS has been prepared as a supporting document to the Lot 6 LSP1.

The Lot 6 LSP1 is approximately 28 hectares in area and is situated within the City of Wanneroo, approximately 45 kilometres north of the Perth city centre. The Site is bound by Bluewater Drive in the existing Shorehaven Development to the south, rural property to the north, future urban development to the west and the Rail Reserve to the east. Most of the Site has been cleared previously, as presented in Figure 1 below.

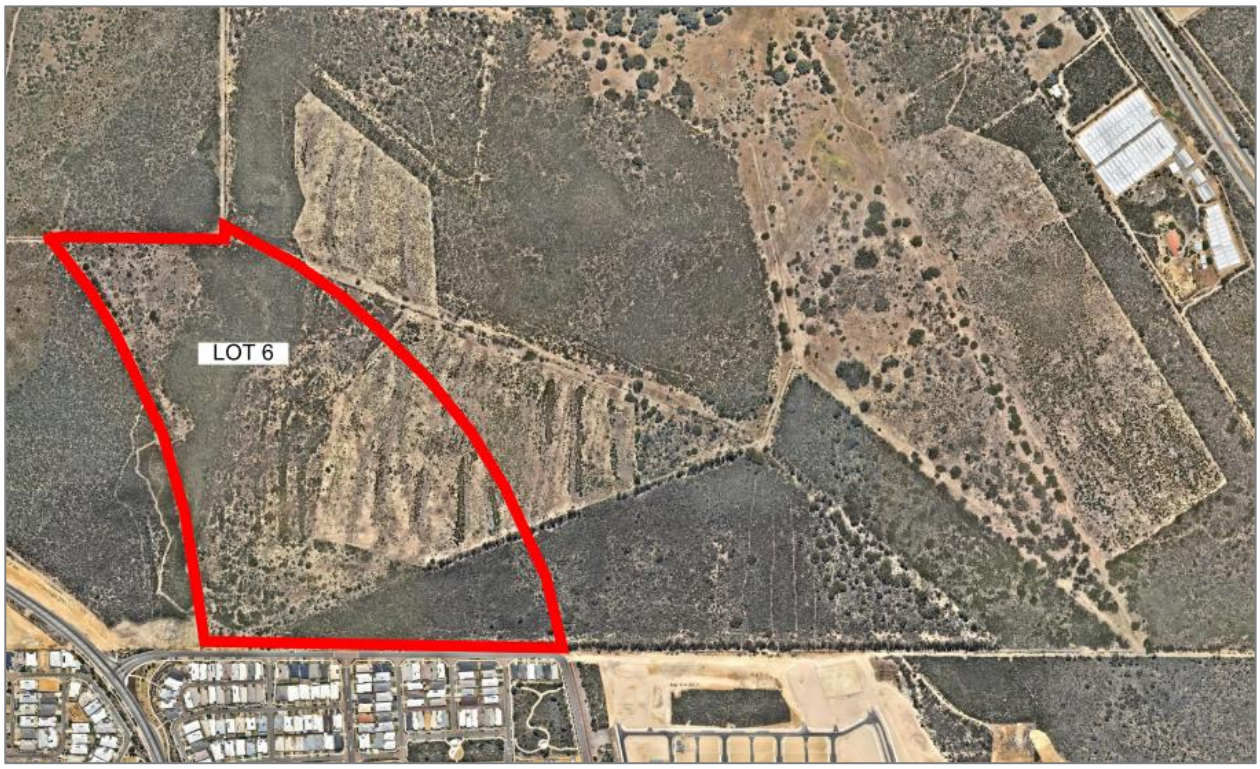

Figure 1 - Arial Photography (Nearmap November 2016)

A LWMS is required by WAPC's Better Urban Water Management (BUWM; WAPC 2008) to support the Lot 6 LSP1 prior to the development of any land zoned Urban.

Table 1 below presents the status of the Planning and Water Management strategies as required under State Planning Policy 2.9 Water Resources (WAPC 2006) and the Stormwater Management Manual for WA (DoW 2007).

Table 1 - Planning Stages and Required Management Strategies

Planning Phase	Planning Document and Status	Water Management Strategy / Plan and Status
Regional	The Alkimos Eglinton District Strategy Plan (CoW, 1995) **COMPLETED**	North West Metropolitan Area Integrated Water Management Study (GHD, 2005) **COMPLETED**
District	Alkimos Eglinton District Structure Plan (CoW, 2010) **COMPLETED**	Alkimos Eglinton District Water Management Strategy (GHD, 2011) **COMPLETED**
Local	Eglinton Lot 6 Taronga Place Local Structure Plan **DRAFT STATUS**	Local Water Management Strategy **THIS DOCUMENT**
Subdivision	Subdivision Application **FUTURE PREPARATION**	Urban Water Management Plan (UWMP) **FUTURE PREPARATION**

2. PROPOSED DEVELOPMENT

2.1 Previous Land Use

The Lot 6 LSP1 has previously been used for stock grazing. There is no evidence of contamination on the site itself or historical land uses which would lead to contamination.

2.2 Structure Plan

The proposed local structure plan for this site area as developed by CLE, Town Planning Consultants, is provided in APPENDIX A. The fundamental objective of the Structure Plan is the establishment of an interconnected road and pedestrian network, along with open spaces and pocket parks for both recreational use and drainage to support a residential community.

The development's land uses will primarily consist of:

- Approximately 25ha of residential land (~468 lots) and roads supporting a combination of traditional, cottage and group housing lots.
- Approximately 3ha Open Space for the provision of passive and active recreation and drainage.

2.3 Landscaping

The Lot 6 Taronga Place POS design provides for approximately 2.9ha of open space with a large part of this provision allocated within a centrally located area of public open space. Smaller, supporting Pocket Parks and streetscape design provide a logical distribution of POS throughout the Estate. The spacing of POS areas throughout the site ensures that all residents are located within 200 metres of a park.

The following parameters also influenced the shape and location of the open space design:

- The landform and ability of the underlying topography to provide for view corridors,
- The potential for limited vegetation retention, and,
- Drainage requirements including integrating drainage within the streetscape and open spaces to

complement passive recreation.

2.3.1 Landscape Theming

The parks will incorporate a multi-tiered structure of tree and shrub planting. All the parks will be designed using sound water sensitive design practice and the majority of planting will be native or native derivative shrub species with a combination of native trees and feature ornamental trees that are recognised as 'one drop' or 'two drop' species in the Water Corporation "Waterwise Guide to Gardening".

Wherever possible, areas of turf will be limited to within the parks where maximum public amenity value can be derived. Otherwise the landscape treatments will explore the use of hard or porous surfacing or alternative treatments to minimise water usage.

Areas of native planting will be positioned to augment retained areas of vegetation where possible. The species to be selected will closely align to the extant species to reinforce the local vegetative assemblage and assist in reducing the long term irrigation requirements over the development site.

2.3.2 Open Space Designs

There are four (4) proposed areas of POS. A brief outline of each follows -

- Central Local POS – 1.75 ha of parkland located in an elevated part of the Site with dramatic outlooks to the south and east. A small area in the south-east corner of this POS will be subject to inundation from time-to-time,
- South-West POS – 0.40 ha of parkland located adjacent to Bluewater Drive at a low point in the road itself. This POS will provide for an inviting entry to the estate and dispose of drainage from a small catchment,
- South-East POS – 0.50 ha of regularly shaped POS surrounded by roads to the north, west and south and overlooked by cottage lots to the east. About 25 lots will have an aspect over this park. A portion of it will be subject to inundation from time-to-time,
- North-West – 0.25 ha of regularly shaped POS surrounded by roads to the north, west and south and overlooked by cottage lots to the east. Some 23 lots will have an aspect over this park. A portion of it will be subject to inundation from time-to-time.

It is proposed the 1 year ARI event be disposed in a combination of tree-pits in front of lots and road-side swales located higher up in the drainage catchment where possible, with the balance being infiltrated in POS areas. Adoption of this philosophy will assist in providing for more flexibility in the landscape design.

2.3.3 General Landscape Treatments

2.3.3.1 Soil Amelioration

Areas of rock will be removed and replaced with soils that promote plant growth. Imported or blended on-site moisture retentive soils will be used in appropriate areas.

2.3.3.2 Overall Irrigation Management

Irrigation systems will be designed to manage the rate of application of water to areas being irrigated.

2.3.3.3 Water Conservation Strategy

At Lot 6 Taronga Place, Eglinton the following measures will be taken to reduce water wastage and to ensure water is used in the landscape in a responsible manner:

1. Adoption of water sensitive urban design (WSUD) principles;
2. Hydro-zoning of Public Open Space Landscape and Irrigation design;
3. Incremental irrigation reduction strategy applied to Streetscapes and POS where applicable;
4. Utilising soil conditioners and mulches in garden bed areas to assist with moisture retention;

5. Utilising tree pits and roadside swales which promote return of water to the environment as close to source as practicable

2.3.3.4 Specification for Irrigation

Irrigation will be designed in accordance with the City of Wanneroo's requirements.

2.3.3.5 Maintenance

The developer intends to maintain completed POS for a period of 2 years. Thereafter, POS will be maintained by the City of Wanneroo.

3. DESIGN CRITERIA

3.1 Stormwater Management Objectives

The following objectives for stormwater management have been adopted for the development in accordance with the Stormwater Management Manual for WA (DoW 2007):

Water quality and quantity – maintain the surface and groundwater quality and quantity (total water cycle balance) within the development areas relative to predevelopment conditions.

Water Conservation – maximise the reuse of stormwater, recognising that urban water flows are a potential resource.

Protection of Public Health and Property – minimise the public risk, including risk of injury or loss of life and protect the built environment from flooding and water logging.

Social Values – ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.

Development and Economic Viability – ensure the delivery of best practice stormwater management through planning and development of high quality developed areas consistent with sustainability and precautionary principles and ensuring the long term viability of these stormwater management systems. A risk assessment shall be provided at the UWMP stage to establish the impact of a 1:500 year ARI storm event on the higher sensitive areas of the development, subject to the City of Wanneroo confirming a hydrological basis for determining the 1:500 year storm event.

3.2 Stormwater Management Principles

The principles as summarised in Table 2 below will be applied to the proposed development to address the water management objectives:

Table 2 – Stormwater Management Principles

Item	Description
Water Conservation	Consider all potential water sources in the water supply planning Minimise potable water usage where possible. If possible, target a potable water consumption target of 40-60kL/person/year. Maximise stormwater reuse
Surface Water Quality	Improve groundwater quality where possible by preventing illegal dumping through development. Introduce treatment trains through the use of tree pits, verge swales, bio-retention areas, open based pit and pits (where not under roads), permeable paving and other structural and non-structural devices outlined in the City of Wanneroo's City Water Management Strategy. Implement end-of-pipe measures to mitigate any remnant contaminants entering the groundwater prior to discharging to receiving environments.
Stormwater Management	Disposal method - On-site infiltration using swales and basins. Up to 1 year ARI events - Where grades permit target capturing "very frequent events" which are to be infiltrated in the vicinity of the stormwater runoff collection points through tree wells and verge swales, with the balance of the 1 in 1 year ARI event to be stored in POS. Greater than 1 year and up to 100 year ARI events - Storm event flow to be transferred to an infiltration swale. - Infiltration swale to be sized for the critical 1 in 5 year and 1 in 100 year ARI storm events. - 100 year ARI events are to be contained within POS depicted on the Lot 6 LSP1.
Stormwater Conveyance System and Treatment	Conveyance system - Pipe system or swales sized for the critical 5-year ARI storm event. Gross pollutants - Suitably sized gross pollutant traps to be included on the outlet of all pipe systems discharging into public area infiltration swales. - Manholes - Use of soakage manholes to enhance stormwater infiltration for low flow events.

	Dissolved nutrients - A combination of various structural and non-structural devices will be determined based on the City of Wanneroo's City Water Management Strategy, and may include features such as infiltration basins, permeable paving, verge swales, tree wells and bio-filtration areas. The selection and location of these features will be determined at the UWMP preparation stage.
Stormwater Collection	- Public roads to be kerbed with side-entry pits or with gaps in the kerbing to allow stormwater to flow to the piped or swale drainage system. This arrangement will allow for easier management of large spills on the road pavement.
Flood Management	Road Reserves - Storage volume is required within the road reserves and at the site of the infiltration swales to accept flows from the critical 100-year ARI storm event. - The flood path for water exceeding the design level of the flood storage area to be directed away from development by providing overflow flow paths and maintain a minimum of 0.3m freeboard between the 100-year flood level and finished lot levels. - A minimum of 500mm freeboard between the 100-year water level and the finished levels for lots adjacent to POS basins.
Local Permeability	In-situ soil permeability is to be tested in drainage disposal locations to ensure the appropriate sizing of the drainage infrastructure at the UWMP stage.
Vector and Nuisance Management	Ensure, as far as practicable, the design of drainage swales, infiltration basins, road gullies etc. do not contribute to onsite mosquito breeding. Provide ongoing maintenance and management of the stormwater system to ensure that it continues to operate as designed, thereby reducing the risk of creating conditions likely to promote mosquito breeding.
Other Requirements	All other requirements as prescribed/allowed by the City of Wanneroo.

4. PRE-DEVELOPMENT ENVIRONMENT

4.1 Site Characteristics

The Site is approximately 28 hectares in area and is situated approximately 45 kilometres north of the Perth city centre, within the City of Wanneroo. An aerial view of the Site is presented in Figure 1.

4.2 Geology and Landform

The Geological Survey of Western Australia Perth Metropolitan Region Soils Maps indicates the majority of the Site is generally characterised by Limestone (LS_1) light yellowish brown, fine to coarse grained with a portion of the Site characterised by Calcareous Sand (S_1) white, fine to medium grained.

This soil type is well suited to urbanisation, and is generally very permeable, allowing for the on-site disposal of runoff from newly created roads and lots. *Figure 2* below presents the geology across the Lot 6 LSP1.

Although no detailed geotechnical investigation has been completed across the Site to our knowledge, it is anticipated that some surface rock is anticipated to occur predominately as cemented limestone along ridge lines within the existing Quindalup Dunes.

Based on our experience on similar projects within the area, the Site is well suited for future urban development and the on-site disposal of runoff generated from newly created roads and lots.

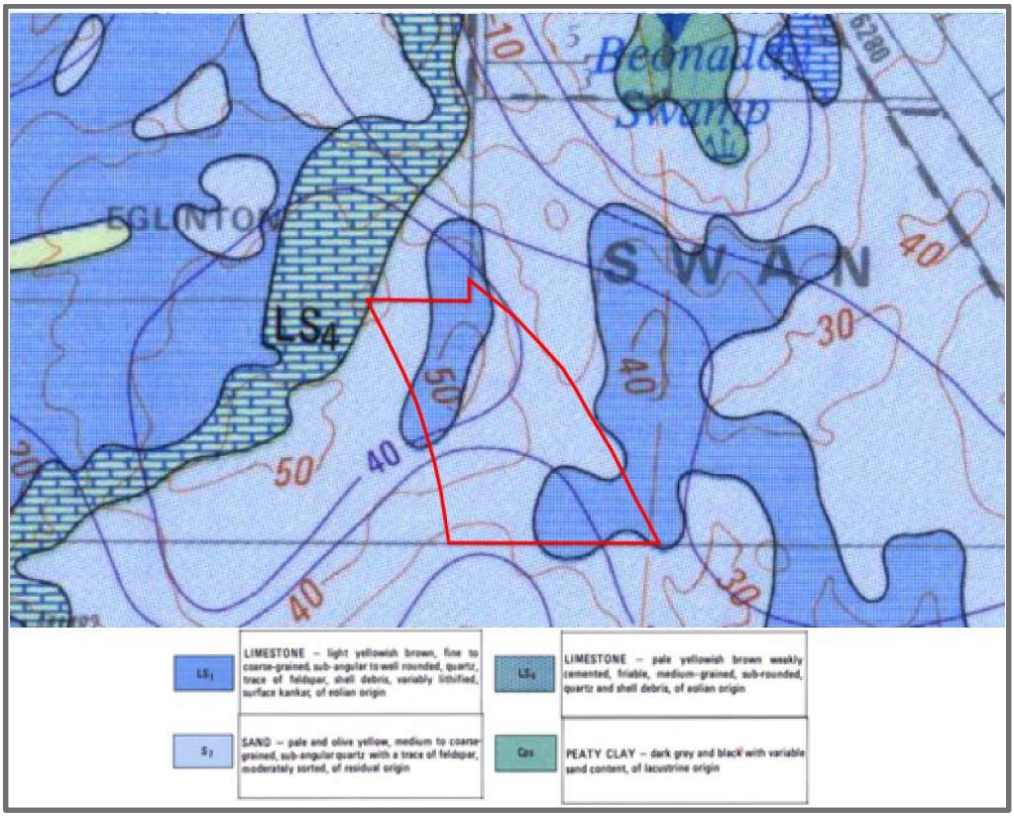

Figure 2 - Geotechnical Information (Geological Survey of WA)

4.3 Existing Topography

The Site comprises undulating dunes ranging in elevation from a peak of 52m AHD in the middle of the northern area down to approximately 30m AHD at the interface with the Shorehaven development to the south as presented in Figure 3 below.

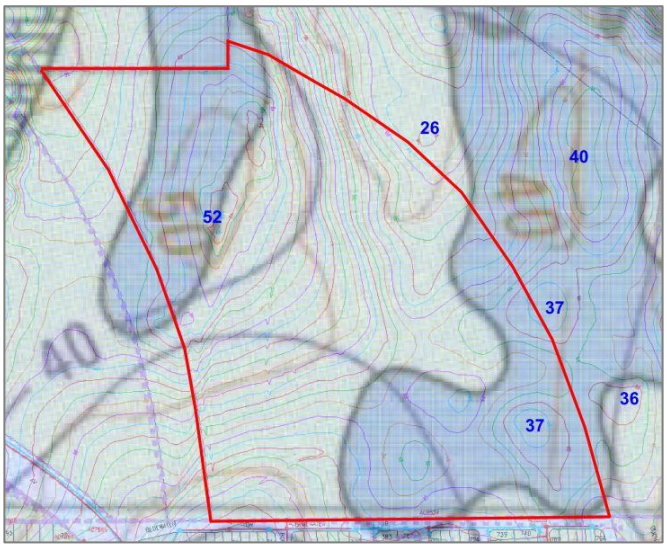

Figure 3 - Geological Survey of WA overlaid onto the site contours (Geological Survey of WA, Esinet)

4.4 Karstic Formations

Karstic ground formations are known to occur in the limestone rock in a north-south band along the eastern side of Wanneroo Road, well clear of the Eglinton West LSP area.

A visual inspection of the site was undertaken by the Western Australian Speleological Group (WASG) in 2007 identifying surface karst, confirming the likely presence of subterranean voids.

CMW Geosciences were engaged to review the likely impact of karst formations within the Site, and their report is presented in Appendix B for information. The eastern portion of the Site is considered to be within a recognised zone of potential karst features as presented below in Figure 4.

CMW's preliminary assessment recommends mitigating the risk where development is proposed within the karst risk zone. The majority of the karst risk area of the site coincides with areas of deep fill (more than 3m). Drainage disposal areas are not located in karstic areas.

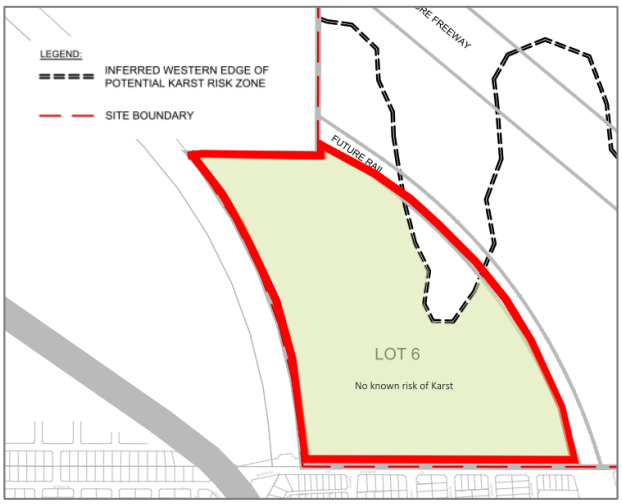

Figure 4: Inferred Potential Karst Risk Zone (CMW)

4.5 Unexploded Ordnance

The Department of Fire and Emergency Services (DFES) Unexploded Ordinance (UXO) has confirmed the Site lies within the north eastern portion of the former WWII Eglinton Training area where there may still be a slight risk from UXO contamination.

There are no known previous UXO assessments or survey over the Site, so whilst the risk from UXO is minimal, it is recommended that a limited UXO assessment survey (Field Validation Search @ 10% Coverage) be completed to confirm or discount whether explosive filled munitions have impacted the Site. If no evidence is found, then the area can be regarded as at very low risk and no further assessment or survey will be required by DFES at or during any future planned subdivision works. The awarded Site Contractor will be required to consider UXO in their Safety Management Plans.

4.6 Acid Sulphate Soils

A desk top review of the Department of Environment and Conservation's ASS Risk Map for the North Metropolitan Region for potential for acid sulphates soils (ASS) indicates the Site is classified as having no known risk of ASS potential. Given the low risk is not proposed to undertake any ASS testing or prepare an ASSMP as part of the development.

4.7 Groundwater Hydrology

The Annual Average Maximum Groundwater Level (AAMGL) varies from approximately RL 1.0m AHD on the western boundary to RL 1.5m AHD at the eastern boundary according to the Department of Water's Perth Groundwater Map. Given the natural ground levels across the Site, ground water will not control earthworks designs, nor impact adversely on any development.

4.8 Wetlands and Water Dependant Ecosystems

There are no wetlands or water dependant ecosystems within the extent of Lot 6 LSP1.Wetland UFI 8016 is located about 400m east-north-east of the Site.

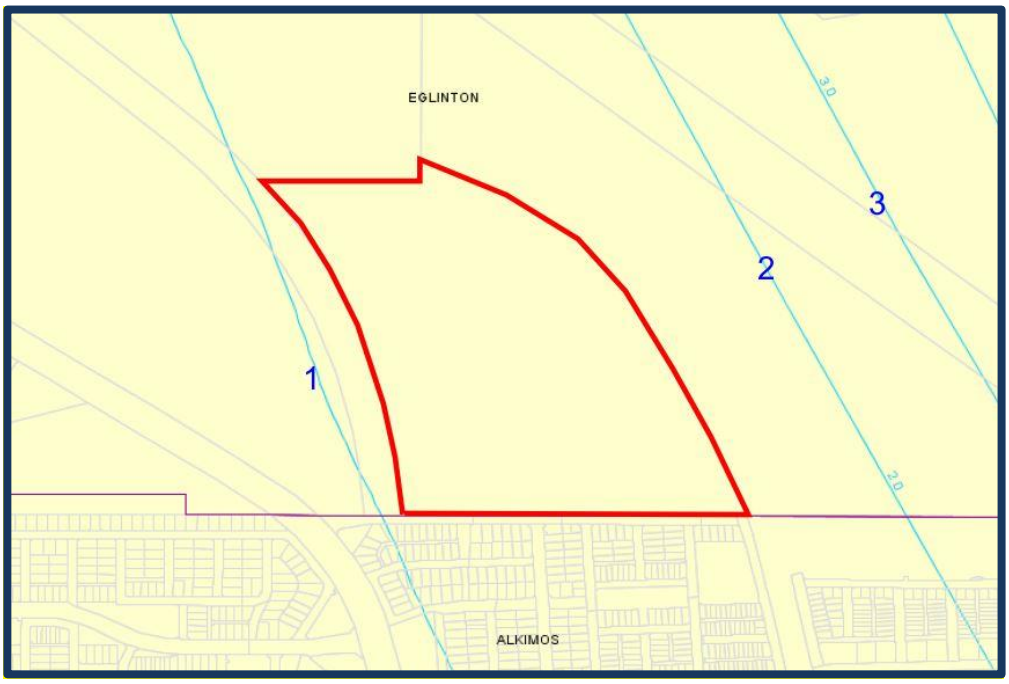

Figure 4 – Ground Water Contours – Historical Maximum (Dept. of Water 2015)

4.9 Environmental Assessment Summary

The following summarises the site from an environmental perspective -

- The majority of the site is undeveloped and consists of native bushland; much of which has been cleared previously. Firebreaks and previously grazed paddocks are also present,
- The land has previously been used to graze stock,
- Vegetation across the site encompasses approximately 28.16ha, comprised of a mixture of coastal scrub and woodlands with occasional larger eucalypt trees which have been planted, possibly as wind breaks. The condition of the vegetation ranges from Completely Degraded to Excellent,
- There are no surface water bodies within the LSP area. The nearest wetland is a Sump-land Resource Enhancement Wetland (UFI 8016) adjacent to the northern boundary of Lot 6 Taronga Place, approximately 650 m from the LSP area. Surface water is largely retained within the site due to the high permeability of the underlying soils and the wetland is up-gradient of the site and.
- The site is within a Priority 3 Public Drinking Water Source Area (PDWSA).
- The EPA has formally assessed Metropolitan Region Scheme Amendment 1029/33 for the broader Alkimos Eglinton area which identified specific areas of regional environmental significance which included scattered Tuart trees and Carnaby's Black-Cockatoo habitat. In response, 500 hectares of the identified environmental significant area (20% of the Alkimos-Eglinton region) was reserved for conservation purposes as Parks and Recreation or Public Purposes (Conservation) zonings.
- The EPA during its assessment of MRS Amendment 1029/33 did not identify any areas of regional conservation significance within the urban zoned portion of the Lot 6 LSP1.

4.10 Pre-Development Groundwater Quality

The Alkimos Eglinton DWMS prepared for the Alkimos Eglinton Land Owners (AELO) by GHD, contains a discussion of groundwater quality but it is only a single round. The DWMS indicates that additional regional monitoring was proposed to be undertaken over 2010/11 (refer Section 6.3.1). It is unknown whether this monitoring was undertaken.

4.11 Public Drinking Water Source Area

The Lot 6 LSP1 is situated within a Priority 3 (P3) Public Drinking Water Source Area (PDWSA) as presented below in Figure 5. P3 PDWSAs are declared over land where drinking water supply sources need to coexist with other land.

Figure 5 – Public Drinking Water Source Area (Dept. of Water 2015)

5. WATER SUSTAINABILITY INITIATIVES

5.1 The Water Cycle

Figure 6 below demonstrates the difference between the pre-development and post-development non-potable water supply.

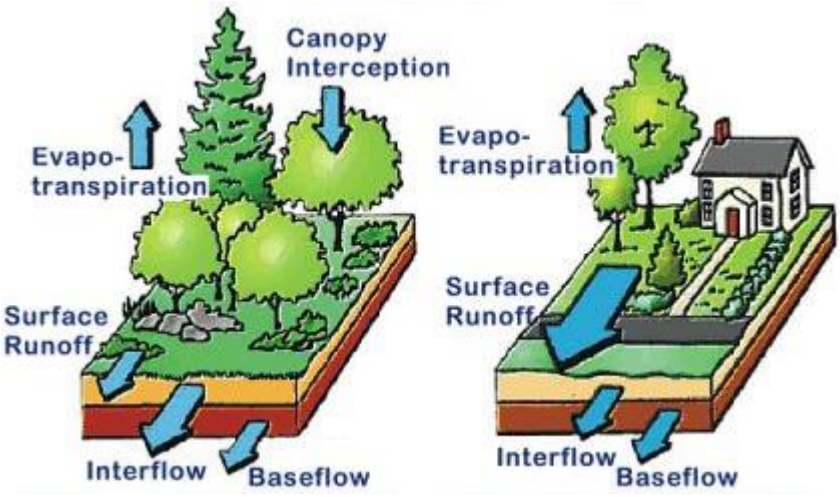

Figure 6 -Water Cycle (Pre and Post Development)

5.2 Water Demand

Water conservation is part the development's objectives with regards to managing a sustainable integrated water cycle. At the broad scale, the approach includes incorporation of water sensitive urban design at the local and lot scales, facilitating reduction in scheme water use, maximising the use of water efficient devices in houses and buildings and water efficient gardens and landscaping and substituting scheme water with non-drinking water for some uses.

In terms of water conservation, the developer recognises water as a valuable natural resource, and is well aware of water conservation initiatives and the need to reduce water use across the estate.

The hierarchy of the five water conservation principles will be followed: avoiding water use, reducing use, recycling, disposing appropriately, and ensuring feedback and adaptive management. The emphasis will be on the most preferred principle of avoiding water use.

The development of the Lot 6 LSP1 will focus on encouraging the community to use water saving devices and appliances through providing incentives; promoting the use of plants native to the locality as well as water wise plants in other areas, providing information and community education programs about water conservation issues.

5.3 Water Balance Modelling

5.3.1 Water Demands

Development of a greenfield site will impose changes to the water cycle within the developable and surrounding area, therefore it is necessary to predict the effects that urban development will have on the land and plan for the water demand of future development. The projected water balance for the Lot 6 LSP1 has been calculated in accordance with the Alkimos Eglinton DWMS.

A lot scale water balance has been undertaken for the Lot 6 LSP1 area to assess the impact of the lot scale water conservation measures on water consumption. The approach is based on three scenarios:

- Scenario 1: Conventional Scenario with a combination of traditional and cottage lots with a median size (371 m^2 lot), 10% of the lot irrigated with no water conservation measures and 2.7 persons/dwelling.
- Scenario 2: Lot 6 LSP1 best outcome: median 371 m^2 lots with all houses having waterwise gardens, 2000L rainwater tanks and water efficient fittings on all lots and 2.7 persons/dwelling
- Scenario 3: Lot 6 LSP1 likely outcome: median 371 m^2 lots with use of waterwise gardens on 30% of lots, 2000L rainwater tanks on 15% of lots and water efficient fittings on 50% of lots and 2.7 persons/dwelling.

Assessments were undertaken on the basis of the Water Corporation spreadsheet water_balance_tool.xls.

Numbers of persons per dwelling are based on the assumptions used in this spreadsheet. In all cases, allowance is made for irrigation of the verge.

The results of the modelling are presented in Table 3 below. The results indicate a total water use of 63 kL/person/year, with 46.7 kL/person/year of scheme water is anticipated. Results of the water balance indicate that an average property without water efficiency measures will meet the current Water Corporation target of 100 kL/person/year water consumption.

Scenario	Total Water Use (kL/person/year)	Potable Water Use (kL/person/year)
Scenario 1	67	47
Scenario 2	61	46
Scenario 3	63	46.7

Table 3 – Lot Water Balance

5.4 Ground Water Allocation

The eastern portion of Lot 6 has a groundwater licence under the name of G. Spiers (Licence No. 153683) who was the previous owner. The total licensed volume is 54 850 kL/yr and the licence is valid until 19 November 2019.

The purchaser of Lot 6 (the proponent of this LSP) intends to transfer the licence to their name.

5.5 Water Conservation and Efficiency

Water conservation is highly dependent on WSUD principles, which promote maximising infiltration through source control Best Management Practices (BMPs), and minimising the effective impervious area of the development plan. Consequently, the adoption of appropriate surface and groundwater management strategies is vital to the viability of total water cycle management and its requirements to maximise water conservation and reuse.

In order to quantify water conservation for the Lot 6 LSP1, a detailed water balance will need to be undertaken at the UWMP phase. Various measures for water reuse (such as rainwater tanks for non-potable use) will also be further investigated at UWMP phase.

The Water Corporation's Domestic Water Study in 2003 revealed that the total average use per household is 460 kL per annum. Assuming 2.7 people per household (Australian Bureau of Statistics 2001 Census Figures), this equates to 164 kL/person/year. The State Water Strategy target was to reduce water usage to 155 kL/person/year, however as this target has been met in recent years, the State Water Plan has set a target of 100 kL/person/year.

The use of potable water should be minimised where drinking water quality is not essential, particularly for irrigation and external uses.

5.5.1 Water conservation initiatives

The Water Corporation estimates that garden watering accounts for up to 60% of Perth's domestic scheme water usage. This is a particularly low value use for what is, in essence, a high quality resource (drinking water). Consequently, a significant reduction in potable water use can be achieved by minimising water use outside of homes. Based on this, the following initiatives will be considered in the LWMS and UWMP phases to reduce water usage for the Lot 6 LSP1:

- Xeriscaping,
- Reduced areas of lawn/gardens that require significant amounts of watering,
- Waterwise POS designs that promote the installation of native coastal or Mediterranean species,
- Promoting infiltration at source,
- Garden and lawn care education,
- Encourage residents to use rainwater tanks.

5.5.2 Waterwise landscaping

Provision of Waterwise landscaping packages will be considered by the proponents to land owners to achieve the following principles (as recommended on the Water Corporation's Waterwise website):

- Minimise the extent of high water consumption planting and lawn areas,
- Maximise the use of water conserving elements and techniques,
- Apply the basic principle of hydrozoning to planting design (grouping plants on the basis of having similar water requirements).

These design principles can be achieved through the following initiatives:

- Maximise the use of non-planting treatments such assoil conditioners and mulches,
- Keep planted areas dense and consolidated since sparse, scattered plants are more difficult to water efficiently than ones that are in defined areas,
- Keep lawn to the minimum consistent with functional and aesthetic requirements and avoid planting lawn on slopes or in narrow necks or paths which are difficult to water efficiently and maintain,
- Plant waterwise lawn and garden areas, which reduce the amount of grassed areas and employ water efficient sprinklers ,
- Controlled water application rates to suit the water requirement of plant, climate and rainfall patterns,
- Maximise at-source infiltration through WSUD principles using soakwells and infiltration BMPs such as bio-retention swales and detention storage zones within the POS areas.

5.5.3 Waterwise POS Design

Groundwater will be considered for POS irrigation at Lot 6 LSP1.

To further reduce this water use, POS areas will be landscaped with the following to reduce irrigated areas:

- Mulches and groundcovers,
- Footpaths,
- Use of native coastal or Mediterranean species,
- Swale littoral planting and rehabilitation planting,
- Reduced turf areas,

- Hardscaping and porous paving to reduce irrigated areas and assist with infiltration at source,
- Incrementally reduce irrigation cycles as plants become established.

5.5.4 Waterwise Streetscaping design

To further reduce this water use, road reserve designs in UWMP stage should consider the following initiatives to reduce water usage:

- Street trees, shrub or groundcover planting should be waterwise, with predominantly native coastal or Mediterranean species,
- Turf to verges should be minimised,
- The promotion of infiltration at source in verge swales in the 1:1 year or (if appropriate) the 1:5 year ARI storm event.

5.5.5 Infiltration

Infiltration of stormwater is common practice in West Australian land development projects and is considered an appropriate source control measure that can significantly reduce the magnitude and volume of stormwater runoff generated from the site.

Infiltration of rainwater generated from roof areas into the groundwater can be adopted without the need for pre-treatment on the basis that roof areas generate significantly lower nutrient loads. The infiltration of roof runoff can be through the use of soakwells installed at the building stage.

5.5.6 Rainwater tanks

Rainwater tanks capable of collecting stormwater directly from a roof or other above ground surfaces promote the reuse of the collected water as a substitute for potable water for use as a source of irrigation water and in some cases toilet flushing, laundry use or for hot water.

The use of rainwater tanks will be encouraged; but not mandated for this development.

5.6 Non-Potable (Third Pipe) Water Supply

The third pipe system for non-potable water supply is a technique where POS and household irrigation water is extracted from a production bore located within close proximity to the irrigation area. The third pipe system generally caters for a broader irrigation area supplying water to many consumers (rather than individual bores for each consumer). Based on the relatively small scale and commercial nature of this project, it is not proposed to install a third-pipe water supply at this development, as the irrigation areas at an allotment scale will be relatively minor.

6. STORMWATER MANAGEMENT STRATEGY

6.1 General

Best Management Practices (BMPs) in accordance with the Department of Environment & Conservation's Stormwater Management Manual and the City of Wanneroo's City Water Management Strategy will be implemented where drainage is required on site. At the detailed design and UWMP preparation stage, the planning layout and site characteristics will guide the selection of BMPs appropriate for the development. BMPs are the best practical approach for achieving water resource management objectives within an urban framework.

Best Management practices include the following elements which will be implemented for this project:

- Integration of active and passive POS areas into local urban water management.
- Design of road layout and streetscape to deal with water as a resource and an amenity. This will generally involve the use of roadside swales planted with natural, coastal vegetation.

- Structural and non-structural control measures such as; bio-retention areas, verge swales, tree wells, open based pit (where permitted by the City) and pipe structures (where not under roads), community education and street sweeping.

6.2 Flood Management Design

The overall stormwater catchment plan for the site is presented in Drawing 5826-00- SK10 provided in Appendix C. The design is based on the following design parameters:

- All runoff from lots greater than 300m^2 will be retained on-site within soakwells and garden areas. Lots less than 300m^2 will retain the 1yr 1hr ARI event in an on-site soakwell, connected to the roadside drainage system for larger events,
- Runoff from the road network for "very frequent events" will be detained as much as practical at source through the use of tree pits and roadside swales. To this end for this project the "very frequent event" adopted is the 15 minute 4 EY event (equivalent to 6.28mm of rainfall as per the BOM website). Any additional runoff not contained upstream in the catchment will be directed to POS areas. Flows which overtop the 1yr 1hr detention areas will flow into the POS storage/infiltration basins,
- Road runoff from events up to 5 year ARI will be conveyed via the piped drainage network to infiltration swales situated within POS areas. This will ensure that roads and walkways remain serviceable during these flood events. Side entry/gully pits will be located to suit appropriate spread rates and pit spacing for the required ARI storm event and road hierarchy,
- The 100 year flow paths are to be conveyed by overland flow paths within the road reserve to POS areas,
- The POS areas will be able to accommodate runoff from events from 1 in 5 year to 1 in 100 year ARI without unreasonably impacting on the amenity of proposed parks,
- Building pad levels will be at least 300 mm above the 100 year ARI flood level within each sub-catchment to the dynamic part of the drainage system, with 500mm freeboard being provided to end-of-line basins,
- An infiltration rate of 2m/day for tree wells, roadside swales and 1 in 1 year basins and an infiltration rate of 5m/day for POS which is not regularly inundated. Infiltration rates are to be validated following the completion of bulk earthworks. In some cases, more than 5m of earthworks is required to expose design levels making it impractical to determine infiltration rates now,
- A coefficient of runoff of 0.6 has been assumed for the 1 in 1 year ARI event. A coefficient of 0.8 from road reserves and 0.9 from lots less than 300m2 has been assumed for all events exceeding the 1 in 1 year ARI event, which is consistent with WCC policy.
- Due to the significant depth to the groundwater table, it is considered appropriate to allow the 1 in 1 year basins to be inundated in larger events. This approach has been assumed and will facilitate more flexibility with respect to POS design and lead to POS which has good amenity.

6.3 Drainage Area Requirements

The strategy adopted for stormwater quantity management for the development plan is to provide storage on a sub-catchment level to detain flows for storm event greater than 1 year 1 hour ARI, and up to the critical 100 year ARI events. Flood storage will take the form of swales and basins within the POS areas.

6.4 Preliminary Drainage Basin Sizes

Drawing 5826-00-SK 10 presented in Appendix C depicts sub-catchment areas as determined by Cossill & Webley and includes a table summarising drainage calculations undertaken as part of preparation of this LWMS.

The following methodology was used to determine preliminary drainage basin areas and volumes -

- Catchments were identified and runoff volumes calculated for the in 1 year, 1 in 5 year and 1 in 100 year

ARI events,

- Drainage for the 1 in 5 year and 1 in 100 year ARI has been assumed to be disposed by way of rectangular basins within POS each having side slopes of 1 in 6, except where in the locations of 1 in 1 year basins where a 300mm step in ground levels is proposed,
- Dimensions of the base of each basin were assumed and iteratively adjusted to ensure the depth of flooding for the 1 in 100 year event is less than 1.2m. PC Sump was used for this exercise and an infiltration rate of 5m/day was adopted. Preliminary volumes and flooded areas were derived for each basin,
- Preliminary volumes and flooded areas were provided to Plan E, the project's Landscape Architect, along with preliminary design levels for each POS including surrounding roads,
- Using the preliminary volumes derived by Cossill & Webley, Plan E prepared indicative conceptual designs for each POS to confirm drainage could be stored and disposed within each POS without compromising the integrity, functionality or usability of POS. Plan E's conceptual designs are included in Appendix D.
- Based upon Plan E's conceptual designs, Cossill & Webley remodelled drainage in each POS using PC Sump to ensure the 1 in 100 year ARI event could be accommodated to City of Wanneroo requirements and to ascertain the extent of flooding for each event. The extent of flooding associated with the 1 in 5 year event was used to inform POS calculations being undertaken by the Town Planning Consultant. Based upon work undertaken to date the extent of Restricted Open Space is less than 20% of the total area of POS associated with the LSP. PC Sump calculations are included in Appendix E.

It is proposed as much of the 1 year 1 hour storm as practical will be retained at-source in roadside swales and tree pits. In a practical sense a target of retaining a 4 EY event has been set with the portion of the 1 in 1 year event not retained at-source to be directed to small basins in POS framed by 300mm high walls.

To demonstrate proof of concept for retention of the 1 in 1 year event we note the following -

- The volume of water generated from roads shown on the LSP from a 1 in 1 year event assuming a coefficient of runoff of 0.6 is 661 m3,
- The volume of water generated from roads shown on the LSP from the 4 EY event is 264m3. It is proposed this event be disposed in the upstream parts of the catchment in tree pits and roadside swales,
- The volume of the 1 in 1 year event which will find its way to swales in POS is the difference in the above volumes and amounts to 397 m3.

Based on preliminary calculations and assuming an infiltration rate of 2m/day, the following indicative volumes are targeted for each storage type to deal with the 4 EY event in the upstream part of the catchment:

Storage Type	Target Disposal Volume (m3)
Roadside Swales	90
Tree Pits (Fronting Lots)	120
Tree Pits or swales (Adjacent to POS)	20
Roadside Swales (One-Sided Road)	35
Total Target Storage Upstream (m3)	**265 (> 264m3)**

The balance of the 1 in 1 year event be contained and disposed in basins having an aggregate area of 1100m2. An infiltration rate of 2m/day is recommended for these basins to reflect their potential for longer term clogging. An

infiltration rate of 5m/day has been assumed for less frequent events which will inundate POS more broadly from time to time.

Actual basin sizes, locations and layouts are to be set as part of the detailed UWMP prepared for each stage of the development. Further consultation will also be undertaken with the City of Wanneroo during this process taking into account their drainage and maintenance requirements for integrated drainage/POS areas.

6.4.1 Existing Stormwater Basins

Preliminary basin sizing has been made on the basis of accommodating for all stormwater runoff generated from the development, however it is noted that there is an existing swale located south of Bluewater Drive which may have additional storage capacity. As part of the UWMP it is proposed that the capacity of this existing swale be investigated further to determine the ability of the swale to accommodate part of Catchments A & E in the southern portion of the proposed development. By utilising any existing capacity which may be available in the existing swale for 1yr ARI events, this may reduce the need to create additional bioretention areas for the City to maintain whilst also increasing the potential amenity of POS areas.

6.5 Stormwater Treatment Trains

WSUD and BMP strategies aim to minimise the impacts of urban development on flooding and water quality whilst realising the greatest potential for the use of stormwater as a resource.

WSUD and BMP strategies involve the implementation of structural and non-structural controls. Structural controls are constructed systems that treat or divert stormwater to achieve a desired objective. Non-structural controls are institutionally managed practices that prevent or minimise pollutants from entering the stormwater system or reduce the volume of stormwater requiring management.

Controls may be located at source, in transit or at end-of-pipe. To protect the receiving environments, the preference is to locate the controls at source and as high up in the catchment as possible. The following stormwater management hierarchy applies:

- Implement source controls (structural and non-structural) to prevent pollution or treat stormwater as high in the catchment as possible.
- Install in transit measures to treat stormwater throughout the conveyance systems.
- Implement end-of-pipe measures to mitigate any contaminants remaining in the stormwater prior to discharging to receiving environments.

Source controls may be either structural or non-structural BMPs designed to minimise the generation of excessive stormwater runoff and/or pollution of stormwater at or near the source. The Stormwater Management Manual for Western Australia (DoW, 2007) encourages a treatment train approach, where combinations of measures (structural and non-structural) are implemented in parallel or sequence to achieve best management of stormwater.

The implementation of structural BMPs into an urban landform has multiple environmental benefits including reducing pollutant export, retarding storm flows, maintaining and improving urban landscape, protecting receiving environments and reducing irrigation requirements.

6.6 Surface Water Quality Management

Structural BMPs will be implemented to achieve the water quality objectives outlined in this document. The following structural BMPs will be considered to treat runoff from regular storm events:

- Lot runoff will be infiltrated at source via soakwells contained within each lot.
- Implement bio-retention swales at appropriate locations within street verges to treat runoff from storm events up to and including part of the 1 year 1 hour ARI.
- A combination of stormwater gully pits and the retention of regular events (up to 1 year 1 hour ARI) on site will ensure that there is at least a 70% reduction in gross pollutants. The gully pits and the riser/orifice structures in the infiltration basins will behave as a series of gross pollutant traps.

  Alternatively, Gross Pollutant Traps (GPTs) can be installed at outlet locations prior to discharging into POS.
- Other treatments such as verge swales, permeable paving and non-structural control measures will also be identified and determined at the UWMP stage.

6.7 Surface Water Quality

The quality of recharge water will be managed by applying structural and non-structural source controls. In transit and end-of-pipe controls may also be incorporated into the drainage design to enhance the quality of aquifer recharge water.

7. GROUNDWATER MANAGEMENT

7.1 General

As discussed in Section 2, the existing groundwater is well below the existing and proposed development levels. Due to the depth to the groundwater, the proximity to the coast and the highly permeable insitu soils, it is unlikely that the existing groundwater levels or quality will be affected by the proposed development.

7.2 Subsurface Drainage

Due to the depth to the groundwater and the highly permeable insitu soils, subsurface drainage to control groundwater levels will not be required for the development.

7.3 Groundwater Quality Management

The following strategy will be adopted to satisfy groundwater quality related conceptual design objectives:

- Where practical, bio-retention swales will be used to treat infiltrated runoff within the road reserves,
- Landowners will be encouraged to minimise turfed areas and to landscape their gardens using native vegetation where practicable,
- Landowners will be encouraged to use loamy topsoil to improve the efficiency of fertilisers and retain phosphorous that would otherwise percolate through the sand limestone subsurface to the water table,

In addition to the above structural initiatives, non-structural BMPs will also be encouraged to prevent or minimise pollutants from entering stormwater runoff and/or reduce the volume of stormwater requiring management. Chapter 7 of the Stormwater Management Manual for Western Australia (DoW, 2007) provides guidance on the use of non-structural BMPs. Initiatives to be implemented for this project include:

- Construction practices that incorporate drainage, erosion, sediment and dust controls
- Maintenance practices, including
    - Regular maintenance of bio-retention and vegetated swales (e.g. removing accumulated litter),

- Street sweeping,
- Manual litter collections,
- Repairing roads and pavements,
- Education and participation programs,
- Focused stormwater education at new estates (e.g. promoting xeriscaping, responsible fertiliser use, and shallow groundwater reuse)

8. THE NEXT STAGE: SUBDIVISION AND URBAN WATER MANAGEMENT PLANS

8.1 General

Water quality management for the site will be in accordance with the Stormwater Management Manual for Western Australia (DoW, 2007), and the City of Wanneroo's City Water Management Strategy. BMPs such as verge swales, bio-retention areas, permeable pavement and open based pit and pipe structures (where not under roads) will all be considered at the detailed design and UWMP stage. Specific BMPs appropriate to the structure plan will be determined as part of the UWMP study when final subdivision layouts are available, enabling necessary further investigations to determine the suitability of BMPs based on site conditions (groundwater levels, geotechnical conditions etc.) and site constraints to be carried out.

8.2 Issues to Address at UWMP

It is expected that an UWMP will be required as a condition of subdivision development. The UWMP will be consistent with the requirements of this LWMS. An UWMP is an extension to an LWMS in that it provides objectives and guidelines applicable to detailed subdivision design.

The UWMP should address the following (where relevant):

- Compliance with the design objectives in the LWMS. Demonstration of compliance should be achieved through appropriate calculations or assessments.
- Characterisation of the soil stratigraphy and geotechnical conditions through formal geotechnical investigations across the site.
- Identification of measures to achieve water conservation and efficiencies of use.
- Detailed design of the stormwater management system, including the size, location and design of POS areas to best manage flood events.
- Specific structural and non-structural BMPs and treatment trains.
- Management of groundwater contamination (hot spots) and other specific site conditions.
- Management of subdivision works (to ensure no impact on regional conservation areas and management of any dewatering and soil sediment including dust).
- Management of disease vector and nuisance insects (mosquitoes and midges).
- Monitoring program and or contribution.
- Implementation including roles, responsibilities, funding and maintenance arrangements.

Further guidance on how to address urban water management at subdivision is contained within Liveable Neighbourhoods Edition 3 (WAPC, 2004), the DoW's Stormwater Management Manual for WA (2007), the Australian Runoff Quality Guidelines (IEA, 2006) and Australian Rainfall and Runoff (IEA, 2001).

The work undertaken in this LWMS was based on a draft structure plan for the site and on high level, estate scale

drainage concepts. Hence the water management strategy proposed in this document will still apply should there be minor adjustments to the structure plan layout.

At the next phase of planning (the UWMP subdivision phase) the final structure plan will be modelled in further detail to consolidate the water management concepts outlined in this report.

8.3 Detailed Hydraulic Design

More detailed hydrologic and hydraulic modelling will be undertaken during the subdivision design phase (UWMP) to enable the drainage design to be implemented.

Specifically, the following drainage design components will need to be specified:

- Finished levels will be gradually refined to maintain the approximate catchment boundaries as illustrated in Appendix C.
- The drainage pipe system will be designed to convey a 5 year ARI rainfall event,
- Lot level infiltration structures will be designed to infiltrate all rainfall events,

8.4 Assessment and Review

Technical review of the water quality and quantity data will be completed by a qualified consultant. The outcomes of these reviews will be used to guide the WSUD strategies, and choice and sizing of BMPs. The LWMS should be reviewed by the developer in consultation with the relevant government bodies and planning agencies. The LWMS should receive periodic review so that it remains applicable to the site following any changes to the regional and local planning and development process.

9. MONITORING AND IMPLEMENTATION

9.1 General

The monitoring programs described in this section will be funded by the Developer. A suitably qualified environmental consultant will be engaged to complete the monitoring exercises and report on the outcomes of the monitoring programs.

9.2 Recommended Program for UWMP

It is proposed the following be undertaken at the UWMP stage of the project –

Undertake hydraulic conductivity tests at basin locations, after bulk earthworks have been completed, to confirm actual hydraulic conductivity values measured are equal to or exceed hydraulic conductivity values assumed in modelling basin sizes,

Review the potential for parts of the southern catchments (A & E) to connect to the existing stormwater drainage network, including the opportunity for use of any existing capacity within existing swale located south of Bluewater Drive

Establish a contingency plan in the event actual hydraulic conductivity values measured are less than or exceed hydraulic conductivity values assumed in the modelling and design of infrastructure,

Source monitoring by the Alkimos Eglinton Land Owners (AELO) Group and adopt this as the basis for pre-development monitoring.

9.3 Recommended Program for Post Development

It is proposed the following be undertaken at the UWMP stage of the project –

Monitor swales, tree wells, and bio-filters to demonstrate their performance is adequate including monitoring of

vegetation condition and check stormwater is infiltration is adequate ,

Undertake testing for nutrients and metals 2 years after the last lot is created, but only if there is reason to suggest levels may be more than one standard deviation higher than typical levels experienced in the north-west corridor.

9.4 Roles, Responsibilities and Funding

The key stakeholders to whom responsibility for implementing Urban Water Management Plans can be assigned are:

- Developer
- City of Wanneroo
- Water Corporation
- Landowners

The roles, responsibilities and funding for each of stakeholder is summarised in Table 5.

Table 5 – Roles, responsibilities and funding for the Water Management Strategy

Organisation	Role	Funding
Developer	▪ Satisfy the relevant WAPC conditions relating to the preparation of a UWMP ▪ Designs and constructs the potable water supply and sewer supply to Water Corporation standards. ▪ Designs, constructs and maintains POS's (maintenance period to be negotiated with City of Wanneroo) ▪ Undertakes post-development activities for the submission to regulatory authorities for a period of 2 years following Practical Completion (As part of the UMWP). ▪ Construction and management consistent with UWMP.	Developer
City of Wanneroo	▪ Assumes responsibility for roads and stormwater drainage infrastructure constructed including the ongoing operations and maintenance. ▪ Maintains the public open space (including irrigation) at the completion of the Developer's maintenance period.	Rates
Water Corporation	▪ Assumes responsibility for the potable and non-potable water supply and sewerage infrastructure constructed including the ongoing operations and maintenance.	Rates

Land Owner	▪ Responsible for meeting all requirements of the relevant City of Wanneroo building codes during the built form phase (including construction and maintenance of soakwells for onsite stormwater disposal). ▪ Compliance with the Water Corporation's Waterwise program	Land Owner

10. REFERENCES

Department of Water (Dec 2008), Interim: Developing a local water management strategy

Department of Water (2007), Stormwater Management Manual for Western Australia, Department of Water, Perth, Western Australia

Essential Environmental Services (2007), Achieving Integrated Water Cycle Management, A framework to integrate land use planning with water resources management on the Swan Coastal Plan, DRAFT

Institution of Engineers Australia (2000), Australian Rainfall and Runoff, A Guide to Flood Estimation, Institution of Engineers Australia

Water Corporation, 2003, Domestic Water Use Study in Perth, Western Australia 1998 -2007

WA State Planning Policy 2.9 (2006) Water Resources

11. CHECKLIST

The Department of Water's Checklist is included in Appendix F, for information. The required deliverables have been cross-referenced with this LWMS to assist in its evaluation.

APPENDIX A – Lot 6 Taronga Place, Eglinton Local Structure Plan (Prepared by CLE Town Planning Consultants)

FUTURE LAND EXCHANGE TO RATIONALISE LOT BOUNDARY WITH LOT 5003

MITCHELL FREEWAY

FUTURE RAIL

PROPOSED PRIMARY SCHOOL BY OTHERS

DRAINAGE

COTTAGE LOTS OVERLOOKING PARK

POSSIBLE FUTURE BRIDGE OVER RAILWAY

COTTAGE LOTS OVERLOOKING PARK

CENTRAL OPEN SPACE

EGLINTON No. 82

RESERVE

GROUP HOUSING/ DENSITY SITE

G.H.

PROPOSED RETAINED VEGETATION BY OTHERS

MARMION AVENUE

COTTAGE LOTS OVERLOOKING PARK

COTTAGE LOTS OVERLOOKING PARK

BLUEWATER DRIVE

EXISTING SHOREHAVE ESTATE

CONCEPT PLAN

Western Precinct

Lot 6, Taronga Place, Eglinton

CLE TOWN PLANNING + DESIGN

DRAFT

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

N

plan no: **3109-50A-01**

date: 2 March 2017

scale: 1:3000 @A3, 1:1500 @A1

APPENDIX B – Preliminary Karst Landform Management Report (Prepared by CMW)

CMW Geosciences Pty Ltd
Chapman Morton Woodward

9 August 2016

LOT 19 TARONGA PLACE, CARABOODA

PRELIMINARY KARST LANDFORM MANAGEMENT METHODOLOGY

Urban Quarter WA

Ref. PER2016-0480AB Rev1

Unit 19 Wembley Green Offices,
127 Herdsman Parade, Wembley, WA 6014

www.cmwgeosciences.com

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Figures

Appendices

1 INTRODUCTION

This report outlines recommended development strategies to manage potential risks associated with karst landforms within Lot 19 Taronga Place, Carabooda. The work was commissioned by Mr Jason Wallis of Urban Quarter WA (Urban Quarter) on 2 August 2016.

It is understood that the 150ha site is proposed for urban development comprising a mixture of residential and commercial subdivision. The strategies in this report are aimed at providing an outline of tasks that will be performed as a precursor to development of a Karst Landform Management Strategy. It also outlines engineering design elements that can be adopted during construction of the subdivision in order to limit the risks associated with karst landforms to a level no greater than those acceptable for other developments on the Swan Coastal Plain. These strategies will be confirmed following detailed site investigations.

2 AVAILABLE INFORMATION

CMW has previously undertaken a desktop and reconnaissance study at the site. Information available for the previous study comprised the following:

- 1:50,000 scale geological mapping (Yanchep Sheet - 2034 IV) produced by the Geological Survey of Western Australia (GSWA) including 1:100,000 scale geomorphology mapping.
- A Western Australian Speleolgical Group field survey report dated 12 December 2007.
- Various project drawings including vegetation mapping, concept plan, existing ground surface contours and proposed finished levels.
- Observations of the site during a reconnaissance drive/walk over.

The available information has been incorporated with our experience of karst areas on the Swan Coastal Plain to allow consideration of development strategies with respect to potential karst ground conditions.

It is noted that the author has extensive knowledge and experience of urban development within areas of potential karst landform risk within the Swan Coastal Plain and has published technical papers on the subject including Mather P.J, 2013. Geotechnical Aspects of Karst within the Swan Coastal Plain, Western Australia. Australian Geomechanics, Vol. 48 No. 2, a copy of which is attached to this letter for reference.

3 DISCUSSION

The eastern part of the site is within a recognised zone of potential karst features as outlined by previous GSWA mapping. The location of the western extent of this potential karst zone has been slightly modified on the basis of local geomorphology observed during site reconnaissance. The inferred western extent of the potential karst zone is shown on the attached Figure 1. Within the areas west of the line shown in Figure 1, the risks associated with potential karst are considered to be very low and therefore can be managed by normal geotechnical investigation and design processes.

The hazards associated with development within areas of karst cannot be eliminated but geotechnical design strategies can be adopted to reduce and manage the risks to acceptable levels. The extent of remediation and modification of foundations to reduce the risk of karst is dependent on the severity of karst phenomenon and sensitivity of proposed development. By international standards karst occurrence on the Swan Coastal Plain is at the lower end of severity. Some internationally accepted design strategies to manage karst risk, in general order of increasing

severity, are as follows:

- Drainage control
- Grout/fill open fissures
- Stiffen footings (rafts or ground beams)
- Geogrids
- Driven piles to rock head
- Cap grouting at rock head
- Groundwater abstraction control
- Bored piles to rock head
- Combinations of the above techniques

The key trigger mechanisms for karst collapse on the Swan Coastal Plain is concentrated storm water runoff. The control and management of concentrated surface water discharge away from structures is considered to be the key factor in limiting the potential risks and impacts of sinkhole formation. Design recommendations for previous developments within karst areas of CoW (e.g. Lots 201 and 202 Breakwater Drive) have included the provision for domestic soak wells to be located no less than 10m from footings and road drainage basins to include a 30m development exclusion zone around their perimeter. Additional strategies that have been adopted locally include the stiffening of residential footings.

Other strategies that could be adopted to adequately reduce the risks in susceptible areas include large scale earthworks involving over excavation and replacement with a 2m thick layer of crushed limestone covered with a 1m thick surface layer of free draining sand. The 2m thick layer of compacted crushed limestone will act as a stiffened raft/geogrid layer in addition to attenuating concentrated stormwater inflows from the surface.

4 PROPOSED MEASURES TO MANAGE KARST

Subject to further, more detailed investigations, we believe the following measures or combination of measures would reduce the karst risk associated with this site to equal or less than that associated with other developments on the Swan Coastal Plain:

- Any exposed fissures should be over-excavated and backfilled in accordance with the geotechnical engineer's requirements;
- During cut-to-fill earthworks, areas in excess of 10m fill require no further mitigation, as the material above potential karst features will form an adequate raft to spread loads and dissipate stormwater infiltration;
- Areas of fill up to 3m thick should include a 2m thick crushed limestone layer as described in Section 3 above;
- Areas of fill less than 3m thick or areas of cut should be over-excavated to 3m below finished design levels, and backfilled to incorporate a 2m thick crushed limestone layer as described in Section 3 above; and,
- Further geotechnical investigations such as EFCPT probes should be undertaken upon completion to assess the presence of karst features at an inter-allotment scale prior to development

Some variation to the excavation and replacement option outlined above is likely to be appropriate based on the anticipated range of ground conditions. For example, in areas of cut which expose a limestone surface that is free of any indication of voids, the required thickness of crushed limestone could be reduced to 1m. Other variations such as backfilling exposed voids and heavy compaction of loose sand zones prior to fill placement may be appropriate depending on the local ground conditions and thickness of fill prosed within specific areas.

Prior to development, further geotechnical site investigation will be required to assess the extent of potential karst risk within the site and refine appropriate remediation options for urban development. It is likely that the results of detailed investigation will identify significant areas of very low risk within the potential karst risk zone, allowing remedial options to be targeted towards areas of higher potential risk.

It is anticipated that the adoption of a range of engineering design strategies as outlined above, targeted across the site on the basis of further detailed geotechnical investigation will result in the reduction of risks associated with karst to a level compatible with development outside of karst areas.

5 SUMMARY

Lot 19 Taronga Place, Carabooda is located partially across an area of the Swan Coastal Plain which has the potential for karst landforms. By international standards the karst risk is relatively low but will need to be addressed as part of the urban residential and commercial development proposed at the site. A range of engineering strategies are available to limit the risks associated with karst. Information obtained from further detailed geotechnical site investigation across the site can be incorporated into an assessment of suitable risk reduction strategies. Appropriate strategies will vary across the site depending on the severity of the ground conditions and proposed land uses. The aim of the design modifications will be to limit the risks associated with development at this site to those applicable to other developments on the Swan Coastal Plain that are outside the zone of potential karst.

6 CLOSURE

We trust this report meets your current project requirements. If you have any queries or require additional information please contact the undersigned.

For and on behalf of
CMW Geosciences Pty Ltd

Philip Mather

Principal

Distribution: 1 copy to Urban Quarter WA (electronic) Original held by CMW Geosciences Pty Ltd

Figures

LEGEND:

INFERRED WESTERN EDGE OF POTENTIAL KARST RISK ZONE

SITE BOUNDARY

NOTES:

1. BASE PLAN ADAPTED FROM: ROBERTS DAY CONCEPT PLAN, DRAWING NO. RD1 016, REV A, DATED 29.06.15

1:7500 0 75 150 225 300 375 m

CMW Geosciences Pty Ltd
Chapman Morton Woodward

CLIENT: URBAN QUARTER WA		DRAWN: DE	PROJECT: PER2016-0780
PROJECT: LOT 19 TARONGA PLACE, CARABOODA, WA		CHECKED: PJM	FIGURE: 01
		REVISION: 0	SCALE: 1:7500
TITLE: PRELIMINARY KARST LANDFORM MANAGEMENT		DATE: 09/08/2016	SHEET: A3 L

Appendix A

Geotechnical Aspects of Karst within the Swan Coastal Plain, Western Australia.

Geotechnical Aspects of Karst within the Swan Coastal Plain, Western Australia

Philip Mather

Coffey Geotechnics Pty Ltd – Perth, Western Australia

ABSTRACT

The occurrence of karst limestone conditions within Western Australia is not well recognised within the general community but can be of major engineering significance for developments that are impacted by it. The presence and engineering significance of karstic limestone on the Swan Coastal Plain has been recorded by local Engineering Geologists with the first officially published recognition presented in the 1:50,000 scale Environmental and Engineering Geology Series Yanchep Sheet in 1986. The Geological Survey of Western Australia (GSWA) mapping highlighted a significant, well defined zone of karst phenomena within Tamala Limestone extending from Joondalup to Two Rocks. Increasing pressure from urban development along Perth's northern corridor lead to several "near miss" incidents which precipitated the incorporation of a requirement for all development applications within the City of Wanneroo to include consideration of the potential for karst.

To date, the published literature relating to karst on the Swan Coastal Plain has been limited to geological descriptions of the phenomena. Although the potential karst hazard is now widely recognised within the geotechnical community there has been very little published information relating to geotechnical design considerations and strategies for urban development within areas affected by karstic limestone relating specifically to the Swan Coastal Plain. Considerable work has been completed over the past decade relating to the identification of karstic ground conditions and geotechnical design strategies to manage potential risks. In addition, the existence of additional areas of karstic limestone has been identified within the City of Cockburn and City of Mandurah.

1 INTRODUCTION

The occurrence of karst limestone conditions within Swan Coastal Plain of Western Australia is restricted to specific localised areas that, for many years, were of limited interest to those other than speleologists and caving enthusiasts. The coincidence of low lying swales with shallow groundwater and interdunal lakes resulted in karstic zones often being amongst areas of market garden and semi rural land uses. The pressure from urban expansion on the coastal plain has increasingly resulted in urban development encroaching into these previously less intensely developed areas. Although often not well recognised by property developers and the general public, the presence of karstic limestone can be of major engineering significance for developments that are impacted by it.

The occurrence of karst limestone was recognized by local Engineering Geologists such as Ray Gordon (2003) who was involved with local authorities to study and assess the potential risks/liabilities associated with this geohazard. These studies were greatly assisted by the work of local Speleologists such as Lex Bastion. Later work by Bob Gozzard with the resources of the Geological Survey of Western Australia (GSWA) resulted in the first official engineering recognition of the occurrence of karst within the Swan Coastal Plain presented on the 1:50,000 scale Environmental and Engineering Geology Series Yanchep Sheet published by the GSWA in 1982. The initial mapping highlighted a significant, well defined zone of karst phenomena within Tamala Limestone extending from Joondalup to Two Rocks.

Increasing pressure from urban development along Perth's northern corridor resulted in several sink hole occurrences associated with residential developments. In recognition of this potential hazard the City of Wanneroo has developed a draft of new requirements for all development applications to include consideration of the potential for karst.

Geotechnical investigations over the last decade have identified additional areas within the Swan Coastal Plain where karstic conditions occur and has focussed consideration of geotechnical design strategies to limit risks for developments.

The purpose of this paper is to provide an introduction to the geotechnical aspects of karst as follows:

- Case studies of karst collapse that have occurred within the Swan Coastal Plain that demonstrate the main features of sink holes and common trigger events.
- Updated geology map outlining two additional zones of significant karst, within the southern part of the Swan Coastal Plain and Mandurah that have never been published.

- Current geological/geomorphological hypotheses relating to the formation of karst environments within the Swan Coastal Plain.
- The effectiveness of various geotechnical investigation techniques available to identify the presence and significance of karstic limestone.
- Geotechnical design issues for development within areas of karst and potential options/solutions to limit associated risks.

2 CASE STUDIES

2.1 REGATTA DRIVE, EDGEWATER

Several sinkhole collapse features occurred within a road drainage basin following a significant rainfall event (Figure 1). The road basin is located within an urban residential development characterised by sand overlying pinnacled limestone at shallow depth. The collapses occurred in the mid 1990's and were investigated by Ray Gordon (2003) who has presented a schematic cross section of the site. No damage to the adjacent houses was reported. Remediation work included replacement of some sections of the boundary fences and precautionary underpinning of the foundations on one of the neighbouring residences.

Figure 1 – Road drainage basin at Regatta Drive, Edgewater showing sinkholes on left and at rear.

2.2 EMERALD DRIVE, CARABOODA

Sinkhole collapse occurred within a road runoff discharge area following winter rainfall soon after construction for a Special Rural subdivision (Figure 2). The collapse occurred in the early 2000's within an area of sand overlying shallow limestone between areas of scattered limestone outcrop. There was no damage reported, however, this example further highlights the potential risks associated with large volumes of concentrated runoff from road drainage basins triggering collapse events.

Figure 2 - Sinkhole within road drainage discharge area, Emerald Drive, Carabooda.

2.3 SWIMMING POOL COLLAPSE, WOODVALE

Undermining of a swimming pool due to sinkhole collapse occurred in March 2007 (Figure 3). The contribution of uncontrolled water discharge from a range of possible sources adjacent to the pool was suspected of contributing to progressive development of the sinkhole over many years which finally resulted in sudden collapse of the pool. Limited investigation at the site indicated a ground profile comprising sand overlying limestone at a depth of approximately 6 m.

Figure 3 - Woodvale swimming pool with bracing following collapse

2.4 BREAKWATER DRIVE, TWO ROCKS

Sinkhole collapse about 4 m wide and 3 m to 4 m deep occurred in December 2007 located approximately 12 m from the edge of a residence within a Special Rural subdivision (Figures 4a and 4b). The site is underlain by a 3 m to 6 m thick surface sand layer overlying limestone. A combination of CPT and air core borehole investigation identified loose

ground conditions within and overlying the limestone and the original building envelope was relocated away from an area within the Lot where numerous small voids had been encountered within the limestone at depths of between 11 m and 15 m.

The collapse occurred at the location of a bore water discharge point within the Lot. The bore discharge arrangement comprised of two child paddle pools. One pool received water from the bore which overflowed into the second pool. The bore was run for about an hour approximately 3 times per week. Water from the pools was bucketed out and distributed around the yard.

This arrangement had been in place for over a year prior to the collapse occurring. On the day of the collapse the owner had turned on the bore pump and then been distracted at the front of the property for between half to one hour with the pump running and pools overflowing. On his return to collect water from the pools they had "disappeared" down the sinkhole. One pool was completely gone and the corner of the second pool was visible at the base of the sinkhole.

Figure 4a – Breakwater Drive, Two Rocks. View of sinkhole from balcony of residence

Figure 4b - Breakwater Drive, Two Rocks. Close up view of sinkhole. Note tension crack around edge of failure zone

Common features with the case studies presented above include a surface layer of sand approximately 5 m thick and, more significantly, the action of concentrated surface water discharge providing a trigger mechanism for sudden sinkhole collapse.

3 GEOLOGY OF THE SWAN COASTAL PLAIN

A broad outline of the geology of the Swan Coastal Plain as presented by Davidson 1995 is shown in Figure 5. The existing 1:50,000 Geological Survey of Western Australia, Yanchep Sheet (Gozzard, 1982) outlines a zone referred to as "Interbarrier depression with prominent karst phenomena" extending between Joondalup and Two Rocks. This zone has been well documented and is well recognised throughout the geotechnical community and includes tourist features and cave systems within the Yanchep National Park.

Field experience from geotechnical site investigations and studies over the years has revealed additional, similar zones with karstic limestone conditions in the Lake Coogee – Munster area and further south along the western margins of the Peel Inlet at Dawesville and Mandurah. Additional isolated occurrences have also been encountered at Gwelup and Warwick. More localised occurrences are likely within similar geomorphological environments that have been revealed in the past and /or will be encountered in the future.

Figure 6 outlines a useful cross section presented by Grimes (2006) based on work by Lex Bastian in the Yanchep area. Meteoric water and groundwater undersaturated in $CaCO_3$ migrating west out of the Bassendean Sand dissolves the carbonate matrix to form "slots" within the limestone at the groundwater interface which enlarge over time through roof collapse to form caves.

Karst on the Swan Coastal Plain is considered to fit into Grimes's category of syngenetic karst which has formed within a soft, porous, soluble sediment at the same time as it has been cemented into a rock. This is quite different to the classical "hardrock" karst which involves dissolution of carbonate along pre-existing joints and fractures within a previously formed limestone or dolomite rock mass.

On the Swan Coastal Plain there appears to be a spatial association with low lying wetland areas where the water table is exposed at the surface and significant deposits of organic rich and peaty soils occur. The association with these wetlands introduces a possible influence of organic acids from peat deposits reducing the pH of groundwater and enhancing/"reinvigorating" the dissolution of carbonates within the adjacent or underlying limestone.

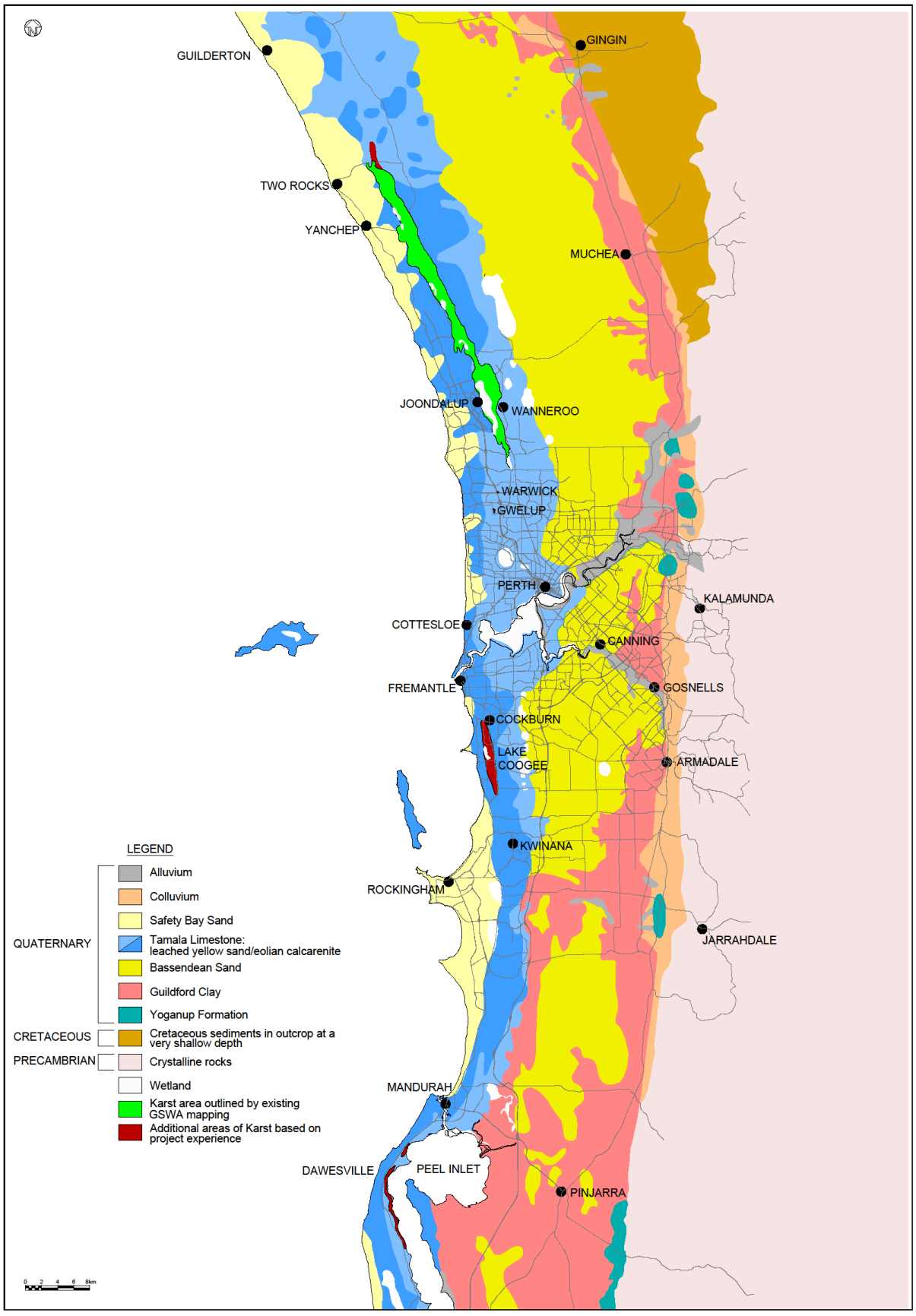

Figure 5 – Geology of the Swan Coastal Plain (from Davidson 1995)

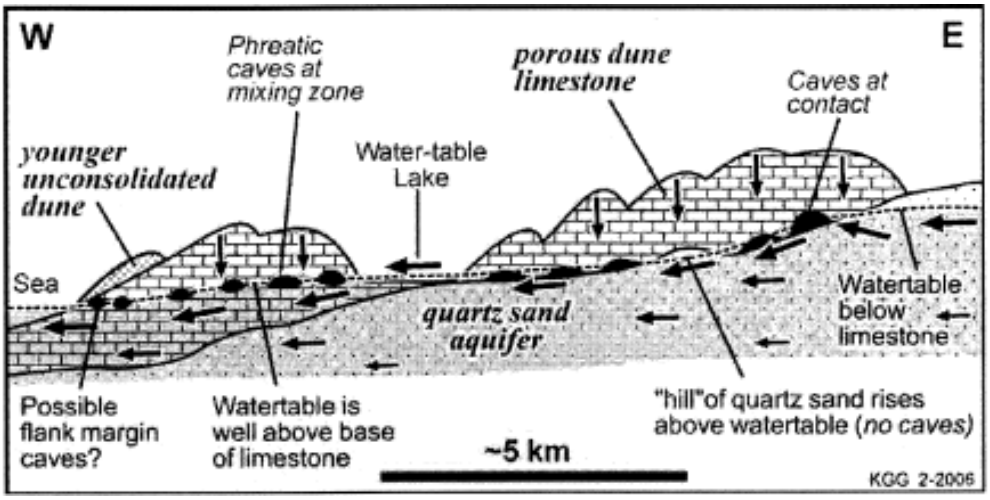

Figure 6 – Hydrology of the Yanchep Area (Grimes 2006 after Bastian)

Karst manifests itself as loose sand near the surface and cavities within the underlying limestone. Surface features include dolines, closed depressions and sinkholes. It is common to observe a characteristic topographic signature of closed depressions on surface contour maps and in particular from surface reconnaissance and field mapping within localised areas where the form of the ground surface appears inconsistent or disrupted within the broader landscape.

Waltham and Fookes (2003) present a classification of sinkholes as shown on Figure 7. Within the Swan Coastal Plain the occurrence of Waltham's Collapse sinkholes and Caprock sinkholes are rare. A more common occurrence highlighted by the case histories and author's experience are Buried sinkholes and Suffusion sinkholes which occur in areas of sand cover over the limestone.

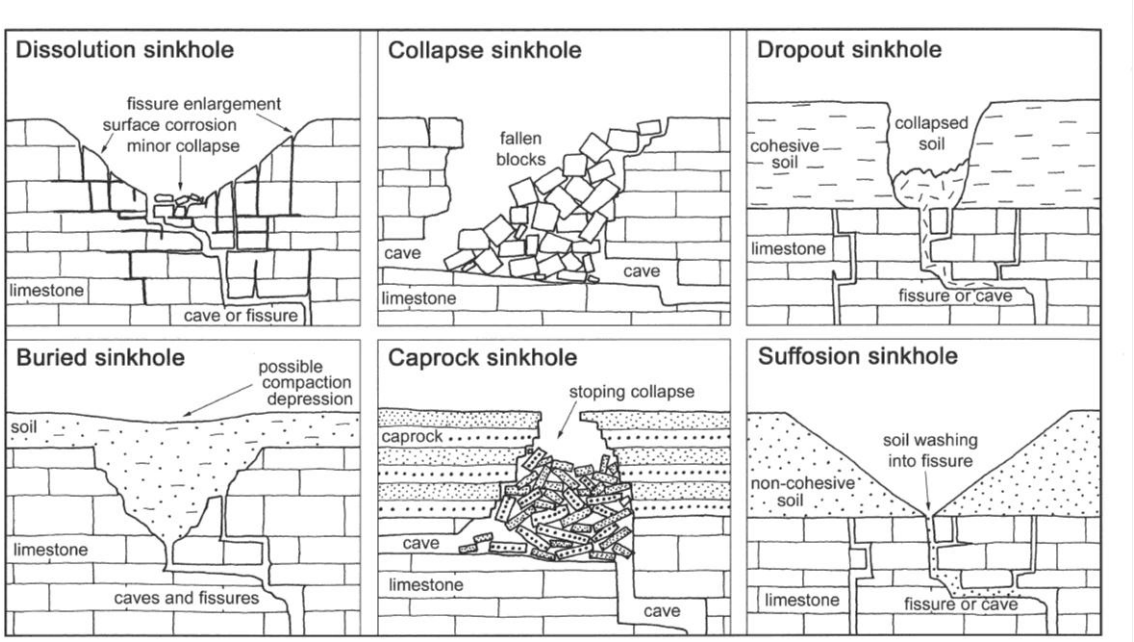

Figure 7 – Classification of Sinkholes via Mechanism of Ground Failure (Waltham and Fookes 2003).

Experience of sinkhole collapse on the Swan Coastal Plain suggests an increased hazard exists where the thickness of sand cover above limestone is in the order of 5 m. It is possible that when the thickness of sand cover exceeds 10m to 15 m it is sufficient to allow bridging of voids within the limestone and distribute any loss of ground over a broader soil zone thereby attenuating the magnitude and timing of ground movements experienced at the surface. In addition the influence of concentrated surface water infiltration is greatly diminished with depth. In areas where the thickness of sand cover is limited to a few metres it appears that the potentially significant sinkhole collapses have already occurred. In addition there is often clear surface evidence to alert the geologist to the presence of voids within the underlying limestone when it is at shallow depth.

Very loose zones within the overlying sand represent an additional hazard within areas of karst. Fortunately loose sand is relatively easy to identify and manage during development. The difficult hazard to manage results from "hidden" features where sudden collapse may be triggered by disturbance and/or changed conditions arising from new development.

4 GEOTECHNICAL INVESTIGATION TECHNIQUES

Extensive loose and very loose sand zones are a common feature of karst areas on the Swan Coastal Plain. Cone Penetrometer Testing (CPT) is an excellent technique to assess the condition of overlying sand and will sometimes penetrate the limestone to encounter voids at depth below the rock head. CPT is relatively quick and cost effective compared to drilling and provides continuous data about the ground conditions. A disadvantage of the CPT is that it can refuse on the limestone rock head. Drilling techniques are limited to the provision of less reliable data due to issues arising from ground disturbance at the bit face, core loss and discontinuous SPT test intervals. Drilling of all techniques is a relatively crude tool from which it is often difficult to distinguish between very loose sand, core loss and voids. However, within areas of very shallow limestone drilling to investigate the near surface ground conditions represents a method of overcoming early CPT refusal to obtain direct information.

Sinkholes are spectacular through their sudden and dramatic impact but are very isolated and, due to their association with concentrated surface water discharge, provide some scope to be managed through strict control of surface water drainage. Within areas of karst on the Swan Coastal Plain it is the loose sand zones overlying voided limestone that represents the significant risk to structures. These loose sand zones are inferred to have a general association with deeper voids and therefore can provide an indication of where hazards may exist within the underlying limestone. Individual voids within the limestone are extremely difficult to investigate. Drilling and probing is "hit and miss". A range of drilling techniques including auger, mud flush, diamond coring and air coring have been utilised. Despite careful observation of the drilling process it is often very difficult to distinguish reliably between air filled voids, sand filled voids, loose sand zones and very weakly cemented limestone. Compared to the crude data derived from drilling the use of intensive CPT testing to investigate the condition of the overlying sand, often penetrating the weaker and voided limestone at depth provides a valuable method to obtain reliable data on which to characterise the ground for input into geotechnical design.

Various geophysical techniques have been utilized with ground probing radar (GPR) typically being the most commonly adopted to assess karst on the Swan Coastal Plain. The author is not aware of any geophysical techniques that reliably indicate the presence, or not, of voids within limestone on the Swan Coastal Plain. Elsewhere surface and borehole seismic techniques have been used with some success to investigate voids at specific locations such as below a building foundation or for linear projects such as tunnel alignments (Whiteley, 2012). For larger areas geophysics can provide a generalised profile of ground conditions that may be useful to target more detailed investigation techniques, however, it provides very little useful information about the condition of the overlying sand which is often a more important factor for geotechnical design than knowing the specific location of voids. In the author's opinion, the use of geophysical techniques to conclusively demonstrate the absence of voids over large areas is unlikely to be practicable but they can provide complementary data for critical infrastructure at specific locations where investigation budgets allow.

5 GEOTECHNICAL DESIGN CONSIDERATIONS

The main considerations during geotechnical design within areas of potential karst are as follows:

- Excessive settlement within areas of loose sand under the load of structures.
- Sudden collapse of ground resulting from sinkholes.
- Concentrated surface and/or subsurface water flow which has been associated with every sinkhole occurrence observed by the author.
- Changes in land use which can concentrate surface water flows leading to a new generation of sinkholes to occur.
- The existence and effectiveness of geotechnical investigation guidelines. For example the City of Wanneroo has recently prepared a draft of new development guidelines for minimum geotechnical investigation requirements specifically related to karst. Other local Authorities are likely to follow.

6 CONCLUSIONS AND DESIGN STRATEGIES

The potential for sinkholes is a real and significant engineering issue within potential karst areas on the Swan Coastal Plain. The GSWA 1:50,000 mapping provides an excellent guide to the distribution of the potential karst zone north of Perth. Additional areas of karst have been encountered outside those shown on published geological mapping. Additional areas are likely to be revealed as urban development expands into areas of less intensive development. Investigation by drilling and probing is "hit and miss". The use of CPT has proved a reliable investigation technique on which to base engineering design within areas with a reasonable thickness of sand cover and can provide some indication of the strength of the underlying limestone sometimes penetrating the rock layer and intersecting voids to provide direct evidence of their existence. In the absence of any investigation techniques that can reliably detect the location of voids within limestone it is considered prudent that once karst conditions have been identified through surface mapping, drilling and probing, geotechnical design is based on the assumption that voids are present within the underlying limestone. For critical structures more specifically targeted techniques incorporating geophysics and intensive, close spaced drilling/probing may be justified.

The control and management of concentrated surface water discharge away from structures is considered to be the key factor in limiting the potential risks and impacts of sinkhole formation. Design recommendations for developments typically include the provision for soak wells to be located no less than 10m from footings. Road drainage basins are typically recommended to include a 30m development exclusion zone around their perimeter. Other design strategies include stiffening of footings to accommodate potential settlements associated with loose zones within sand and loss of ground above sinkholes. Structural assessments indicate that under typical loads associated with masonry residential structures a stiffened beam adopted for a site classification of M in accordance with AS2870-2011 will span a 1.8m wide void.

The hazards associated with development within areas of karst cannot be eliminated but geotechnical design strategies can be adopted to reduce the risks.

7 ACKNOWLEDGEMENTS

The author gratefully acknowledges the contribution and assistance from Geoff Cocks and Alan Moon during the preparation of this paper.

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APPENDIX C – Drainage Catchment Plan and Drainage Calculations (Prepared by Cossill & Webley)

LOT 6 - TARONGA - DRAINAGE CALCULATIONS

DESIGN CATCHMENT PARAMETERS	CATCHMENT A ENTRY WEST DRAINAGE	CATCHMENT B EASTERN DRAINAGE	CATCHMENT C NORTHERN DRAINAGE	CATCHMENT D CENTRAL DRAINAGE	CATCHMENT E ENTRY EAST DRAINAGE
CATCHMENT AREAS					
Net Road Area Catchment G (m2)	6108	24307	7044	31739	4182
Lots < 300m2 Area Catchment (m2) - Q10 and Q100 only	1788	7600	1491	7565	0
Road Runoff Coefficient - C for Q1	0.60	0.60	0.60	0.60	0.60
Road Runoff Coefficient - C for Q10 and Q100	0.80	0.80	0.80	0.80	0.80
Lot Runoff Coefficient - C for Q10 and Q100 only	0.95	0.95	0.95	0.95	0.95
EIA Roads - Q1	3665	14584	4226	19043	2509
EIA Roads - Q10 and Q100	4886	19446	5635	25391	3346
EIA Lots - Q10 and Q100 only	1699	7220	1416	7187	0
EIA TOTAL (m2) - Q1	3665	14584	4226	19043	2509
EIA TOTAL (Ha) - Q1	0.37	1.46	0.42	1.90	0.25
EIA TOTAL (m2) Q10 & Q100	6585	26666	7052	32578	3346
EIA TOTAL (Ha) Q10 & Q100	0.66	2.67	0.71	3.26	0.33
CoW EMPERICAL DRAINAGE SIZING CRITERIA					
1 in 10 year, (600m3 per Ha)	395	1600	423	1955	201
1 in 100 year, (1330m3 per Ha)	876	3547	938	4333	445
SWALE STORAGE REQUIRED (PC SUMP INFILTRATION)					
1 in 1 Year, 1 Hour, Volume (m3), 15mm calc = Area x C x 0.015	55	219	63	286	38
1 in 1 year, less upstream storage (1/3) = 1 in 1 basin storage required (m3)	37	146	42	190	25
1 in 5 year, Critical (m3)	191	733	200	856	87
1 in 10 year, Critical (m3)	220	850	230	995	100
1 in 100 year, Critical (m3)	379	1524	395	1790	169
Swale Side Slope	1 in 6 / walled	1 in 6 / walled	1 in 6	1 in 6	1 in 6 / walled
Swale Base Area (m2)	128	488	219	636	91
Swale Base Level	25.80	30.00	37.10	34.50	25.80
Infiltration Rate	5m/day	5m/day	5m/day	5m/day	5m/day
Swale TWL Area, 1 in 1 year (m2)	96	381	110	497	66
Swale TWL Area, 1 in 5 year (m2)	441	1850	535	2135	456
DRAINAGE STORAGE PROVIDED					
1 in 10 year, Volume (m3) - CoW criteria of max 900 deep	290	1213	340	1409	344
1 in 100 year, Volume (m3) - CoW criteria of max 1200 deep	459	1881	577	2196	564

NOTES

1. EIA makes an allowance for lots < 300m2 catchment, for events greater than 1 in 1 as per CoW requirements.
2. Storage volumes required have been calculated using PCSump V5 and adopting an initial infiltration rate of 5m/day,

LEGEND

- CATCHMENT A
- CATCHMENT A LOTS < 300m2 AREA
- CATCHMENT B
- CATCHMENT B LOTS < 300m2 AREA
- CATCHMENT C
- CATCHMENT C LOTS < 300m2 AREA
- CATCHMENT D
- CATCHMENT D LOTS < 300m2 AREA
- CATCHMENT E

0m 40.0 80.0 120.0m
1:2000

REV	DATE	DRN	CKD	APP	AMENDMENT
F	08.03.17	DPM			LANDSCAPE CONCEPTS INCORPORATED
E	01.03.17	DPM	BRM	A. THOMSON	SW SPLIT INTO TWO CATCHMENTS
D	21.02.17	DPM			LAYOUT AMENDED
C	30.01.17	DPM			5M/DAY INFILTRATION, ISSUED FOR INFORMATION
B	24.01.17	DPM			ISSUED FOR INFORMATION
A	15.12.16	DPM			ISSUED FOR INFORMATION

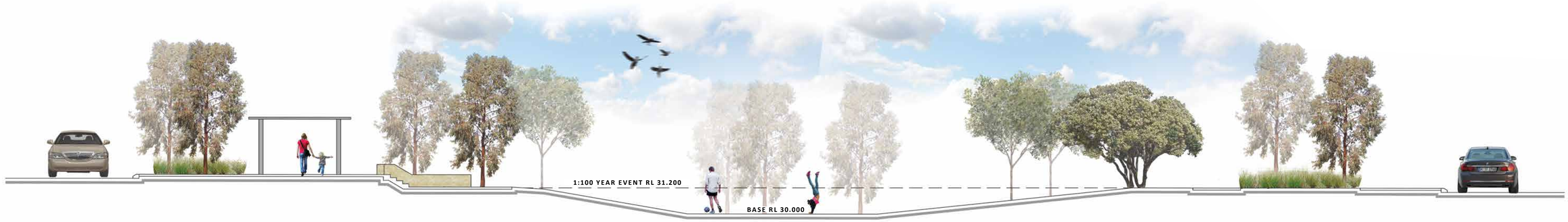
Cossill & Webley CONSULTING ENGINEERS
Mailing Address: PO Box 680, Subiaco WA 6904
Street Address: B12 (Level 2) 431 Roberts Road, Subiaco WA 6008
T (08) 9422 5800 F (08) 9422 5801 E admin@cosweb.com.au

CLIENT: URBAN QUARTER
APPROVED: AVRIL THOMSON
DESIGNED: DPM
SCALE: 1:2000
PROJECT: LOT 19 TARONGA PLACE, EGLINGTON
TITLE: DRAINAGE CATCHMENT CONCEPT PLAN
WAPC No.
DRAWING No.: 5826-00-SK10
REVISION: F
ORIGINAL SIZE: A1

P:\5826 Lot 6 Spen\HS\5826-00Acad\Sketches\5826-00-SK10.dwg, 8/03/2017 9:19:38 AM, donm, Digital Signing PDF.pc3, 1:1, - CW Reference

APPENDIX D – Lot 6 Taronga Place, Eglinton Conceptual POS Designs (Prepared by Plan E)

SECTION A-A
POS 1



SECTION B-B
POS 2

SECTION D-D
POS 4

TARONGA PLACE, EGLINTON - LOT 6
PREPARED FOR URBAN QUARTER

LANDSCAPE SECTIONS

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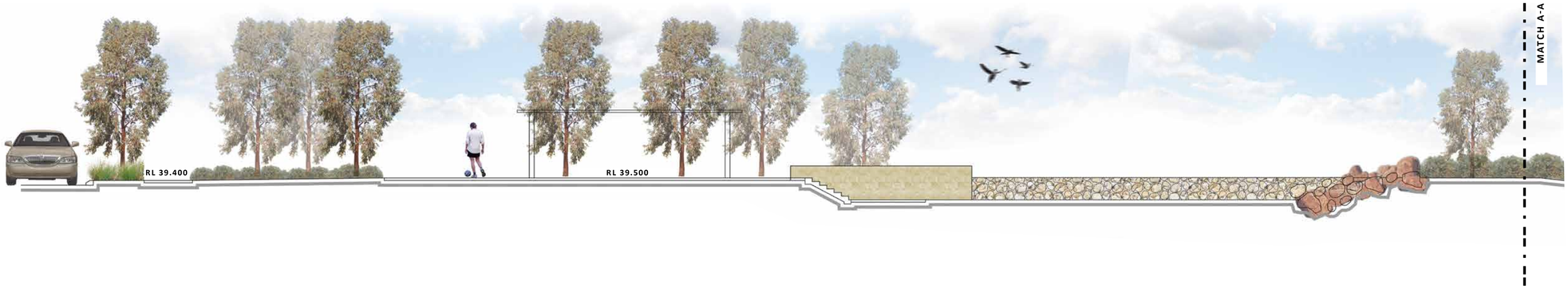
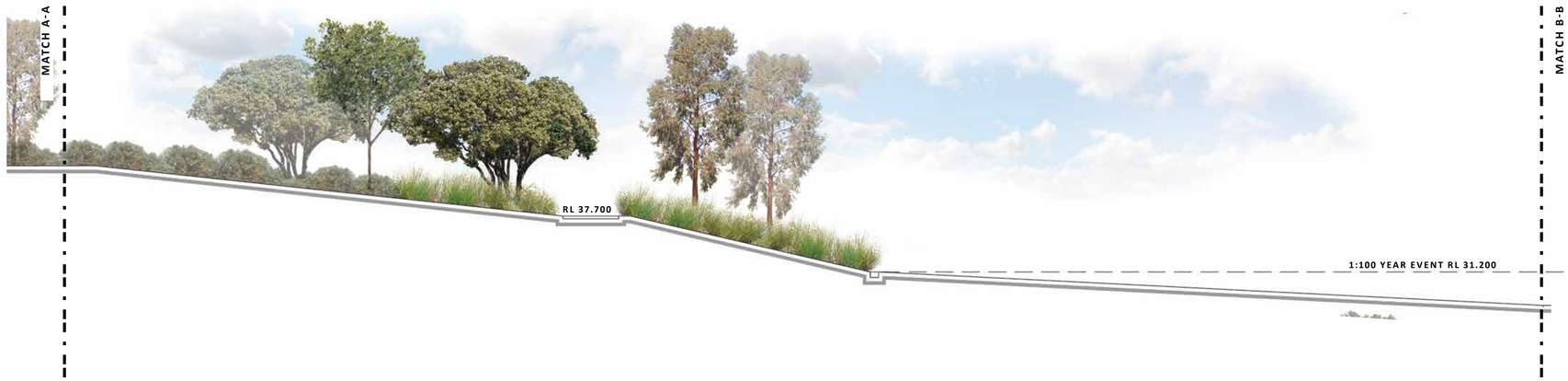
1:50 @ A1

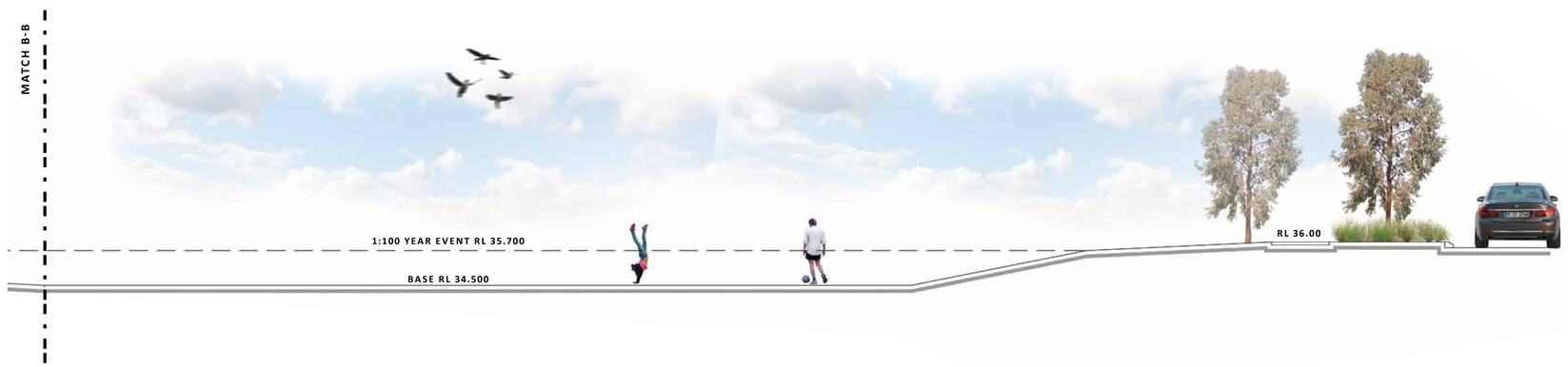
0 0.25 0.5 1.0 1.5 2.5M

LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au
LANDSPACE PTY LTD ACN 056 538 679

PLAN E







SECTIONC-C
POS 3

TARONGA PLACE, EGLINTON - LOT 6
PREPARED FOR URBAN QUARTER

LANDSCAPE SECTIONS

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1:50 @ A1

C1.102 REV A MARCH 2017

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LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au
LANDSPACE PTY LTD ACN 056 538 679

PLAN E

APPENDIX E – PC Sump Calculations (Prepared by Cossill & Webley)

Catchment A

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Internal Roads	6108	0.8	4886	
Lots < 300m2	1788	0.95	1699	
			0	
TOTAL	7896		6585	

INPUT DATA			
Location	Perth		
$A_{impervious}$	0.6585	ha	
GWL	1.000	m AHD	
Depth to GWL from base	24.800	m	
Max Allowable TWL	27.000	m AHD	
Sump Base Level	25.800	m AHD	
Sump Width at base	10	m	
Sump Length at base	11	m	
Side Slope	6.0	1 in --	
Soil Permeability, K	5	m/d	
Permeability Clogged Layer	0.15	m/d	
Thickness of Clogged Layer	200	mm	
Reduction Factor - Shallow	0.800		
Reduction Factor - Deep	0.400		
Reduction Factor - Clogged	1.000		

Catchment A Deep Water Table – 1:5 Year Model

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Kadjusted (m/day)	Water Depth, H (m)	H' (m)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage (m3)
5	0.5	40.1	132.0	2.0000	0.606	0.30	401.6	8	123.7
5	1	25.4	167.3	2.0000	0.683	0.34	428.5	18	149.4
5	2	16.2	213.4	2.0000	0.754	0.38	454.2	38	175.5
5	3	12.3	243.0	2.0000	0.779	0.39	463.1	58	185.1
5	4	10.2	268.7	2.0000	0.793	0.40	468.5	78	190.6
5	5	8.75	288.1	2.0000	0.793	0.40	468.4	98	190.5
5	6	7.75	306.2	2.0000	0.790	0.40	467.5	117	189.3
5	9	5.91	350.3	2.0000	0.762	0.38	457.1	171	178.8
5	12	4.88	385.6	2.0000	0.723	0.36	443.0	221	164.1
5	18	3.79	449.2	2.0000	0.646	0.32	415.6	312	137.5
5	24	3.17	501.0	2.0000	0.568	0.28	388.6	389	112.4
5	36	2.43	576.1	2.0000	0.411	0.21	337.3	506	70.1
5	48	2	632.2	2.0000	0.275	0.14	295.7	591	40.8
5	60	1.71	675.6	2.0000	0.157	0.08	262.0	655	20.7
5	72	1.49	706.4	2.0000	0.052	0.03	233.4	700	6.1
				Maximum	0.793			Maximum	190.6

Catchment A Deep Water Table – 1:100 Year Model

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Kadjusted (m/day)	Water Depth, H (m)	H' (m)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage (m3)
100	0.5	76	250.2	2.0000	0.907	0.45	511.9	11	239.6
100	1	46.2	304.2	2.0000	0.995	0.50	546.3	23	281.5
100	2	28.9	380.6	2.0000	1.090	0.54	585.0	49	331.9
100	3	21.9	432.6	2.0000	1.134	0.57	603.4	75	357.2
100	4	17.9	471.5	2.0000	1.154	0.58	612.1	102	369.5
100	5	15.3	503.8	2.0000	1.164	0.58	616.3	128	375.3
100	6	13.5	533.4	2.0000	1.170	0.58	618.7	155	378.7
100	9	10.2	604.5	2.0000	1.162	0.58	615.6	231	373.7
100	12	8.36	660.6	2.0000	1.136	0.57	604.3	302	358.5
100	18	6.6	782.3	2.0000	1.103	0.55	590.7	443	339.3
100	24	5.57	880.3	2.0000	1.051	0.53	569.1	569	311.2
100	36	4.35	1031.2	2.0000	0.930	0.46	520.6	781	250.3
100	48	3.63	1147.4	2.0000	0.810	0.41	474.9	950	197.6
100	60	3.13	1236.7	2.0000	0.696	0.35	433.1	1083	153.9
100	72	2.75	1303.8	2.0000	0.587	0.29	395.2	1186	118.1
				Maximum	1.170			Maximum	378.7

Catchment B

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Internal Roads	24307	0.8	19446	
Lots < 300m2	7600	0.95	7220	
			0	
TOTAL	31907		26666	

INPUT DATA		
Location	Perth	
$A_{impervious}$	2.6666	ha
GWL	1.000	m AHD
Depth to GWL from base	29.000	m
Max Allowable TWL	31.200	m AHD
Sump Base Level	30.000	m AHD
Sump Width at base	27	m
Sump Length at base	30	m
Side Slope	6.0	1 in --
Soil Permeability, K	5	m/d
Permeability Clogged Layer	0.15	m/d
Thickness of Clogged Layer	200	mm
Reduction Factor - Shallow	0.800	
Reduction Factor - Deep	0.400	
Reduction Factor - Clogged	1.000	

Catchment B Deep Water Table – 1:5 Year Model

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Kadjusted (m/day)	Water Depth, H (m)	H' (m)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage (m3)
5	0.5	40.1	534.6	2.0000	0.497	0.25	1982.8	41	493.3
5	1	25.4	677.3	2.0000	0.578	0.29	2044.9	85	592.1
5	2	16.2	864.0	2.0000	0.653	0.33	2103.6	175	688.7
5	3	12.3	984.0	2.0000	0.676	0.34	2121.7	265	718.7
5	4	10.2	1088.0	2.0000	0.687	0.34	2130.9	355	732.8
5	5	8.75	1166.6	2.0000	0.679	0.34	2124.7	443	724.0
5	6	7.75	1240.0	2.0000	0.669	0.33	2116.8	529	710.8
5	9	5.91	1418.3	2.0000	0.616	0.31	2075.1	778	640.2
5	12	4.88	1561.5	2.0000	0.545	0.27	2019.5	1010	551.8
5	18	3.79	1819.1	2.0000	0.403	0.20	1911.7	1434	385.4
5	24	3.17	2028.7	2.0000	0.253	0.13	1800.1	1800	228.6
5	36	2.43	2332.7	2.0000	0.000	0.00	1619.9	2430	0.0
5	48	2	2559.9	2.0000	0.000	0.00	1619.9	3240	0.0
5	60	1.71	2735.9	2.0000	0.000	0.00	1619.9	4050	0.0
5	72	1.49	2860.7	2.0000	0.000	0.00	1619.9	4860	0.0
				Maximum	0.687			Maximum	732.8

Catchment B Deep Water Table – 1:100 Year Model

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Kadjusted (m/day)	Water Depth, H (m)	H' (m)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage (m3)
100	0.5	76	1013.3	2.0000	0.850	0.42	2262.1	47	966.2
100	1	46.2	1232.0	2.0000	0.958	0.48	2351.7	98	1134.0
100	2	28.9	1541.3	2.0000	1.081	0.54	2455.3	205	1336.7
100	3	21.9	1751.9	2.0000	1.140	0.57	2505.3	313	1438.8
100	4	17.9	1909.3	2.0000	1.167	0.58	2528.3	421	1487.9
100	5	15.3	2039.9	2.0000	1.179	0.59	2539.4	529	1510.9
100	6	13.5	2159.9	2.0000	1.187	0.59	2545.5	636	1523.5
100	9	10.2	2447.9	2.0000	1.173	0.59	2533.5	950	1497.8
100	12	8.36	2675.1	2.0000	1.132	0.57	2498.4	1249	1425.9
100	18	6.6	3167.9	2.0000	1.077	0.54	2451.1	1838	1329.6
100	24	5.57	3564.7	2.0000	0.990	0.50	2378.5	2378	1186.2
100	36	4.35	4175.8	2.0000	0.782	0.39	2206.6	3310	865.9
100	48	3.63	4646.2	2.0000	0.565	0.28	2034.9	4070	576.4
100	60	3.13	5007.8	2.0000	0.350	0.18	1871.7	4679	328.6
100	72	2.75	5279.8	2.0000	0.141	0.07	1719.4	5158	121.6
				Maximum	1.187			Maximum	1523.5

Catchment C

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Internal Roads	7044	0.8	5635	
10% of Lot area (45942)	1491	0.8	1193	
			0	
TOTAL	8535		6828	

INPUT DATA		
Location	Perth	
$A_{impervious}$	0.6828	ha
GWL	1.000	m AHD
Depth to GWL from base	34.000	m
Max Allowable TWL	36.200	m AHD
Sump Base Level	35.000	m AHD
Sump Width at base	7	m
Sump Length at base	15	m
Side Slope	6.0	1 in --
Soil Permeability, K	5	m/d
Permeability Clogged Layer	0.15	m/d
Thickness of Clogged Layer	200	mm
Reduction Factor - Shallow	0.800	
Reduction Factor - Deep	0.400	
Reduction Factor - Clogged	1.000	

Catchment C Deep Water Table – 1:5 Year Model

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Kadjusted (m/day)	Water Depth, H (m)	H' (m)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage (m3)
5	0.5	40.1	136.9	2.0000	0.622	0.31	404.9	8	128.5
5	1	25.4	173.4	2.0000	0.702	0.35	433.9	18	155.4
5	2	16.2	221.2	2.0000	0.773	0.39	460.6	38	182.8
5	3	12.3	252.0	2.0000	0.800	0.40	470.8	59	193.1
5	4	10.2	278.6	2.0000	0.814	0.41	476.3	79	199.2
5	5	8.75	298.7	2.0000	0.815	0.41	476.5	99	199.4
5	6	7.75	317.5	2.0000	0.813	0.41	475.8	119	198.5
5	9	5.91	363.2	2.0000	0.788	0.39	466.1	175	188.4
5	12	4.88	399.8	2.0000	0.750	0.38	451.8	226	174.0
5	18	3.79	465.8	2.0000	0.678	0.34	424.9	319	147.1
5	24	3.17	519.5	2.0000	0.602	0.30	397.7	398	121.8
5	36	2.43	597.3	2.0000	0.451	0.23	345.7	519	78.8
5	48	2	655.5	2.0000	0.321	0.16	303.3	607	48.9
5	60	1.71	700.6	2.0000	0.209	0.10	269.0	672	28.1
5	72	1.49	732.5	2.0000	0.108	0.05	239.8	719	13.0
				Maximum	0.815			Maximum	199.4

Catchment C Deep Water Table – 1:100 Year Model

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Kadjusted (m/day)	Water Depth, H (m)	H' (m)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage (m3)
100	0.5	76	259.5	2.0000	0.925	0.46	520.2	11	248.6
100	1	46.2	315.5	2.0000	1.014	0.51	556.4	23	292.3
100	2	28.9	394.7	2.0000	1.110	0.55	596.8	50	344.9
100	3	21.9	448.6	2.0000	1.154	0.58	616.1	77	371.6
100	4	17.9	488.9	2.0000	1.176	0.59	625.6	104	384.6
100	5	15.3	522.3	2.0000	1.186	0.59	630.3	131	391.0
100	6	13.5	553.1	2.0000	1.193	0.60	633.0	158	394.8
100	9	10.2	626.8	2.0000	1.186	0.59	630.0	236	390.6
100	12	8.36	685.0	2.0000	1.161	0.58	618.9	309	375.5
100	18	6.6	811.2	2.0000	1.130	0.56	605.5	454	357.0
100	24	5.57	912.8	2.0000	1.080	0.54	584.3	584	328.5
100	36	4.35	1069.3	2.0000	0.962	0.48	535.1	803	266.7
100	48	3.63	1189.7	2.0000	0.845	0.42	488.5	977	212.8
100	60	3.13	1282.3	2.0000	0.734	0.37	445.7	1114	168.0
100	72	2.75	1351.9	2.0000	0.629	0.31	407.1	1221	130.6
				Maximum	1.193			Maximum	394.8

Catchment D

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Internal Roads	31739	0.8	25391	
Lots < 300m2 area	7565	0.8	6052	
			0	
TOTAL	39304		31443	

INPUT DATA		
Location	Perth	
$A_{impervious}$	3.1443	ha
GWL	1.000	m AHD
Depth to GWL from base	33.600	m
Max Allowable TWL	36.800	m AHD
Sump Base Level	34.600	m AHD
Sump Width at base	25	m
Sump Length at base	40	m
Side Slope	6.0	1 in --
Soil Permeability, K	5	m/d
Permeability Clogged Layer	0.15	m/d
Thickness of Clogged Layer	200	mm
Reduction Factor - Shallow	0.800	
Reduction Factor - Deep	0.400	
Reduction Factor - Clogged	1.000	

Catchment D Deep Water Table – 1:5 Year Model

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Kadjusted (m/day)	Water Depth, H (m)	H' (m)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage (m3)
5	0.5	40.1	630.4	2.0000	0.483	0.24	2399.2	50	580.5
5	1	25.4	798.7	2.0000	0.563	0.28	2468.0	103	695.8
5	2	16.2	1018.8	2.0000	0.636	0.32	2532.7	211	807.7
5	3	12.3	1160.3	2.0000	0.658	0.33	2551.7	319	841.3
5	4	10.2	1282.9	2.0000	0.667	0.33	2560.2	427	856.2
5	5	8.75	1375.6	2.0000	0.659	0.33	2553.2	532	843.7
5	6	7.75	1462.1	2.0000	0.648	0.32	2543.4	636	826.3
5	9	5.91	1672.5	2.0000	0.591	0.30	2492.8	935	737.7
5	12	4.88	1841.3	2.0000	0.517	0.26	2427.9	1214	627.3
5	18	3.79	2145.1	2.0000	0.366	0.18	2299.1	1724	420.8
5	24	3.17	2392.2	2.0000	0.207	0.10	2167.2	2167	225.0
5	36	2.43	2750.7	2.0000	0.000	0.00	1999.9	3000	0.0
5	48	2	3018.5	2.0000	0.000	0.00	1999.9	4000	0.0
5	60	1.71	3226.1	2.0000	0.000	0.00	1999.9	5000	0.0
5	72	1.49	3373.2	2.0000	0.000	0.00	1999.9	6000	0.0
				Maximum	0.667			Maximum	856.2

Catchment D Deep Water Table – 1:100 Year Model

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Kadjusted (m/day)	Water Depth, H (m)	H' (m)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage (m3)
100	0.5	76	1194.8	2.0000	0.836	0.42	2712.3	57	1138.3
100	1	46.2	1452.7	2.0000	0.945	0.47	2812.6	117	1335.5
100	2	28.9	1817.4	2.0000	1.069	0.53	2928.4	244	1573.4
100	3	21.9	2065.8	2.0000	1.128	0.56	2984.7	373	1692.7
100	4	17.9	2251.3	2.0000	1.154	0.58	3010.2	502	1749.6
100	5	15.3	2405.4	2.0000	1.167	0.58	3022.2	630	1775.8
100	6	13.5	2546.9	2.0000	1.174	0.59	3028.6	757	1789.7
100	9	10.2	2886.5	2.0000	1.158	0.58	3013.5	1130	1756.4
100	12	8.36	3154.4	2.0000	1.115	0.56	2972.8	1486	1668.0
100	18	6.6	3735.5	2.0000	1.056	0.53	2916.1	2187	1548.4
100	24	5.57	4203.3	2.0000	0.965	0.48	2830.7	2831	1372.7
100	36	4.35	4924.0	2.0000	0.744	0.37	2628.7	3943	981.0
100	48	3.63	5478.7	2.0000	0.515	0.26	2426.6	4853	625.4
100	60	3.13	5905.0	2.0000	0.287	0.14	2233.1	5583	322.3
100	72	2.75	6225.8	2.0000	0.066	0.03	2052.6	6158	67.8
				Maximum	1.174			Maximum	1789.7

Catchment E

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Internal Roads	3667	0.8	2934	
Lots < 300m2	0	0.95	0	
			0	
TOTAL	3667		2934	

INPUT DATA		
Location	Perth	
$A_{impervious}$	0.2934	ha
GWL	1.000	m AHD
Depth to GWL from base	24.600	m
Max Allowable TWL	27.000	m AHD
Sump Base Level	25.600	m AHD
Sump Width at base	5	m
Sump Length at base	5	m
Side Slope	6.0	1 in --
Soil Permeability, K	5	m/d
Permeability Clogged Layer	0.15	m/d
Thickness of Clogged Layer	200	mm
Reduction Factor - Shallow	0.800	
Reduction Factor - Deep	0.400	
Reduction Factor - Clogged	1.000	

Catchment E Deep Water Table – 1:5 Year Model

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Kadjusted (m/day)	Water Depth, H (m)	H' (m)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage (m3)
5	0.5	40.1	58.8	2.0000	0.654	0.33	160.9	3	55.5
5	1	25.4	74.5	2.0000	0.720	0.36	175.3	7	67.2
5	2	16.2	95.0	2.0000	0.781	0.39	189.5	16	79.3
5	3	12.3	108.2	2.0000	0.804	0.40	194.9	24	83.9
5	4	10.2	119.7	2.0000	0.816	0.41	197.9	33	86.7
5	5	8.75	128.3	2.0000	0.818	0.41	198.3	41	87.0
5	6	7.75	136.4	2.0000	0.818	0.41	198.3	50	86.8
5	9	5.91	156.0	2.0000	0.801	0.40	194.2	73	83.2
5	12	4.88	171.8	2.0000	0.774	0.39	187.9	94	77.9
5	18	3.79	200.1	2.0000	0.723	0.36	176.2	132	68.0
5	24	3.17	223.2	2.0000	0.672	0.34	164.7	165	58.5
5	36	2.43	256.6	2.0000	0.569	0.28	142.8	214	42.4
5	48	2	281.6	2.0000	0.480	0.24	125.2	250	31.1
5	60	1.71	301.0	2.0000	0.404	0.20	111.1	278	23.1
5	72	1.49	314.7	2.0000	0.337	0.17	99.2	298	17.0
				Maximum	0.818			Maximum	87.0

Catchment E Deep Water Table – 1:100 Year Model

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Kadjusted (m/day)	Water Depth, H (m)	H' (m)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage (m3)
100	0.5	76	111.5	2.0000	0.903	0.45	219.5	5	106.9
100	1	46.2	135.5	2.0000	0.973	0.49	237.6	10	125.6
100	2	28.9	169.6	2.0000	1.049	0.52	257.8	21	148.1
100	3	21.9	192.7	2.0000	1.085	0.54	267.8	33	159.3
100	4	17.9	210.0	2.0000	1.102	0.55	272.6	45	164.6
100	5	15.3	224.4	2.0000	1.109	0.55	274.7	57	167.2
100	6	13.5	237.6	2.0000	1.113	0.56	275.8	69	168.7
100	9	10.2	269.3	2.0000	1.106	0.55	273.9	103	166.6
100	12	8.36	294.3	2.0000	1.087	0.54	268.5	134	160.1
100	18	6.6	348.5	2.0000	1.062	0.53	261.6	196	152.3
100	24	5.57	392.2	2.0000	1.025	0.51	251.3	251	140.9
100	36	4.35	459.4	2.0000	0.939	0.47	228.5	343	116.6
100	48	3.63	511.2	2.0000	0.856	0.43	207.6	415	95.9
100	60	3.13	550.9	2.0000	0.778	0.39	188.9	472	78.7
100	72	2.75	580.9	2.0000	0.705	0.35	172.1	516	64.6
				Maximum	1.113			Maximum	168.7

APPENDIX F – Department of Water Checklist

The following checklist has been taken from Appendix 2 of the Department of Water's Interim: Developing a local water management strategy to be used as a guide for items that should be addressed by relevant parties in the preparation of this Local Water Management Strategy. This checklist will aid in the assessment by the relevant authority when an application for the local structure plan is lodged.

Local Water Management Strategy Item	Required Deliverable	Deliverable		☐	Comment
		LWMS Reference	Comment		
Executive Summary					
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements and requirements for BMP's and critical control points	Section 3.2		☐	
Introduction					
Total water cycle management – principles & objectives Planning background Previous studies		Section 1		☐	
Proposed Development					
Structure plan, zoning and land use. Key landscape features Previous land use	Site Context Plan Structure Plan	Section 2.2 Section 2.3 Section 2.1		☐	
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas	Landscape Plan	Section 2.3, 5		☐	

Local Water Management Strategy Item	Required Deliverable	Deliverable		☐	Comment
		LWMS Reference	Comment		
Design Criteria					
Agreed design objectives and source of objective		Section 3		☐	
Pre-development Environment					
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		Section 4		☐	
Site Conditions - existing topography / contours, aerial photo underlay, major physical features	Site Condition Plan	Section 4.1, 4.3		☐	
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical Plan	Sections 4.2, 4.4, 4.6		☐	
Environmental - areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting datasets where appropriate	Sections 4.8, 4.9		☐	
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	Section 4.10		☐	
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	Sections 4.7, 4.10		☐	
Water Use Sustainability Initiatives					

Local Water Management Strategy Item	Required Deliverable	Deliverable		☐	Comment
		LWMS Reference	Comment		
Water efficiency measures – private and public open spaces including method of enforcement		Section 5		☐	
Water supply (fit-for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		Section 5		☐	
Wastewater Management		Section 5		☐	
Stormwater Management Strategy					
Flood protection - peak flow rates, volumes and top water levels at control points,100 year flow paths and 100 year detentions storage areas	100 year Event Plan Long Section of critical points	Section 6		☐	
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5 year Event Plan	Section 6		☐	
Protect ecology – detention areas for the 1 yr. 1 hr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1 year Event Plan Typical Cross Sections	Section 6		☐	
Groundwater Management Strategy					

Local Water Management Strategy Item	Required Deliverable	Deliverable		☐	Comment
		LWMS Reference	Comment		
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoils areas/exclusion zones	Groundwater/Subsoil Plan	Section 7		☐	
Actions to address acid sulfate soils or contamination		N/A - Section 4.6		☐	
The Next Stage – Subdivision and Urban Water Management Plans					
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design.		Section 8		☐	
Monitoring					
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		Section 9		☐	
Implementation					
Developer commitments		Section 9		☐	
Roles, responsibilities, funding for implementation		Section 9		☐	
Review		Section 9		☐	

EGLINTON WEST LOCAL WATER MANAGEMENT STRATEGY

APPENDIX 6

Landscape Master Plan and Cross-Sections (Plan E)

01 LOCAL PARK LOCATED AT THE ENTRY TO THE ESTATE. THE POS WILL INCLUDE A KEY ENTRY MARKER AND MATURE TREES TO DEFINE THE PRIMARY ACCESS TO THE INITIAL PHASES OF THE PROJECT. TERRACED GARDEN BEDS, TURF AND FORMAL PAVEMENT WILL DEFINE THE PARK AND ALLOW FOR PASSIVE RECREATION. ALLOWANCE HAS BEEN MADE FOR 1:1, 1:5 AND 1:100 YEAR DRAINAGE EVENTS ABOVE GROUND.

02 NEIGHBOURHOOD PARK LOCATED IN THE SOUTH EAST CORNER OF THE SITE. THE POS WILL INCORPORATE A VIEWING AREA WITH PLAY SPACE SUITABLE FOR 3-8 YEAR OLDS, OVERLOOKING A TURF AREA FOR PASSIVE AND ACTIVE RECREATION. ALLOWANCE HAS BEEN MADE FOR 1:1, 1:5 AND 1:100 YEAR DRAINAGE EVENTS ABOVE GROUND.

03 LARGE NEIGHBOURHOOD PARK WHICH WILL PROVIDE A CENTRAL FOCAL POINT FOR THE ESTATE. THE AREA INCLUDES SIGNIFICANT LEVEL DIFFERENCE FALLING FROM NORTH-WEST TO SOUTH-EAST. MEANDERING FOOTPATHS WILL CONNECT AREAS OF ACTIVE AND PASSIVE RECREATION. VIEWING NODES WILL BE LOCATED AT KEY LOCATIONS WITH THE POTENTIAL FOR SIGNIFICANT PLAY OPPORTUNITIES TO BE INCLUDED. SUBSTANTIAL, HEALTHY EXISTING TREES MAY BE RETAINED IN SELECTIVE POCKETS WHERE APPROPRIATE. ALLOWANCE HAS BEEN MADE FOR 1:1, 1:5 AND 1:100 YEAR DRAINAGE EVENTS ABOVE GROUND.

04 LOCAL PARK LOCATED IN THE NORTH WEST PORTION OF THE ESTATE. AN AREA ALLOWING FOR SMALLER COMMUNAL GATHERINGS WILL BE LOCATED OVERLOOKING TERRACED GARDEN BEDS AND A TURF AREA SUITABLE FOR PASSIVE AND ACTIVE RECREATION. ALLOWANCE HAS BEEN MADE FOR 1:1, 1:5 AND 1:100 YEAR DRAINAGE EVENTS ABOVE GROUND.

INDICATIVE 1:5 YEAR TOP WATER LEVEL

TARONGA PLACE, EGLINTON - LOT 6
PREPARED FOR URBAN QUARTER

LANDSCAPE MASTER PLAN

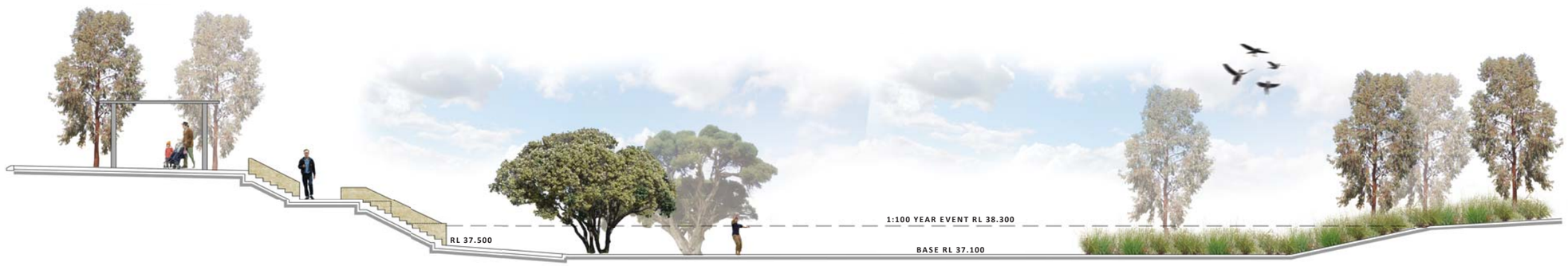
JOB NO. 1612801 M1.101 REV C MARCH 2017
1:1500 @ A1
0 15 30 60 90 150M

LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au
LANDSPACE PTY LTD ACN 056 538 679

PLAN E

SECTION A-A
POS 1

SECTION B-B
POS 2



SECTION D-D
POS 4

TARONGA PLACE, EGLINTON - LOT 6
PREPARED FOR PRIME EGLINTON

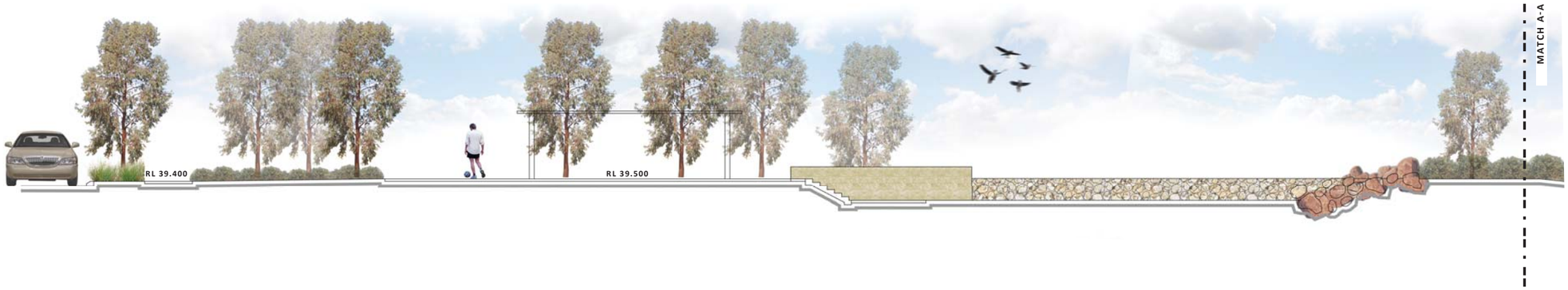
LANDSCAPE SECTIONS

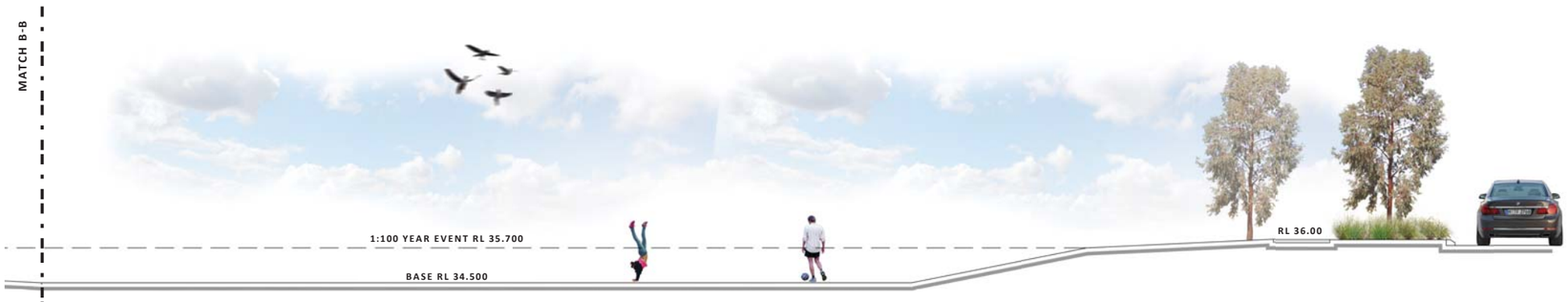
JOB NO. 1612801 C1.101 REV A MARCH 2017
1:50 @ A1

0 0.25 0.5 1.0 1.5 2.5M

LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au
LANDSPACE PTY LTD ACN 056 538 679

PLAN E





SECTIONC-C
POS 3

TARONGA PLACE, EGLINTON - LOT 6
PREPARED FOR PRIME EGLINTON

LANDSCAPE SECTIONS

JOB NO. 1612801
1:50 @ A1

C1.102 REV A MARCH 2017

0 0.25 0.5 1.0 1.5 2.5M

LANDSCAPE ARCHITECTS
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PLAN E

APPENDIX 7

Transportation Noise Assessment (Lloyd George)

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Transportation Noise Assessment

Lot 6 Taronga Place, Eglington

Reference: 16113816-01A

Prepared for:
Urban Quarter

Member Firm of Association of Australian Acoustical Consultants

Report: 16113816-01A

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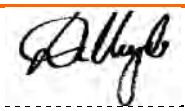
M:	0439 032 844	0400 414 197	0412 611 330	0439 987 455

Prepared By:	Daniel Lloyd 
Position:	Project Director
Verified	Terry George 
Date:	2 March 2017

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1 INTRODUCTION

This report has been prepared to assess the impact of passenger railway noise to the proposed development at Lot 6 Taronga Place Eglington. The noise from the railway has been predicted to the proposed residential lots and compares the results against the relevant transportation criteria for Western Australia. Whilst outside the scope of this assessment, comment on impacts from ground borne vibration is also provided.

The development layout used in this assessment is provided in *Figure 1-1*.

Figure 1-1 Proposed Subdivision Layout

Appendix B contains a description of some of the terminology used throughout this report.

2 CRITERIA

The criteria relevant to this assessment is the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (hereafter referred to as the Policy) produced by the Western Australian Planning Commission (WAPC). The objectives in the Policy are to:

- Protect people from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of proposals;
- Protect major transport corridors and freight operations from incompatible urban encroachment;
- Encourage best practice design and construction standards for new development proposals and new or redevelopment transport infrastructure proposals;
- Facilitate the development and operation of an efficient freight network; and
- Facilitate the strategic co-location of freight handling facilities.

The Policy's outdoor noise criteria are shown below in *Table 2-1*. These criteria applying at any point 1-metre from a habitable façade of a noise sensitive premises and in one outdoor living area.

Table 2-1 Outdoor Noise Criteria

Period	Target	Limit
Day (6am to 10pm)	55 dB $L_{Aeq(Day)}$	60 dB $L_{Aeq(Day)}$
Night (10pm to 6am)	50 dB $L_{Aeq(Night)}$	55 dB $L_{Aeq(Night)}$

Note: the 5 dB difference between the target and limit is referred to as the margin.

In the application of these outdoor noise criteria to new noise sensitive developments, the objectives of this Policy is to achieve -

- acceptable indoor noise levels in noise-sensitive areas (e.g. bedrooms and living rooms of houses); and
- a 'reasonable' degree of acoustic amenity in at least one outdoor living area on each residential lot.

If a noise sensitive development takes place in an area where outdoor noise levels will meet the *target*, no further measures are required under this Policy. For 'greenfield" sites such as this, where neither the development or the railway is constructed, there is an expectation under the Policy that the *target* is achieved.

In areas where the *target* is exceeded, but noise levels are likely to be within the 5 dB margin (i.e. less than the *limit*), customised noise mitigation measures should be implemented with a view to achieving the *target* in at least one outdoor living area on each residential lot, or if this is not practicable, within the *margin*. Where indoor spaces are planned to be facing outdoor areas that are above the *target*, mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces.

3 NOISE PREDICTION METHODOLOGY

To assess the transportation noise levels to the proposed development, the computer programme *SoundPLAN 7.4* was utilised incorporating the Nordic Rail Prediction Method (Kilde Rep. 130) algorithm. The algorithm has been modified to reflect local conditions as follows:

The Nordic Rail Prediction Method (Kilde Rep. 130) algorithm is for generic train types in Europe and requires modification to align with measured noise levels of passenger trains operating in the Perth northern suburbs. The sound pressure levels used in the modelling are shown in *Table 3-1*.

Table 3-1 Sound Pressure Levels Used in the Noise Model

Description	dB(A) at One-Third Octave Frequencies (Hz)									Overall dB(A)
	31.5	63	125	250	500	1K	2K	4K	8K	
Train speed of 100 km/hr at a distance of 15m	27	48	56	59	70	76	76	74	66	84
	32	51	58	62	70	76	77	71	61	
	39	50	58	66	75	77	75	69	55	

The predictions are made at a height of 1.4 metres above ground floor level for single storey dwellings and 4.4 metres for two-storey dwellings and at 1.0 metre from an assumed building facade (resulting in a + 2.5 dB correction due to reflected noise). Noise to upper floors is only predicted to determine the extent of facade treatments required to ensure acceptable internal noise levels.

Other input data included in the modelling includes ground topography, rail design and train configurations and movements.

Ground Topography, Rail Design & Cadastral Data

Topographical data was based on that provided by Cossill and Webley. The contours are in 0.1 metre intervals and cover the development area.

Buildings have also been included as these can provide barrier attenuation when located between a source and receiver, much the same as a hill. All single storey buildings are assumed to have a height of 4.0 m and double storey 7.0 m.

Train Movements

The train configuration and numbers of movements used in the noise prediction modelling are presented below in *Tables 3-2 and 3-3.*

Table 3-2 **Variables Used in the Noise Prediction Model**

Description of Variable		Value
Train length	3 Car Set	75 metres
	4 Car Set	100 metres
	6 Car Set	150 metres
Train Speeds		130 km/h

Table 3-3 Rail Movements Per Hour Assumed in Noise Model

Train Description	Train Movements per Hour	
	Day	Night
Northbound		
3 Car Sets	3.9	0.5
4 Car Sets	0.4	0.4
6 Car Sets	1.5	0.25
Southbound		
3 Car Sets	4.0	0.5
4 Car Sets	0.2	0.4
6 Car Sets	1.6	0.25

4 RESULTS

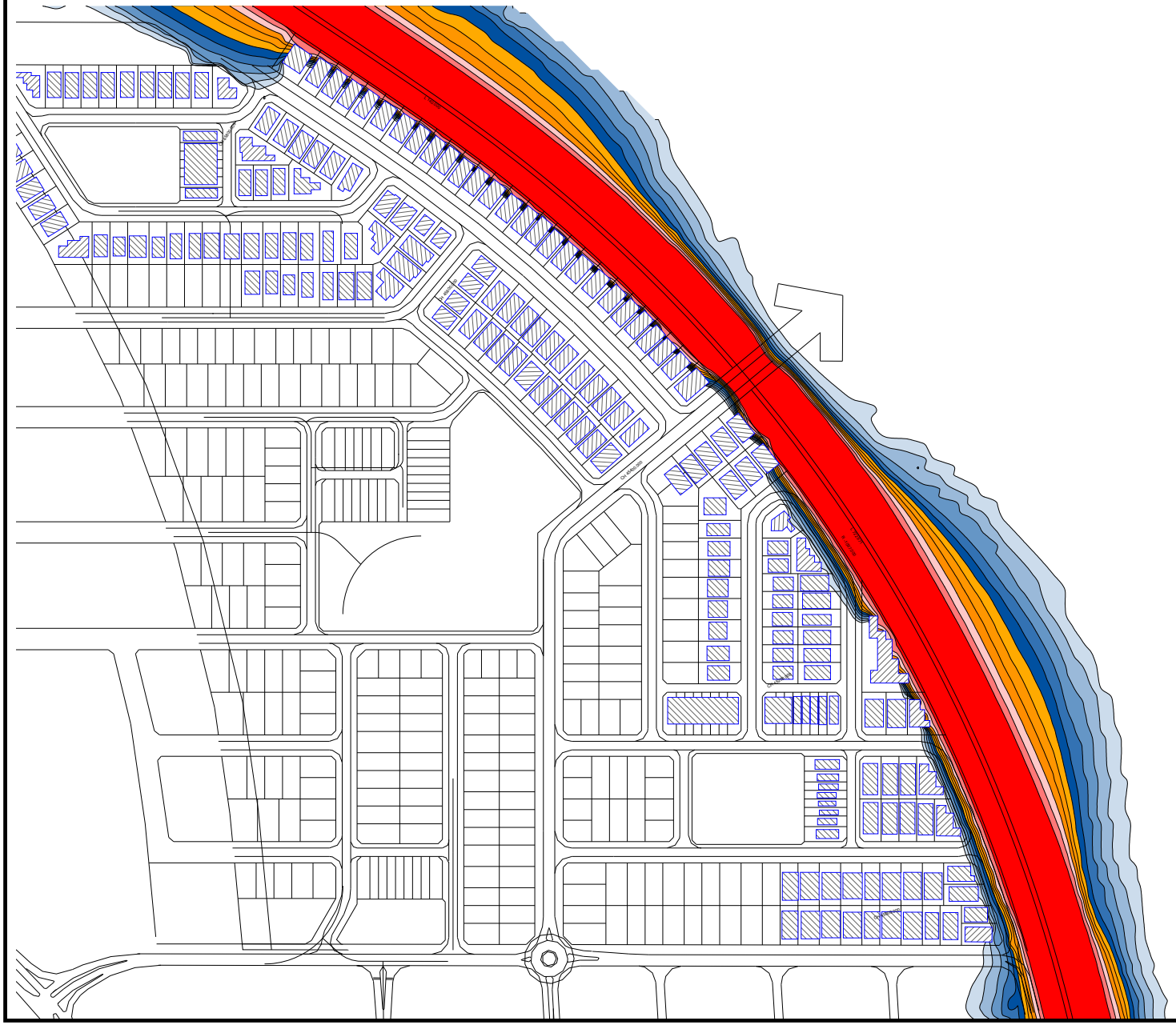
The results of the noise assessment assuming a train speed of 130 km/h are provided in *Figure 4-1.* From previous acoustic studies undertaken by Lloyd George Acoustics in the northern suburbs, it has been determined that it is the daytime noise levels that will dictate compliance with the Policy for passenger rail noise. Therefore only the daytime noise level contours are provided.

The results show that the noise levels are above the *limit* criteria and therefore noise mitigation measures must be considered.

Lot 6, Taronga Place, Eglington

$L_{Aeq,Day}$ Noise Level Contours at Ground Floor - Train Speed 130 km/h

Figure 4-1



Noise levels
$L_{Aeq,Day}$ dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	< 64
64 <=	< 65
65 <=	

Signs and symbols

Building

Other Stage

N

Scale

0 20 40 80 120 160 20

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5 ASSESSMENT

The objectives of the Policy criteria are for noise at all houses to be no more than the *limit* and preferably no more than the *target*. Where the *target* is achieved, no further controls are required; where the *limit* is achieved or noise levels are within the margin (between the *limit* and *target*), further controls are necessary.

For a greenfield site such as this, where neither the railway nor the development have been constructed, the Policy states that there is an expectation that the design of the proposal and railway will be consistent with the *target* ultimately being achieved and that this burden should be shared between the Developer and the railway Provider.

From *Figure 4-1*, it can be seen that the noise would exceed the *target* criteria and therefore noise mitigation measures must be considered.

The mitigation options relevant to developments adjacent to passenger rail corridors are:

- Increased setbacks;
- Noise Barrier along the boundary of the railway reserve; and
- Treatment to the facade of properties exceeding the *target* criteria.

Increased Setbacks

Increasing the setbacks from a railway can result in reduced noise levels at residential premises. The design of this subdivision includes service roads between the railway and the lots to ensure setbacks are maximised while maintaining the viability of the subdivision in terms of lot yield. It is therefore assumed that this noise control option has been addressed in the design.

Noise Barrier

Noise barriers located on the subdivision boundary would be an effective way of achieving the Policy criteria at receivers located at ground floor level, as required under Policy. Two noise barrier designs are provided. These include:

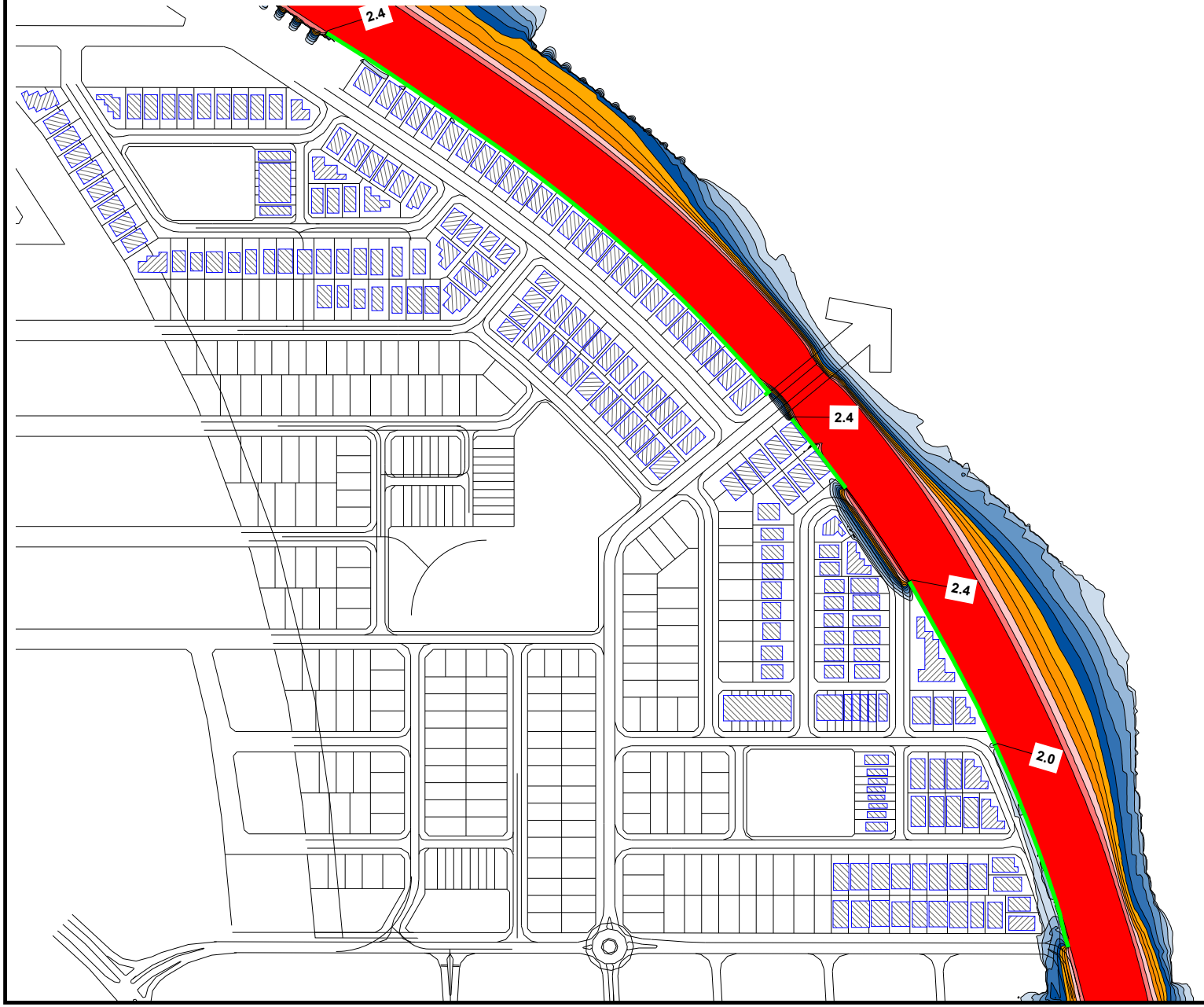
- Option A - The barrier design ensures all noise sensitive premises receive a noise level below the target criteria; and
- Option B – The barrier design ensures the Policy criteria are achieved using a combination of noise barriers and facade protection.

The barrier heights and corresponding predicted noise levels for the two options are provided in *Figures 5-1 to 5-4*. *Figures 5-1 and 5-2* relate to barrier Option A at ground and upper floors respectively, and *Figures 5-3 and 5-4* relate to barrier Option B at ground and upper floors respectively.

It should be noted that while the noise to both ground and upper floors requires consideration under the Policy, noise barriers are only designed to achieve the criteria at ground floor.

Lot 6, Taronga Place, Eglington - Includes Noise Barrier Option A
$L_{Aeq,Day}$ Noise Level Contours - Ground Floor - Train Speed 130 km/h

Figure 5-1



Noise levels
$L_{Aeq,Day}$ dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	< 64
64 <=	< 65
65 <=	

Signs and symbols
Building
Noise Barrier

N

Scale
0 20 40 80 120 160 200

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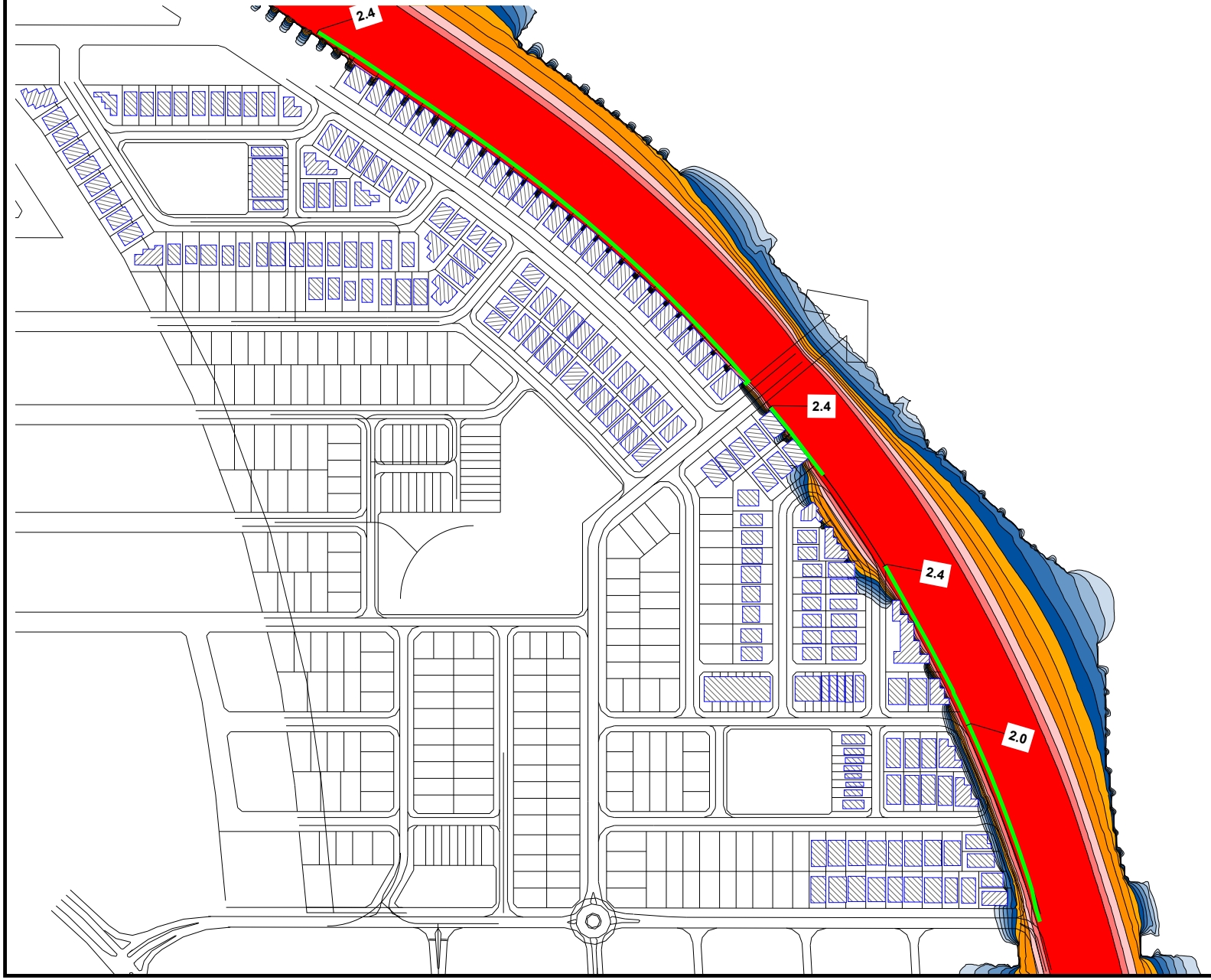
Lot 6, Taronga Place, Eglington - Includes Noise Barrier A
$L_{Aeq,Day}$ Noise Level Contours - Upper Floor - Train Speed 130 km/h

Figure 5-2



Noise levels
$L_{Aeq,Day}$ dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	< 64
64 <=	< 65
65 <=	

Signs and symbols
Building
Noise Barrier

N

Scale
0 20 40 80 120 160 200

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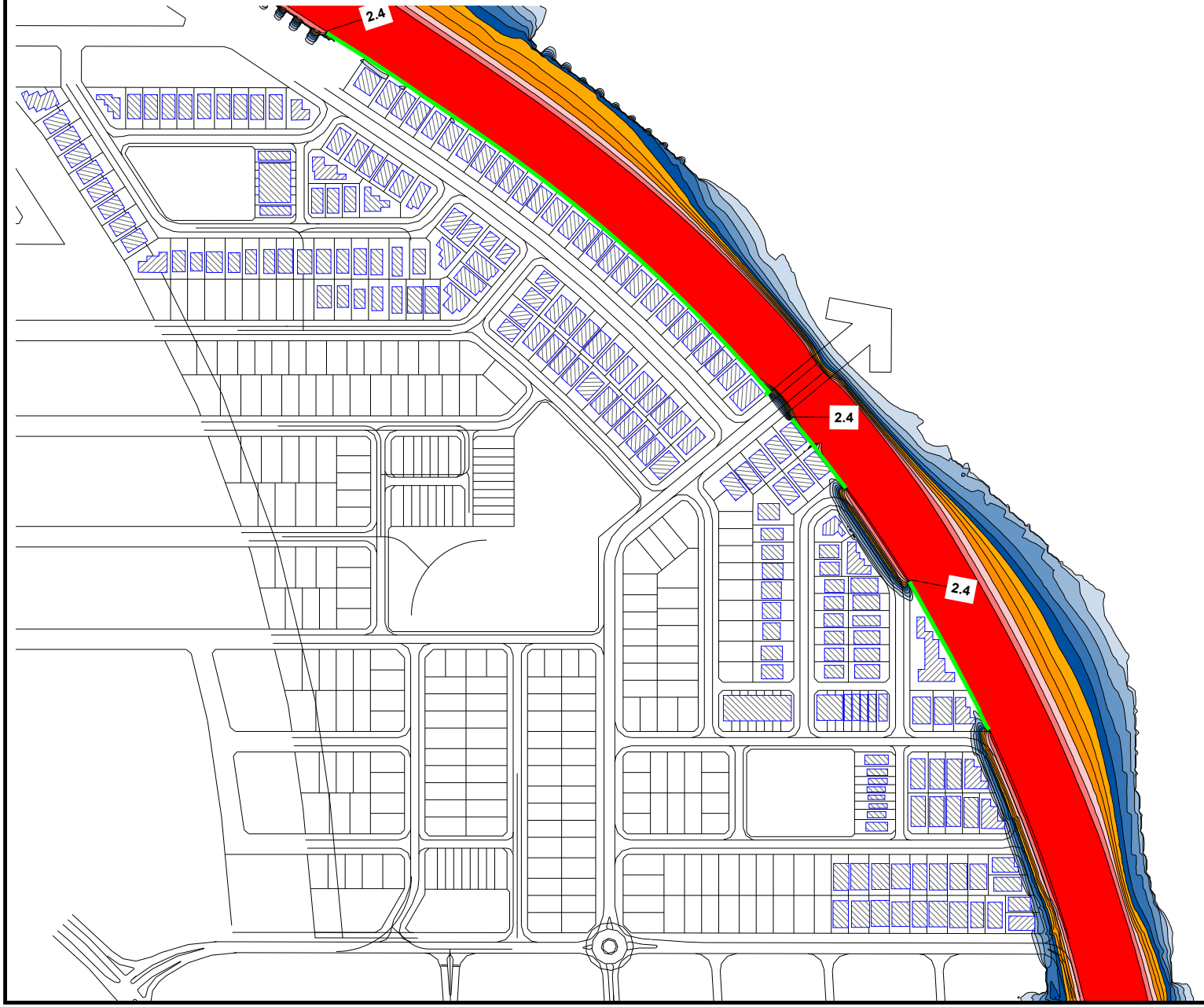
Lot 6, Taronga Place, Eglington - Includes Noise Barrier Option B

$L_{Aeq,Day}$ Noise Level Contours - Ground Floor - Train Speed 130 km/h

Figure 5-3



Noise levels

$L_{Aeq,Day}$ dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	< 64
64 <=	< 65
65 <=	

Signs and symbols

Building

Noise Barrier

N

Scale

0 20 40 80 120 160 200

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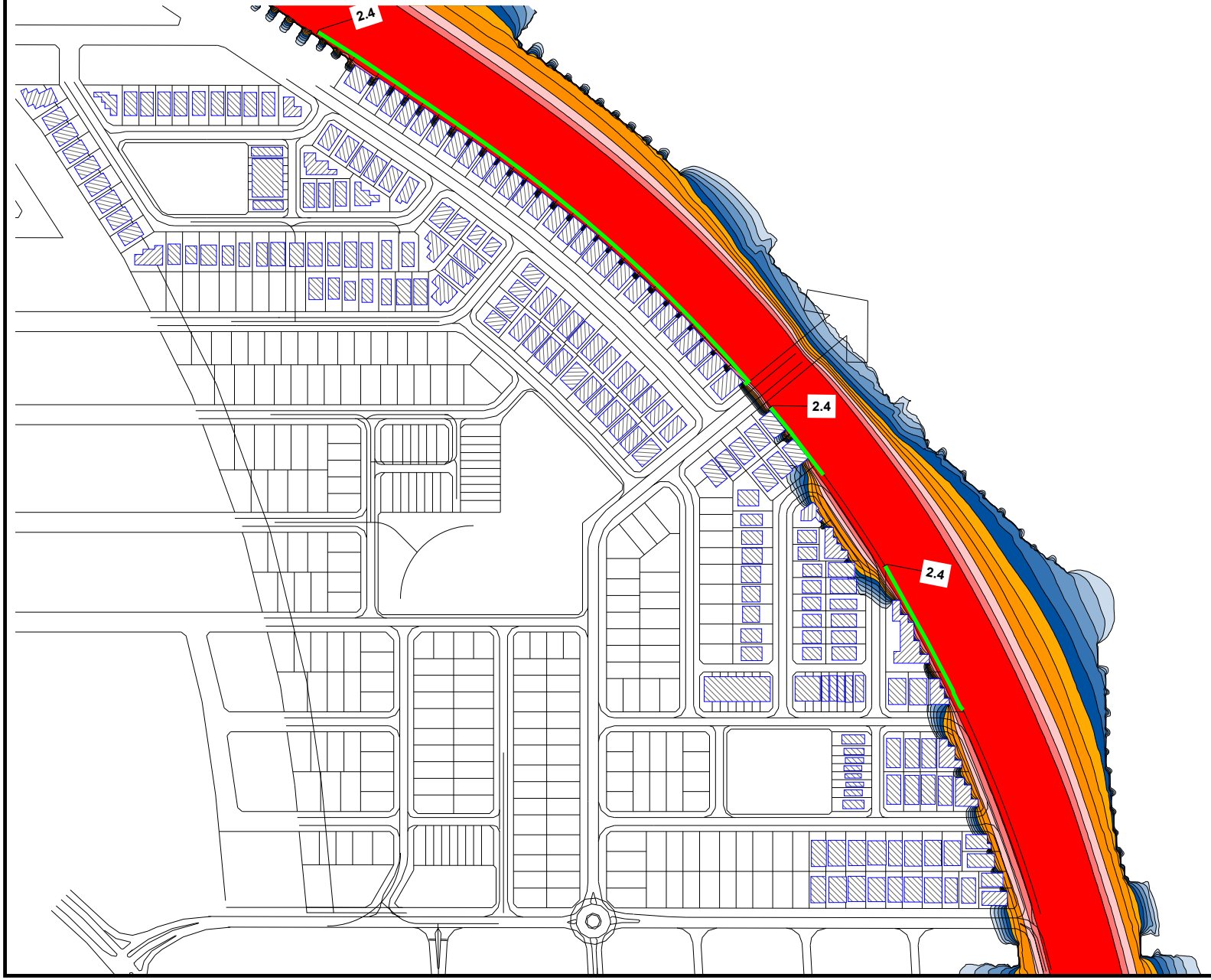
Lot 6, Taronga Place, Eglington - Includes Noise Barrier B
$L_{Aeq,Day}$ Noise Level Contours - Upper Floor - Train Speed 130 km/h

Figure 5-4



Noise levels
$L_{Aeq,Day}$ dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	< 64
64 <=	< 65
65 <=	

Signs and symbols
Building
Noise Barrier

N

Scale
0 20 40 80 120 160 200

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Facade Treatments

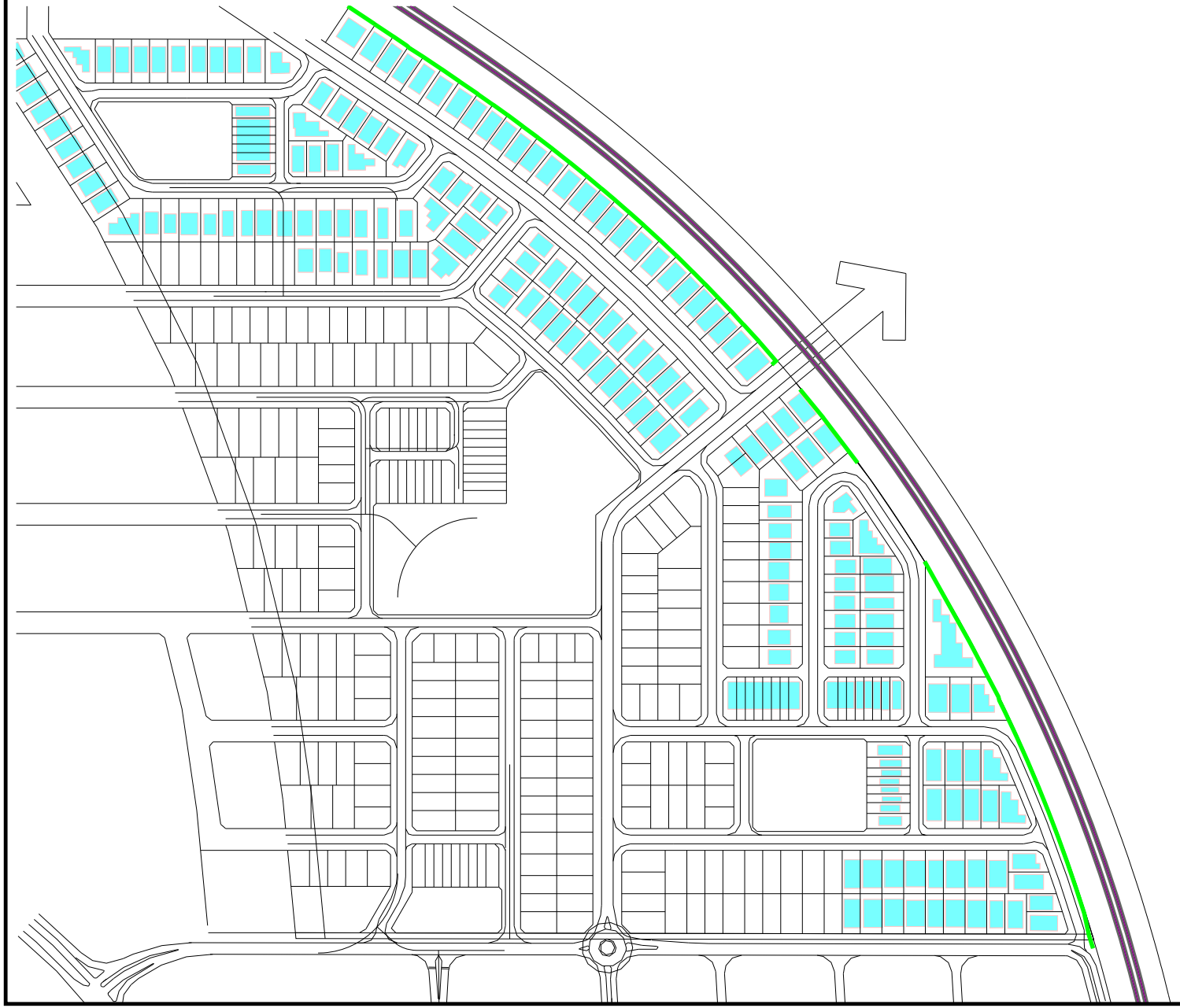
The Policy Guidelines provide 'deemed to comply' facade protection options where the noise from a transportation corridor exceeds the *target* criteria. The three packages A, B and C are provided in *Appendix A.* Should the noise be greater than 5 dB above the *limit* criteria, specialist acoustic advice is required.

From *Figures 5-1* and *5-2*, it can be seen that assuming the barrier Option A, all lots directly adjacent to the railway would be below the Policy *target* at ground floor level, however, are above the *target* at upper floor levels. Therefore no facade treatment would be required for single storey houses and facade packages would be required for the upper floor of two-storey houses. From *Figures 5-3* and *5-4*, it can be seen that assuming the barrier Option B, facade protection would be required for some lots on both ground and upper floors.

The lots requiring facade protection for barrier Option A are provided in *Figures 5-5 and 5-6* (ground and upper floors) and lots requiring facade protection for barrier Option B are provided in *Figure 5-7 and 5-8* (ground and upper floors).

Lot 6, Taronga Place, Eglington - Assuming Noise Barrier Option A
Facade Treatment Required to Ground Floor

Figure 5-5



Signs and symbols

- Protection Not Req'd
- Package A
- Package B
- Package C
- Specialist Advice
- Wall

N

Scale

0 15 30 60 90 120 150 m

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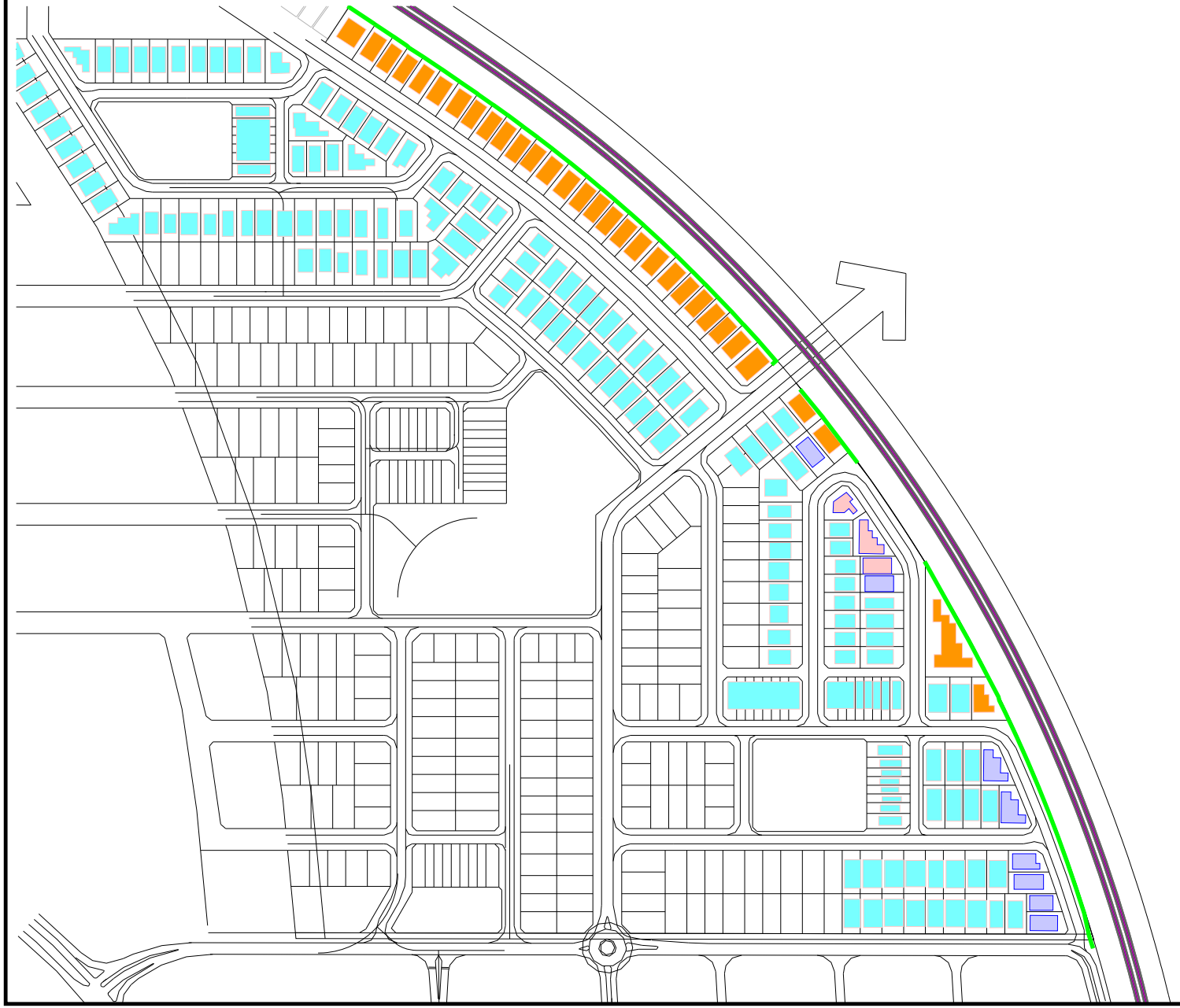
Lot 6, Taronga Place, Eglington - Assuming Noise Barrier Option A
Facade Treatment Required to Upper Floors

Figure 5-6



Signs and symbols

- Protection Not Req'd
- Package A
- Package B
- Package C
- Specialist Advice
- Wall

N

Scale

0 15 30 60 90 120 150 m

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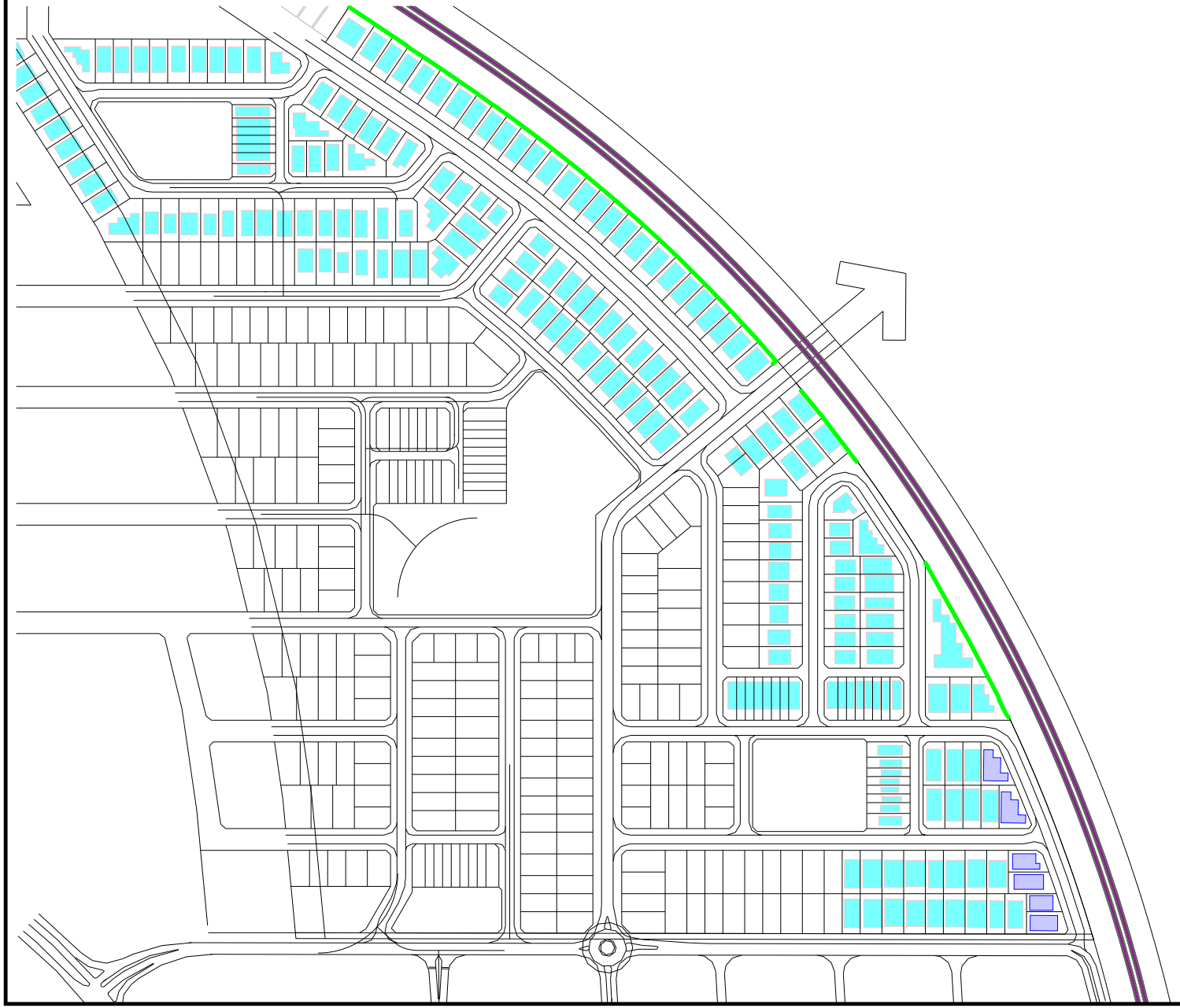
Lot 6, Taronga Place, Eglington - Assuming Noise Barrier Option B
Facade Treatment Required to Ground Floor

Figure 5-7



Signs and symbols

- Protection Not Req'd
- Package A
- Package B
- Package C
- Specialist Advice
- Wall

N

Scale

0 15 30 60 90 120 150 m

Lloyd George Acoustics
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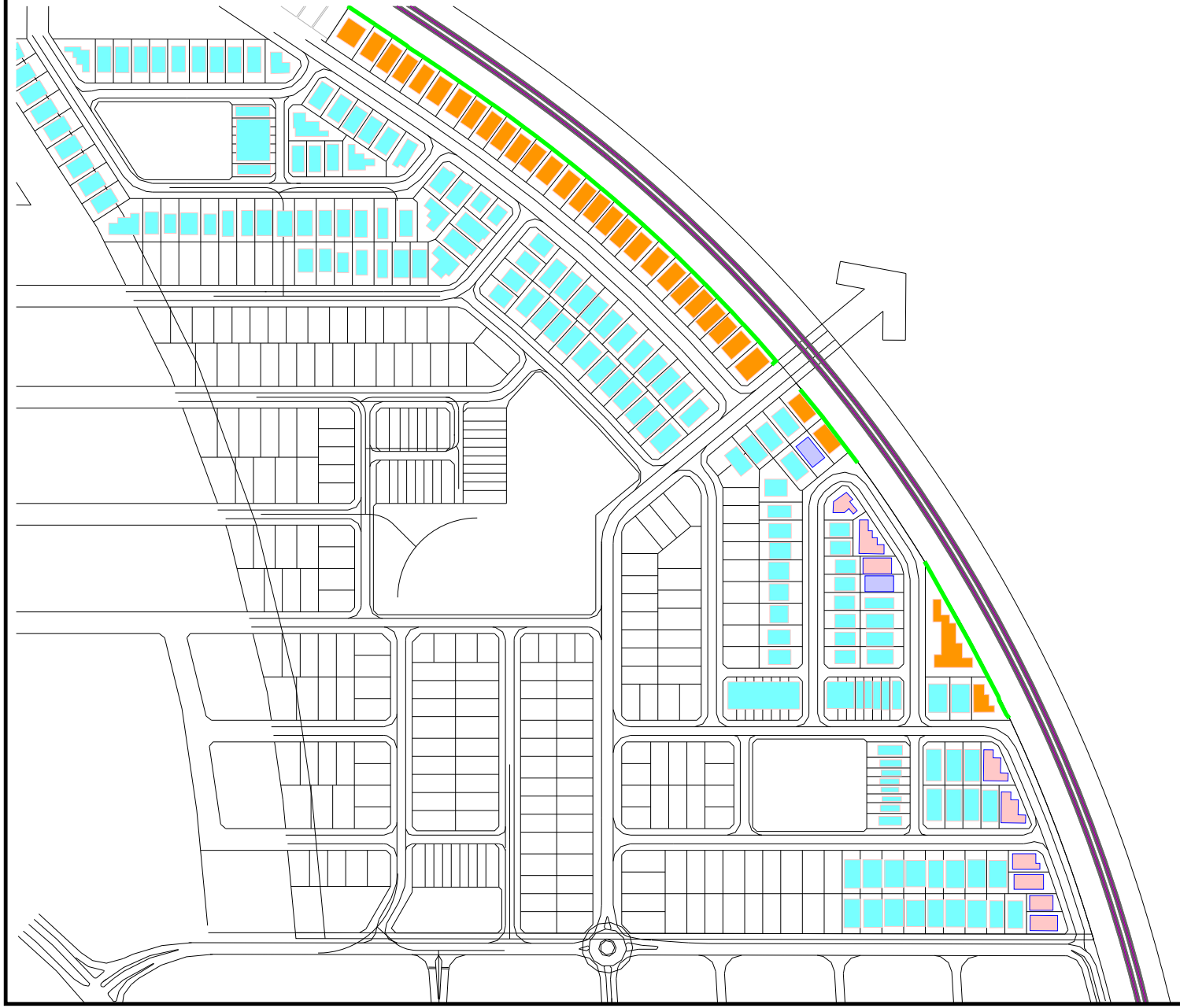
Lot 6, Taronga Place, Eglington - Assuming Noise Barrier Option B
Facade Treatment Required to Upper Floors

Figure 5-8



Signs and symbols

- Protection Not Req'd
- Package A
- Package B
- Package C
- Specialist Advice
- Wall

N

Scale

0 15 30 60 90 120 150 m

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6 GROUND-BORNE VIBRATION

Generally, vibration mitigation measures are required where houses are close to the rail reserve. It is our understanding that the PTA has committed to the use of ballast matting where the railway is close to residential developments as vibration isolation to residential premises is not generally a practicable solution. It is suggested that the Developer contact the PTA to ensure they are aware that the development would be close to their proposed railway.

7 CONCLUSION

The results of this assessment shows that for lots adjacent to the railway, the noise level is predicted to be above the Policy *target* criteria at some lots.

To satisfy the requirements of the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning*, the following is required:

- Implement noise mitigation as shown in *Figures 5-5 to 5-8*;
- For dwellings requiring facade packages, alternative treatment to the deemed to comply packages can be accepted if supported by a report by a suitable qualified acoustical engineer (member firm of the Association of Australian Acoustical Consultants);
- All affected lots on ground floor are to have notifications on lot titles as per the Policy requirements – refer *Appendix A*; and
- All affected lots are to provide one outdoor entertaining area where noise levels are below the *limit*.

Appendix A

DEEMED TO COMPLY FACADE PACKAGES

The packages and information provided on the following pages are taken from *Implementation Guidelines for State Planning Policy 5.4 Road and Rail Transport Noise and freight Considerations in Land Use Planning*; December 2014.

Where outdoor noise levels are above the ***target*** level, excluding the effect of any boundary fences, the Guidelines propose acceptable treatment packages that may be implemented without requiring detailed review. The packages are also intended for residential development only. At higher noise levels or for other building usages, specialist acoustic advice will be needed.

The acceptable treatment packages are intended to simplify compliance with the noise criteria, and the relevant package should be required as a condition of development in lieu of a detailed assessment.

Transition between each package should be made on the basis of the highest incident $L_{Aeq(Day)}$ or $L_{Aeq(Night)}$ value to the nearest whole number determined for the building development under assessment.

Any departures from the acceptable treatment specifications need to be supported by professional advice from a competent person that the proposal will achieve the requirements of the Policy.

With regards to the packages, the following definitions are provided:

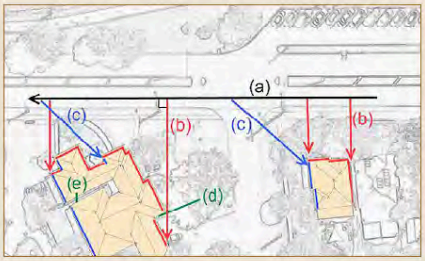
- **Facing** the transport corridor: Any part of a building façade is 'facing' the transport corridor if any straight line drawn perpendicular to its nearest road lane or railway line intersects that part of the façade without obstruction (ignoring any fence).

- **Side-on** to transport corridor: Any part of a building façade that is not 'facing' is 'side-on' to the transport corridor if any straight line can be drawn from it to intersect the nearest road lane or railway line without obstruction (ignoring any fence).

- **Opposite** to transport corridor: Neither 'side on' nor 'facing', as defined above.

Determining building face orientation

The following sketch shows two residences in proximity to a road.



'Facing' façades are identified by drawing straight lines (b) perpendicular (at a 90 degree angle) to the road (a). Where these lines intersect a façade – without obstruction – the façades are shown in red as 'facing' the road.

Façades shown in blue are not 'facing' but have clear lines (c) that intersect the road at any angle, and are therefore classed as 'side on' to the road.

The remaining façades are 'opposite' to the road.

Package A

Area	Orientation to Road or Rail Corridor	Package A (up to 60 dB $L_{Aeq(Day)}$ and 55 dB $L_{Aeq(Night)}$)
Bedrooms	Facing	• Windows systems: Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 28) – 6mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings.
	Side	• Windows systems: As above.
	Opposite	No requirements
Other Habitable Rooms Including Kitchens	Facing	• Windows and external door systems: Glazing up to 60% of floor area (minimum $R_w + C_{tr}$ 28) – 6mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings. Doors to be either 35mm thick solid timber core door with full perimeter acoustic seals. Glazed inserts to match the above. Sliding glass doors to be same performance including brush seals.
	Side	• Windows and external door systems: As above.
	Opposite	No requirements
General	Any	• Walls (minimum $R_w + C_{tr}$ 45) – Two leaves of 90mm thick brick with minimum 50mm cavity • Roof and ceiling (minimum $R_w + C_{tr}$ 35) – Standard roof construction with 10mm plasterboard ceiling and minimum R2.5 insulation between ceiling joists. • Eaves to be closed using 4mm compressed fibre cement sheet. • Mechanical ventilation – Refer following pages.
Outdoor Living Area		• Boundary wall to be minimum 2m high; or • Locate on the side of the building that is opposite to the corridor; or • Locate within alcove area so that the house shields it from corridor.

Note: Any penetrations in a part of the building envelope must be acoustically treated so as to not downgrade the performance of the building elements affected. Most penetrations in external walls such as pipes, cables or ducts can be sealed through caulking gaps with non-hardening mastic or suitable mortar.

Package B

Area	Orientation to Road or Rail Corridor	Package B (up to 63 dB $L_{Aeq(Day)}$ and 58 dB $L_{Aeq(Night)}$)
Bedrooms	Facing	• Windows systems: Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 31) – 10mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings.
	Side	• Windows systems: As above.
	Opposite	• Windows systems: Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 25) – 4mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings. Alternatively, 6mm thick glass (monolithic, toughened or laminated) in sliding frame.
Other Habitable Rooms Including Kitchens	Facing	• Windows and external door systems: Glazing up to 60% of floor area (minimum $R_w + C_{tr}$ 31) – 10mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings. Doors to be either 35mm thick solid timber core door with full perimeter acoustic seals. Glazed inserts to match the above. Sliding glass doors to have laboratory certificate confirming $R_w + C_{tr}$ 31 performance. Alternative, change to hinged door with perimeter acoustic seals and 10mm thick glass.
	Side	• Windows and external door systems: Glazing up to 60% of floor area (minimum $R_w + C_{tr}$ 28) – 6mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings. Doors to be either 35mm thick solid timber core door with full perimeter acoustic seals. Glazed inserts to match the above. Sliding glass doors to be same performance including brush seals.
	Opposite	No requirements
General	Any	• Walls (minimum $R_w + C_{tr}$ 50) – Two leaves of 90mm thick brick with minimum 50mm cavity. Cavity to include 50mm thick insulation and where wall ties are required, these are to be anti-vibration/resilient type. • Roof and ceiling (minimum $R_w + C_{tr}$ 35) – Standard roof construction with 10mm plasterboard ceiling and minimum R2.5 insulation between ceiling joists. • Eaves to be closed using 4mm thick compressed fibre cement sheet. • Mechanical ventilation – Refer following pages.
Outdoor Living Area		• Boundary wall to be minimum 2.4m high; or • Locate on the side of the building that is opposite to the corridor; or • Locate within alcove area so that the house shields it from corridor.

Note: Any penetrations in a part of the building envelope must be acoustically treated so as to not downgrade the performance of the building elements affected. Most penetrations in external walls such as pipes, cables or ducts can be sealed through caulking gaps with non-hardening mastic or suitable mortar.

Package C

Area	Orientation to Road or Rail Corridor	Package C (up to 65 dB $L_{Aeq(Day)}$ and 60 dB $L_{Aeq(Night)}$)
Bedrooms	Facing	• Windows systems: Glazing up to 20% of floor area (minimum $R_w + C_{tr}$ 31) – 10mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings.
	Side	• Windows systems: • Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 31) – 10mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings.
	Opposite	• Windows systems: Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 28) – 6mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings.
Other Habitable Rooms Including Kitchens	Facing	• Windows and external door systems: Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 31) – 10mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings. Doors to be either 35mm thick solid timber core door with full perimeter acoustic seals. Glazed inserts to match the above. Sliding glass doors to have laboratory certificate confirming $R_w + C_{tr}$ 31 performance. Alternative, change to hinged door with perimeter acoustic seals and 10mm thick glass.
	Side	• Windows and external door systems: Glazing up to 60% of floor area (minimum $R_w + C_{tr}$ 31) – 10mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings. Doors to be either 35mm thick solid timber core door with full perimeter acoustic seals. Glazed inserts to match the above. Sliding glass doors to have laboratory certificate confirming $R_w + C_{tr}$ 31 performance. Alternative, change to hinged door with perimeter acoustic seals and 10mm thick glass.
	Opposite	• Windows systems: Glazing up to 60% of floor area (minimum $R_w + C_{tr}$ 28) – 6mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings.
General	Any	• Walls (minimum $R_w + C_{tr}$ 50) – Two leaves of 90mm thick brick with minimum 50mm cavity. Cavity to include 50mm thick insulation and where wall ties are required, these are to be anti-vibration/resilient type. • Roof and ceiling (minimum $R_w + C_{tr}$ 40) – Standard roof construction with 2 x 10mm plasterboard ceiling and minimum R3.0 insulation between ceiling joists. • Eaves to be closed using 6mm thick compressed fibre cement sheet. • Mechanical ventilation – Refer following pages.
Outdoor Living Area		• Locate on the side of the building that is opposite to the corridor; or • Locate within alcove area so that the house shields it from corridor.

Note: Any penetrations in a part of the building envelope must be acoustically treated so as to not downgrade the performance of the building elements affected. Most penetrations in external walls such as pipes, cables or ducts can be sealed through caulking gaps with non-hardening mastic or suitable mortar.

Mechanical Ventilation requirements

It is noted that natural ventilation must be provided in accordance with F4.6 and F4.7 of Volume One and 3.8.5.2 of Volume Two of the National Construction Code. Where the noise *limit* is likely to be exceeded, a mechanical ventilation system is usually required. Mechanical ventilation systems will need to comply with AS 1668.2 – *The use of mechanical ventilation and air-conditioning in buildings*.

In implementing the acceptable treatment packages, the following must be observed:

- Evaporative air conditioning systems will meet the requirements for Packages A and B provided attenuated air vents are provided in the ceiling space and designed so that windows do not need to be opened.
- Refrigerant based air conditioning systems need to be designed to achieve fresh air ventilation requirements.
- External openings (e.g. air inlets, vents) need to be positioned facing away from the transport corridor where practicable.
- Ductwork needs to be provided with adequate silencing to prevent noise intrusion.

Notification

Notifications on certificates of title and advice to prospective purchasers warning of the potential for noise impacts from major transport corridors help with managing expectations.

The area of land for which notification is required should be identified in the noise management plan and contain a description of major noise sources nearby (e.g. 24-hour freight rail).

Notification should be provided to prospective purchasers, and required as a condition of subdivision (including strata subdivision) for the purposes of noise sensitive development or planning approval involving noise sensitive development, where external noise levels are forecast or estimated to exceed the 'target' criteria as defined by the Policy.

In the case of subdivision and development, conditions of approval should include a requirement for registration of a notice on title, which is provided for under Section 165 of the Planning and Development Act 2005 and Section 70A of the Transfer of Land Act 1893. An example of a suitable notice is:

Notice: This lot is situated in the vicinity of a transport corridor and is currently affected, or may in the future be affected, by transport noise. Transportation noise controls and Quiet House design strategies at potential cost to the owner may be required to achieve an acceptable level of noise reduction. Further information is available on request from the relevant local government offices.

Appendix B

Terminology

The following is an explanation of the terminology used throughout this report.

Decibel (dB)

The decibel is the unit that describes the sound pressure and sound power levels of a noise source. It is a logarithmic scale referenced to the threshold of hearing.

A-Weighting

An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound level is described as L_A dB.

L_1

An L_1 level is the noise level which is exceeded for 1 per cent of the measurement period and is considered to represent the average of the maximum noise levels measured.

L_{10}

An L_{10} level is the noise level which is exceeded for 10 per cent of the measurement period and is considered to represent the "*intrusive*" noise level.

L_{90}

An L_{90} level is the noise level which is exceeded for 90 per cent of the measurement period and is considered to represent the "*background*" noise level.

L_{eq}

The L_{eq} level represents the average noise energy during a measurement period.

$L_{A10,18hour}$

The $L_{A10,18\ hour}$ level is the arithmetic average of the hourly L_{A10} levels between 6.00 am and midnight. The *CoRTN* algorithms were developed to calculate this parameter.

$L_{Aeq,24hour}$

The $L_{Aeq,24\ hour}$ level is the logarithmic average of the hourly L_{Aeq} levels for a full day (from midnight to midnight).

$L_{Aeq,8hour}$ / $L_{Aeq\ (Night)}$

The $L_{Aeq\ (Night)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 10.00 pm to 6.00 am on the same day.

$L_{Aeq,16hour}$ / $L_{Aeq\ (Day)}$

The $L_{Aeq\ (Day)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 6.00 am to 10.00 pm on the same day. This value is typically 1-3 dB less than the $L_{A10,18hour}$.

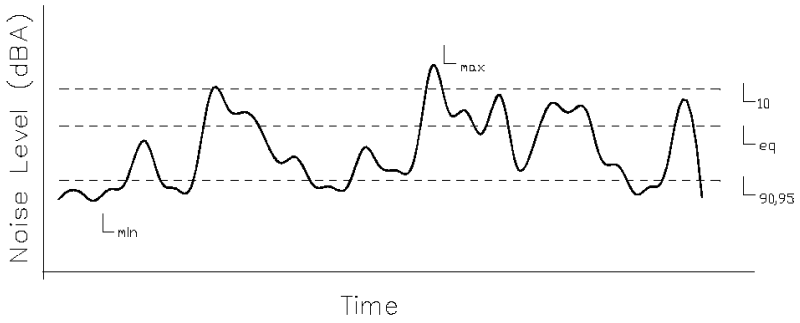
Satisfactory Design Sound Level

The level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive.

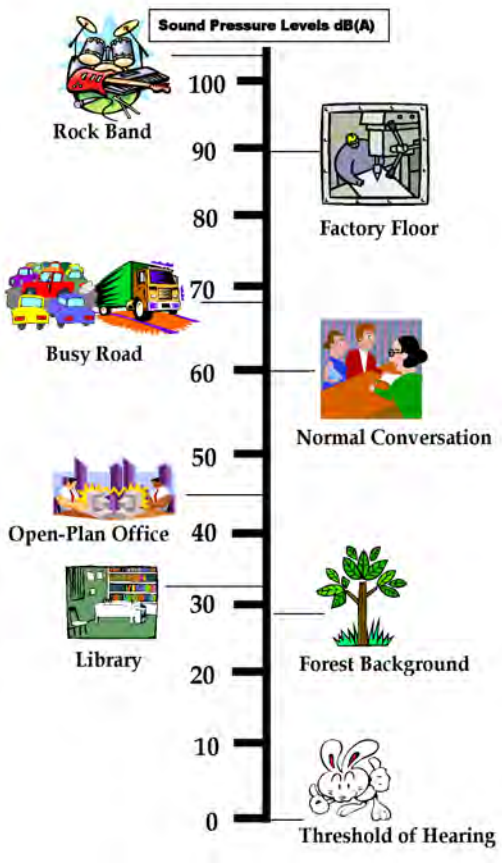
Maximum Design Sound Level

The level of noise above which most people occupying the space start to become dissatisfied with the level of noise.

Chart of Noise Level Descriptors



Typical Noise Levels



APPENDIX 8

Engineering Report (Cossill & Webley)

Cossill & Webley
CONSULTING ENGINEERS

LOCAL STRUCTURE PLAN REPORT
LOT 6 TARONGA PLACE, EGLINTON
March 2017

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CONTENTS

1. EXECUTIVE SUMMARY

This report has been prepared by Cossill & Webley Pty Ltd (CW) for the Lot 6 Taronga Place, Eglinton Local Structure Plan (Lot 6 LSP1). It summarises the results of a review of the civil engineering aspects which have informed and support the delivery of the structure plan and are related to the future servicing of the developed land.

This report provides details on each major infrastructure type and a servicing strategy for the implementation required for the development of the LSP area. The level of detail provided is consistent with the requirements of a Local Structure Plan, and acknowledges further detailed work will be required at the time of subdivision.

The engineering review has covered siteworks, roadworks, stormwater drainage, sewerage, water supply and utility services.

The investigation has found the land is capable of supporting development in accordance with the proposed Local Structure Plan with a logical progressive extension of infrastructure and base capacity.

The existing ground conditions and past land uses will not limit the proposed urban development.

Road access to the development will be via the existing Bluewater Drive to the south, which connects to Marmion Avenue to the west. This will provide the development with road access to the external arterial road system.

Sewer infrastructure will be provided via a connection to the existing sewer reticulation south of Bluewater Drive which grades to the existing Alkimos Waste Water Pump Station No 59, which ultimately pumps sewage to the Alkimos Waste Water Treatment Plant south-west of the site.

Water supply will be provided via an extension of the existing water reticulation network in Bluewater Drive.

Initial power supply can be provided by extension of the existing high voltage HV underground infrastructure in Marmion Avenue from the Romeo Road (Yanchep) Zoned Substation. It is likely within approximately ten years (subject to individual dwelling loads and rate of development) the capacity of the Romeo Road (Yanchep) Zoned Substation will be exceeded and a new substation will be required to be constructed in Eglinton as planned through the Alkimos Eglinton District Structure Plan.

Telecommunications and gas are available from existing services in Marmion Avenue. We understand there is capacity in the existing network to service the proposed development.

The investigations and preparation of this report is largely based on preliminary advice from the various service authorities. The information is current as of December 2016 and is subject to change as development proceeds in the Perth north-west corridor resulting in the extension of service infrastructure and the creation of new capacity.

2. INTRODUCTION

This report has been prepared by Cossill & Webley Pty Ltd (CW) for the Lot 6 Taronga Place, Eglinton Local Structure Plan (Lot 6 LSP1). It summarises the results of a review of the civil engineering issues which have influenced the form of the structure plan and which are related to the future servicing of the developed land.

The preparation of the Lot 6 Taronga Place, Eglinton Local Structure Plan (Lot 6 LSP1) has been carried out by a team of consultants, led by CLE on behalf of Urban Quarter and covers an area of approximately 28 hectares which yields approximately 474 residential allotments.

The Lot 6 LSP1 area is identified by the red boundary presented below in

Figure 1.

Figure 1 - Site Plan (Google Maps 2016)

3. SITE DESCRIPTION

The Lot 6 LSP1 is situated within the City of Wanneroo, approximately 45 kilometres north of the Perth city centre. The Site is bound by Bluewater Drive to the south, rural property to the north, future urban development to the west and a proposed Rail Reserve to the east. Approximately 50% of the Site is covered with vegetation, which mostly consisting of shrubs and low lying bushes. The balance of the land is cleared of large vegetation, which was completed in 2008 under a clearing permit. *Figure 2* below refers.

Figure 2 – Aerial Photography (Nearmap 2015)

3.1 Acid Sulphate Soils

A desk top review of the Department of Environment and Conservation's ASS Risk Map for the North Metropolitan Region for potential acid sulphate soils (ASS) indicates the site has no known risk of ASS occurring within 3m of the natural soil surface (or deeper).

3.2 Existing Topography

The Site comprises undulating dunes ranging in elevation from a peak of 52m AHD to approximately 32m AHD near the southern interface with the Shorehaven development as presented in *Figure 3* below.

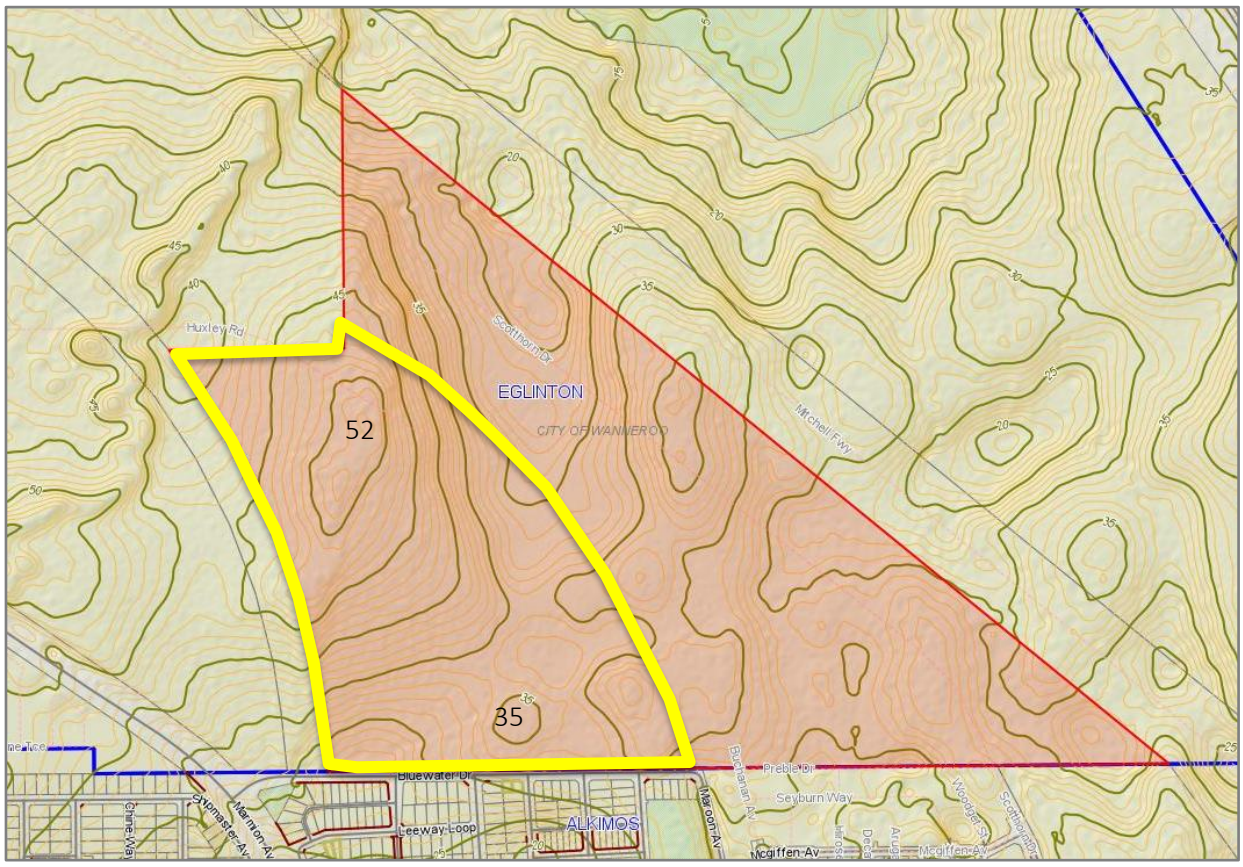


Figure 3 – Site Contours (City of Wanneroo Intramaps, 2016)

3.3 Geology and Landform

The Geological Survey of Western Australia Perth Metropolitan Region Soils Maps indicates the majority of the Site is generally characterised by Sand derived from Tamala Limestone (S_7) and Tamala Limestone as presented in *Figure 4* below.

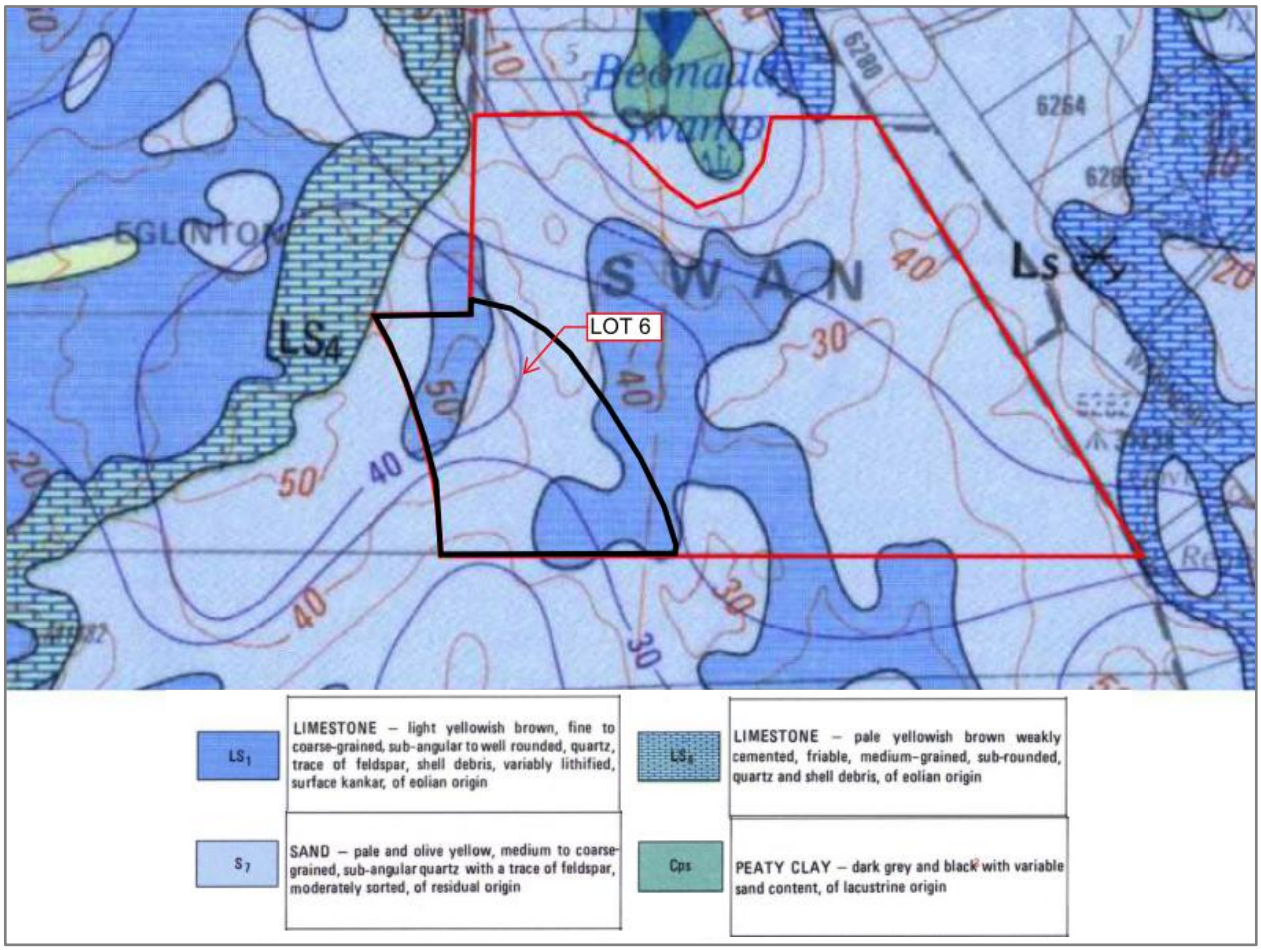


Figure 4 - Geotechnical Information (Geological Survey of WA)

Both of these soil types are well suited to urbanisation, and are generally very permeable, allowing for the on-site disposal of runoff from newly created roads and lots.

Although no detailed geotechnical investigation has been completed across the Site, it is anticipated that some surface rock will be present, predominately as cemented limestone along ridge lines within the existing dunes.

We anticipate, based on the above geological conditions, the majority of the Site will be Class A under the Australian Standard AS2870 – Residential Slabs and Footings code.

Based on our experience on similar projects within the area, the Site is well suited for future urban development in terms of topography and soils and will provide a suitable foundation for roads, infrastructure and residential development.

3.4 Karstic Formations

Karstic ground formations are known to occur in the limestone rock in a north-south band along the eastern side of

Wanneroo Road.

A visual inspection of the Site was undertaken by the Western Australian Speleological Group (WASG) in 2007 identifying surface karst, confirming the likely presence of subterranean voids.

Subsequently, CMW Geosciences were engaged to review the likely impact of karst formations on future development, and confirmed the eastern portion is likely to be within a recognised zone of potential karst features. *Figure 5* below presents the likely inferred western edge of a potential karst risk zone within the LSP area. CMW Geosciences has prepared a Preliminary Karst Landform Management Methodology report which describes the manner in which any karst identified within the Site can be treated, which is presented in Appendix B for information, and is discussed further in Section 4.2 below.

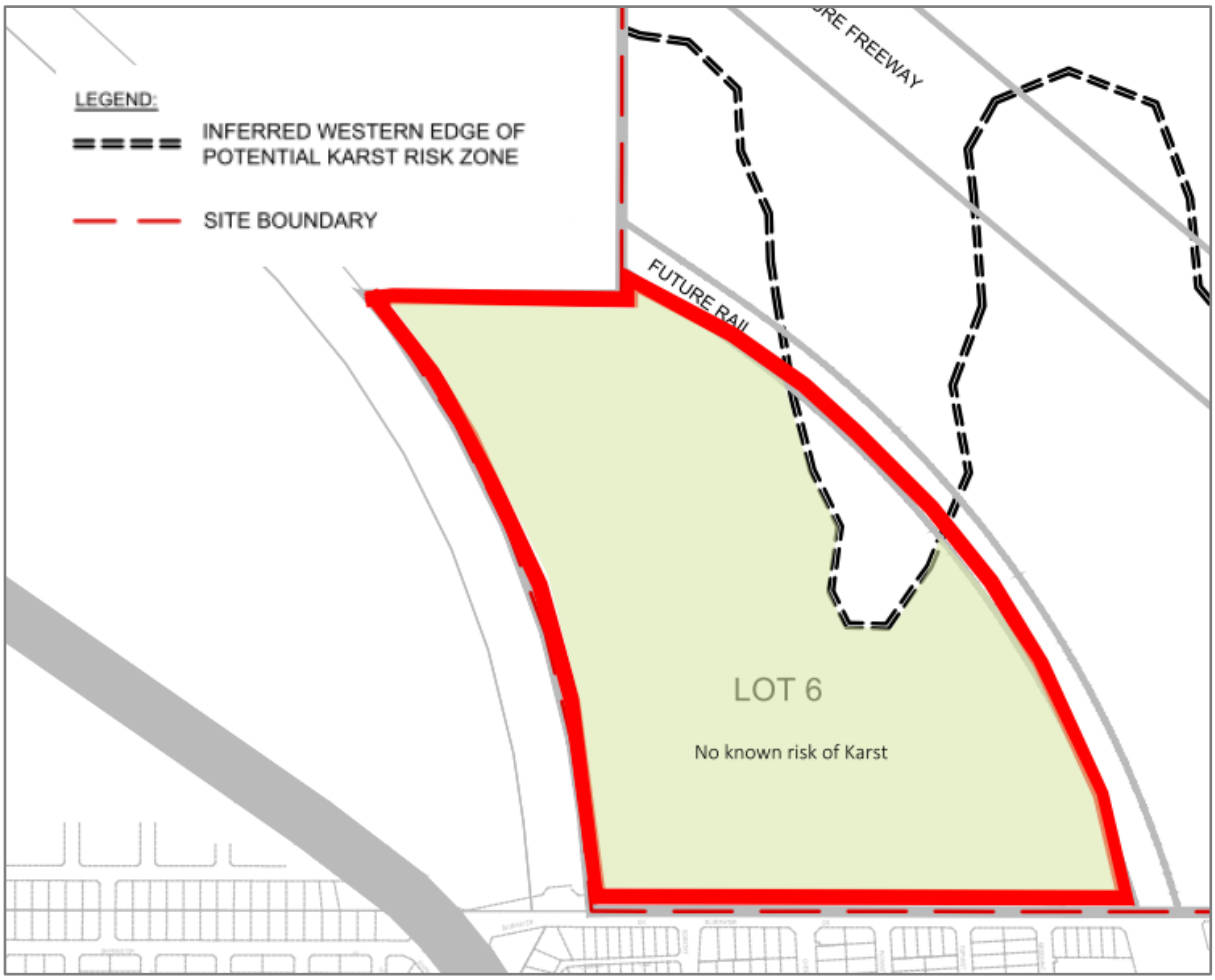


Figure 5: Inferred Potential Karst Risk Zone (CMW)

3.5 Unexploded Ordnance

The Department of Fire and Emergency Services (DFES) Unexploded Ordinance (UXO) has confirmed the Site lies within the north eastern portion of the former WWII Eglinton Training area where there may still be a slight risk from UXO contamination.

There are no known previous UXO assessments or survey over the Site, so whilst the risk from UXO is minimal, a limited UXO assessment survey (Field Validation Search @ 10% Coverage) is likely to be required as a condition of Subdivision to confirm or discount whether explosive filled munitions have impacted the Site. If no evidence is found, then the area can be regarded as at very low risk and no further assessment or survey will be required by DFES at or during any future planned subdivision works. The awarded Site Contractor will be required to consider

UXO in their Safety Management Plans.

3.6 Groundwater

The Annual Average Maximum Groundwater Level (AAMGL) varies from approximately RL 1.0m AHD on the western boundary to RL 1.5m AHD at the eastern boundary according to the Department of Water's Perth Groundwater Map. Given the natural ground levels across the Site provide at least 25 metres separation to groundwater, it is not anticipated that the proposed development will impact on groundwater adversely, nor will groundwater affect the design of the proposed development.

4. SITEWORKS & EARTHWORKS

4.1 Typical Earthwork Strategy

Siteworks for urban development typically comprise the clearing of existing vegetation and, where necessary, the earthworking of existing ground to facilitate future development.

In Perth it is often the case that the extent of siteworks is dictated by the density and nature of development and by the finished ground shape required for building houses. Increased densities and decreasing lot sizes has led to a current trend for the development areas to be fully earthworked to create level lots which are terraced utilising inter-allotment retaining walls.

This approach provides a number of positive outcomes:

- It reduces house building costs.
- It rationalises retaining wall layouts and designs consistent with Local Authority specifications.
- It enables lots to be terraced up natural slopes to maintain elevation and views.

The Lot 6 LSP1 has been designed in accordance with the following objectives:

- To maximise the preservation of the significant topographic features.
- To allow for roads and development sites to be graded to best follow the existing topography and to best reflect the coastal landscape.
- To allow for the retention of some existing vegetation and topography within the designated open space.

A preliminary earthworks design has been prepared for the Lot 6 LSP1 area and is presented in Appendix A in Drawing 5826-00-SK07. This design generally allows for the retention of vegetation within the central public open space, minimal interface batters with the adjoining western and northern boundaries, tying into existing levels on Bluewater Drive to the south and maintaining an average of 2 metres separation to the proposed rail design levels to optimise noise considerations.

4.2 Mitigation of Karst Risk

Historically, subterranean void failure usually occurs in karst risk zones when there is a concentration of water in one location above a subterranean void. If water is concentrated near a void, this can cause soil to migrate into the void leading to a collapse at the surface.

Advice from CMW Geosciences confirms the risk of karst collapse is negligible within the Karst Risk zone in areas of deep fill (greater than 10 metres), as the placement and compaction of sand layers will disperse any water discharged through soakwells or detention basins and provide a bridge of compacted ground that will attenuate surface settlements due to the potential loss of ground/collapse at depth. CMW advised that subterranean void collapses are most likely in areas where the existing natural thickness of sand overlying limestone is in the order of 5 metres.

In these areas, CMW's preliminary assessment recommends the following treatment to mitigate the karst risk:

- Any exposed fissures should be over-excavated and backfilled in accordance with the geotechnical engineer's requirements;
- During cut-to-fill earthworks, areas in excess of 10m fill require no further mitigation, as the material above potential karst features will form an adequate raft to spread loads and dissipate stormwater infiltration;
- Areas of fill up to 3m thick should include a 2m thick crushed limestone layer to act as a stiffened raft/geogrid layer in addition to attenuating concentrated stormwater inflows from the surface;
- Areas of fill less than 3m thick or areas of cut should be over-excavated to 3m below finished design levels, and backfilled to incorporate a 2m thick crushed limestone layer as described above; and
- Further geotechnical investigations such as EFCPT probes should be undertaken upon completion to assess the presence of karst features at an inter-allotment scale prior to development.

5. DRAINAGE STRATEGY

5.1 Integrated Urban Water Management

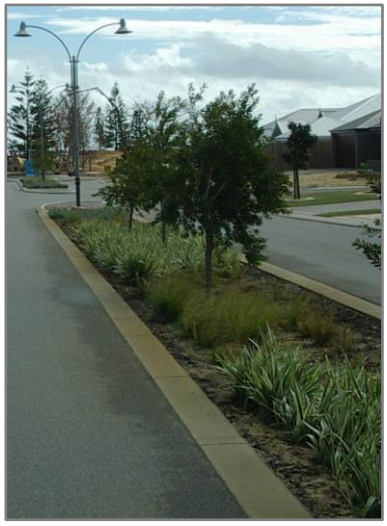
The Lot 6 LSP 1 Taronga Place, Eglinton Local Water Management Strategy (LWMS) has been prepared by Cossill & Webley as a separate document. This provides a basis for ongoing development to ensure that appropriate allowances are made for total water management including the minimisation of scheme water use and the maximisation of recharge of stormwater runoff.

Stormwater drainage management is proposed by adopting a Water Sensitive Urban Design (WSUD) approach. Objectives of WSUD include:

- Detention of stormwater rather than rapid conveyance;
- Use of stormwater to conserve potable water;
- Use of vegetation for filtering purposes; and
- Water efficient landscaping.

For the Lot 6 LSP1, the main WSUD practices which should be incorporated into the ongoing implementation of the site as follows:

1.5.1 Stormwater Management



Stormwater recharge of the shallow aquifer should be maximised through the adoption of 'Best Management Practices', which promote the dispersion and infiltration of runoff. These include the use of porous paving for roads and car parks, the diversion of runoff into road medians and road-side swales, drainage soakwells to infiltrate runoff from buildings and private open space areas and the disposal of road runoff into infiltration basins within areas of public open space POS.

1.5.2 Water Quality Management

The maximisation of the quality of recharge water through the adoption of "Best Management Practices", which promote the disposal of runoff via water pollution control facilities (including vegetated swales and basins, detention storage and gross pollutant traps) and the implementation of non-structural source controls (including urban design, street sweeping, community education, low fertiliser landscaping regimes, etc.).

5.2 Stormwater Collection and Management

The Lot 6 LSP1 land consists of free draining sand with substantial cover to the prevailing groundwater. Overall, therefore, the land is highly suited to the implementation of the WSUD management practices outlined above.

It is anticipated that runoff within future residential allotments will be contained on-site. Stormwater disposal will be via soakwells or other infiltration facilities which form part of the building and private open space development.

Drainage from public roads and lanes can be managed in a number of ways depending on the nature of the adjacent land uses, the extent of traffic and pedestrians and the objectives for drainage management.

For the development of the Lot 6 LSP1 it is proposed to adopt the WSUD approach advocated by the Department of Water (DoW) to provide an improved environmental outcome. DOW's target of infiltrating storms up to 1 in 1 year ARI at source (dispersed throughout the drainage catchments) may however be difficult to economically achieve throughout the catchment where there are highly urbanised roads. Conservatively, CW has assumed some of the 1:1 year event will be conveyed to the local low points within public open space. Stormwater runoff will soak efficiently into the ground and return a significant proportion of the runoff to the unconfined aquifer.

Infiltration could also be via swales within or adjacent to road reserves, via gully pits with permeable bases, slotted drainage pipes, porous road pavements or under road storages subject to the City of Wanneroo approval.

Runoff from storms up to 1 in 5 years ARI would be conveyed via an underground pipe system to low point infiltration basins consistent with the requirements of the City of Wanneroo.

Roads and POS will be designed to cater for the surface overflow for more severe storms with building pads constructed at least 300 millimetres above the 1 in 100 year ARI flood or storage level at any location.

The dispersion of stormwater disposal will maximise the area of recharge down through the soil profile to the shallow aquifer, thereby, maximising the potential for nutrient stripping and water quality improvements.

The LWMS details the stormwater drainage plan for the Lot 6 LSP1. The plan shows the approximate location of stormwater disposal sites based on a preliminary assessment of finished development levels.

The LWMS also includes tabulated data for areas required at each low point infiltration swale to cater for the 1 in 1 year, 1 in 5 year and 1 in 100 year ARI storms.

6. Roadworks & Footpaths

6.1 Traffic and Transportation

An assessment of the traffic and transport planning for the Lot 6 LSP1 has been undertaken by GTA.

The results of this assessment include a recommended hierarchy for the roads within the Lot 6 LSP1 and the future subdivision development together with recommendations for public transport services, pedestrian and cyclist facilities.

In all cases the engineering review has taken account of the recommendations outlined in the GTA Consultant report and they will be incorporated into future detailed subdivision planning and design.

6.2 Regional Roads

Road access to the Site is currently via Bluewater Drive, which connects onto Marmion Avenue west of the Site. The intersection of Bluewater Drive with Marmion Ave has been constructed as a full movement T-intersection, consistent with the City of Wanneroo's Marmion Ave Access Policy.

6.3 Development Roads

The Lot 6 LSP 1comprises a network of development roads including a Neighbourhood Connector running south-west to north-east, and local access roads and laneways. The Lot 6 LSP1 proposes an urban design hierarchy for the development roads, which is an expansion of the traffic hierarchy, to better reflect the intended functions of the roads and their corresponding streetscape characters.

In all cases the road cross-sections will be designed to cater for utility services, on standard verge alignments, street trees, parking embayments where appropriate, off-street and on-street cycling lanes in accordance with the overall pedestrian and cycling network.

The engineering design of roads will be carried out to comply with the Department of Planning's Liveable Neighbourhoods recommendations for design speeds and sight distances and with the requirements of the City of Wanneroo. Roadworks will generally consist of kerbed and asphalted pavements.

In particular, it is proposed that the development roads be designed to suit lower vehicle operating speeds to ensure safer operation and improved pedestrian movement. The lower speeds on local roads will also support initiatives to adopt smaller street truncations and associated intersection curve radii where suitable.

6.4 Footpaths

Footpaths will be provided in accordance with *Liveable Neighbourhoods* and the City of Wanneroo standards and will consist of one path in every road, and dual use paths in Neighbourhood Connector roads as outlined in the GTA Consultants Traffic Report accompanying the LSP.

6.5 Public Transport

The Alkimos Eglinton District Structure Plan Report (AE DSP) makes provision for the extension of the Perth Transit Authority's (PTA) northern corridor metropolitan railway network to the east of Marmion Ave. Preliminary planning proposes a station at the Eglinton District Centre north of Eglinton Drive.

The existing rail network has recently been extended to the new Butler railway station, with no known plans to extend the rail further north at this stage.

There is currently a bus service utilising Marmion Avenue to connect Yanchep – Two Rocks to destinations south of the site. The PTA is likely to develop additional bus services as the broader Eglinton area is occupied by residents and demand justifies the service.

The Alkimos Eglinton DSP makes provision for a 'Secondary Transit System' (STS) which is likely to comprise a high frequency bus service.

6.6 Noise Attenuation

The eastern boundary of the LSP area abuts the future northern corridor metropolitan railway extension, and hence in accordance with State Planning Policy 5.4 "Noise Considerations", Lloyd George has been engaged to prepare an Acoustic Report to assess the requirements for the site for transportation noise from the railway.

Some noise mitigation strategies will be required for these interfaces and could consist of noise bunds, noise walls, facade protection and/or in-house acoustic mitigation techniques.

7. WASTEWATER

The Site falls within the Water Corporation's Alkimos Sewer District as shown in *Figure 6* below.

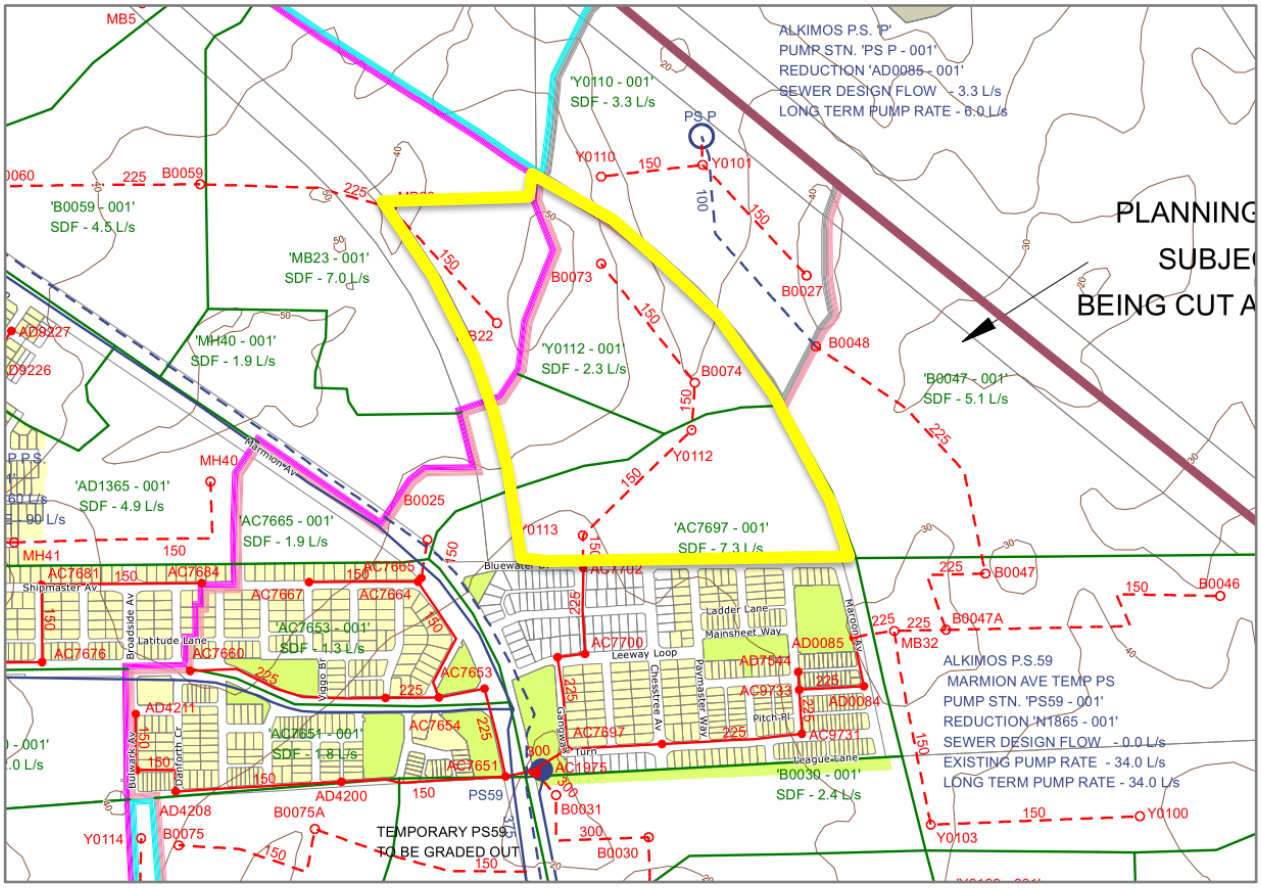


Figure 6 - Conceptual Long Term Wastewater Scheme Planning (Water Corporation, 2015)

Water Corporation planning indicates that the Site is to be serviced by a connection to the existing sewer reticulation network located in Bluewater Drive south of the Site. Sewage flows gravitate via this connection to the existing Alkimos WWPS (Waste Water Pumping Station) No 59, which ultimately discharges to the Alkimos Wastewater Treatment Plant (WWTP) located south west of the Site.

Standard Water Corporation sewerage headworks will apply.

8. WATER RETICULATION

8.1 Water Resources

The Alkimos Eglinton area has been identified by the Water Corporation as a future ground water source for potable water supply. Provision has been made for some time for the development of this ground water resource.

Water supply to the area will ultimately be via a series of groundwater bores, located throughout the Alkimos Eglinton area, linked by collector water mains to a central treatment plant and reservoir.

Current Water Corporation planning includes provision for a future superficial aquifer bore (EG 60) located at a proposed future primary school site as indicated below in *Figure 7*. This bore will have a well head protection of 300 metres restricting land uses as per the Department of Water's P3 ground water protection zones; which generally limits placement of sensitive land uses (eg petrol stations) within the buffer. There may also be a noise buffer requirement of approximately 35 metres limiting land uses or requiring some form of noise mitigation.

Detailed negotiations will be required with the Water Corporation at the time of subdivision will be required to ensure suitable provision for production bores and land requirements is made. The exact locations of any potential bores will depend on final planning and design work to be undertaken by the Water Corporation.

Figure 7 – Eglinton Groundwater Scheme (Water Corporation, 2015)

8.2 Initial Water Supply Network

The Water Corporation has constructed a DN700 trunk water main in Marmion Avenue to Shorehaven Boulevard. On this basis, it is anticipated there will be no off-site water headwork infrastructure required to service the development.

It is anticipated the initial stages can be supplied with water via the existing DN200 water main stub at the southern boundary of the Site. Areas of urban development will be serviced by a network of distribution water mains, from the reservoir, connected to the reticulation network.

8.3 Ultimate Water Supply Network

The Water Corporation has long term distribution network planning that includes the construction of a DN900 water main in Romeo Road (Alkimos City Centre), linking a DN1200 main in east Romeo Road with the other trunk distribution mains south into Butler.

The Water Corporation has reviewed the latest date the trunk water main in Romeo Road is required. The timing for this main had previously been estimated to coincide with approximately 8,000 to 10,000 allotments in the Alkimos Eglinton area, when the security of supply and capacity of the single Marmion Avenue trunk main would require augmentation. Water Corporation has advised the DN900 in Romeo Road is required to be designed and built prior to 2017/18 such that it can be completed for commissioning in 2018/19 at the latest.

The balance of the trunk water main network will be progressively expanded by the Water Corporation directly or through Developer Constructed Works with negotiated pre-funding arrangements. The Water Corporation is currently planning to fund capital works associated with the orderly development of urban areas without prefunding by the developers.

9. GAS SUPPLY

The existing high pressure gas network has recently been extended in Marmion Ave from Butler to Yanchep by Atco Gas. Atco has confirmed this main will have capacity for development in the Butler, Jindalee, Alkimos and Eglinton areas. Therefore we do not anticipate there will be any gas supply capacity issues.

Gas reticulation will be supplied and funded by Atco Gas and installed by the Contractor concurrent with other service installation.

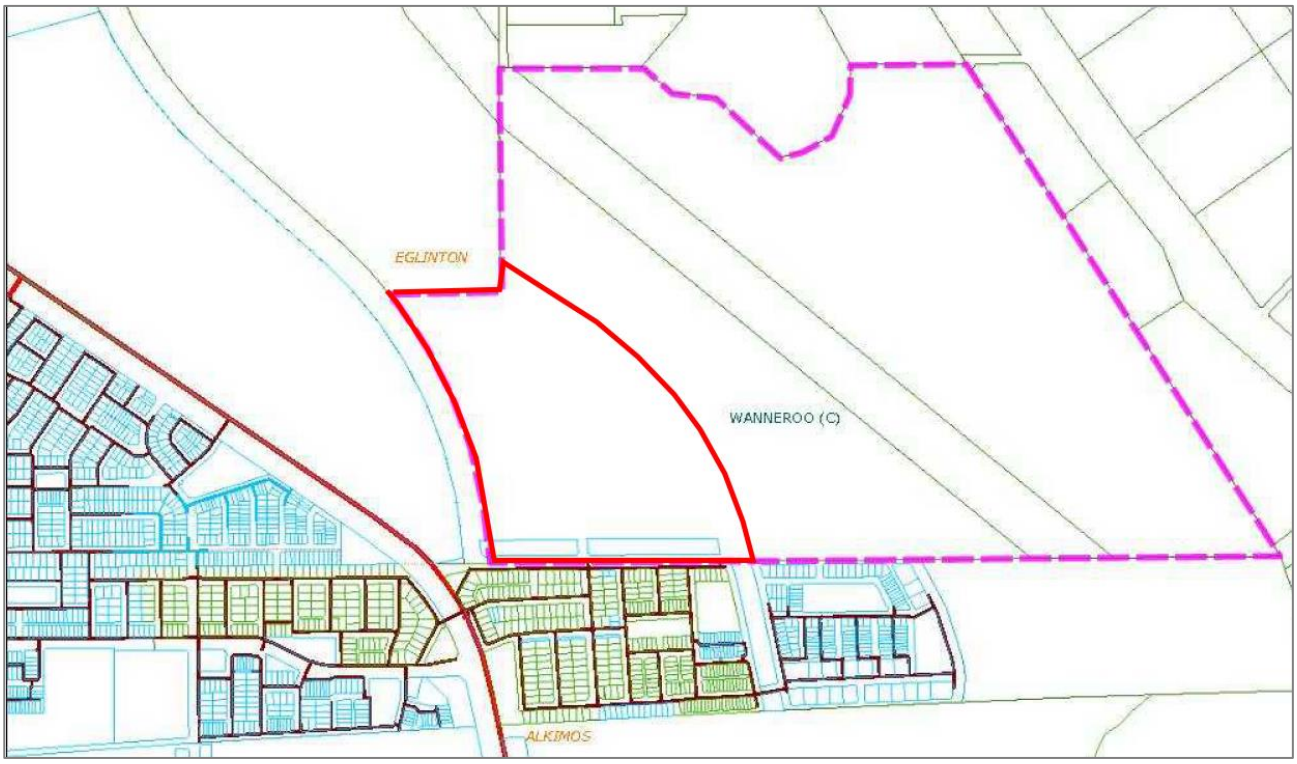


Figure 8 – Extent of Existing Gas Network (Atco Gas, 2016)

10. ELECTRICAL POWER SUPPLY

10.1 Power Network

There is an existing 22kV high voltage underground power cable in Marmion Ave (eastern verge) which extends power from the existing "Yanchep Zone Substation" on Romeo Road south of Lot 6 to Yanchep. This same feed is currently used to supply Shorehaven, Amberton, Alkimos, Jindowee, Allara, Capricorn and Yanchep Golf Estate. This existing cable is approaching its capacity based on existing developments utilising this cable.

There is also an existing overhead power cable that runs from the Yanchep zone substation north in Wanneroo Road and west on Pipidinny Road as depicted below in Figure 9.

The Yanchep Zone Substation is located at the intersection of Romeo Road and Wanneroo Road and is a two transformer outdoor 132/22 kV zone substation with provision for a third transformer to be installed to service additional load in the surrounding areas, including the Alkimos Eglinton area.

It is expected that the new Eglinton zone substation (currently shown south of Eglinton Drive and between the Railway reserve and the Mitchell Freeway reserve but a site has not been acquired by Western Power) will need to be established to accommodate the growth of new and existing loads in the region. Due to factors such as changing energy use, more efficient appliances, and emerging technologies, the timing of the substation is uncertain and is expected to be beyond the next 10 years.

It is anticipated that the local network will be incrementally extended from the 22kV HV feed in Marmion Avenue into the Site. Western Power will also require interconnections to be made between the 22kV feeders on Wanneroo Road with the feeder on Marmion Ave which will entail a future freeway crossing.

A series of HV feeds, switch stations and transformers will be required throughout Lot 6 to meet individual site requirements.

Additional reinforcement of the power network by the developer of Lot 6 may be required, however, further details of the proposed load within the development are required to confirm this.

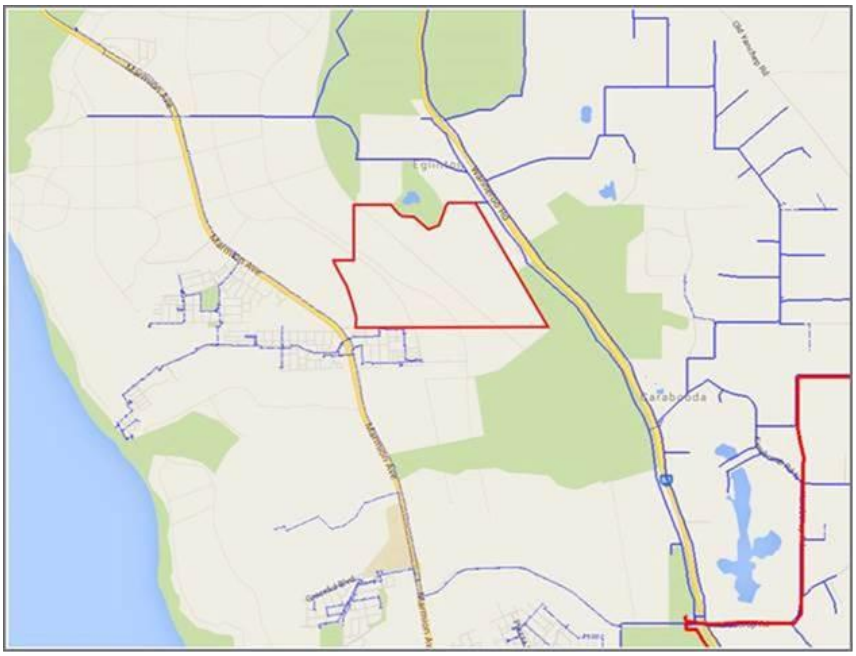


Figure 9 – Existing Overhead Powerlines (Western Power)

10.2 Future 132kV HV Feeder

Western Power has advised that an easement will be required to allow for the construction of a future 132kV overhead transmission line along the western boundary of the freeway east of the Site. The anticipated width of the power line corridor is 24 metres, however this may vary if Western Power confirm the detailed design requirements prior to construction of the subdivision. Western Power has no program for the installation of this line, and anticipate it could be some 15 to 20 years away at this stage.

11. TELECOMMUNICATIONS

The Site is within NBN's fixed line footprint, and hence can be serviced with optic fibre under their roll-out scheme for greenfield developments.

Under the Federal Government's Telecommunications in New Developments Policy, developers are responsible for contributing to the cost of delivering the NBN™ network in new developments. This includes contributing to part of the costs of the build (civils and any backhaul required) as well as a $600 per lot deployment change.

Through the NBN, the ownership issues of delivering the wholesale fibre to the home system have been transferred to the Government with more than 100 retail service providers offering services over the network. There are other private telecommunication providers that can also offer similar services.

Developers of new residential estates have the option to pay NBN or an alternative service provider for provision of a high speed broadband network. In either case the developer will install pit and pipe infrastructure that can accommodate a future high speed broadband network.

The current design practice for road reserves, pavement and verge provisions will make adequate allowance for services including broadband in accordance with the agreed Utilities Service Providers handbook. There will be some local land requirements for equipment sites, similar to current provisions which will be accommodated at detailed subdivision stage.

12. STAGING

The staging of subdivision and development will be heavily influenced by market forces. Whilst development staging is still to be refined, the following provides the basis for future decision-making:

- Land in the southwest corner of the site adjacent Bluewater drive is likely to be developed first, as that area is closest to available utilities;
- Subsequent staging will need to consider drainage and sewer catchments, providing connectivity through key access streets and the supply of neighbourhood amenity;
- Subdivision is expected to occur in 30-50 lot stages constructed towards the north and then progressively extending towards the eastern side of the Site.

13. CONCLUSION

The Lot 6 Taronga Place Eglinton Local Structure Plan 1 has planned strategies for water and sewerage supply and other public utility services are available or can be extended to service the proposed urban area.

There are no engineering impediments to the development, though co-ordination and co-operation with the relevant Service Authorities will be required as the development progresses.

Appendix A

Drawings

GENERAL NOTES

1. ALL LEVELS IN METRES TO AHD. EXISTING SURVEY BY AERIAL LIDAR SURVEY.
2. BATTERS TO EXISTING SURFACE AT 1:3 (CUT) 1:4 (FILL) UNLESS NOTED OTHERWISE.
3. BATTER POSITION FOR FUTURE WALLS TO ENSURE CUT TO FILL EARTHWORKS BALANCE.
4. ALL UNSUITABLE MATERIAL TO BE REMOVED BY THE CONTRACTOR TO APPROVED TIPPING SITE PRIOR TO COMMENCEMENT OF CONSTRUCTION. ALL FEES TO BE PAID BY CONTRACTOR.
5. EXTENT OF EARTHWORKS TO BE LIMITED TO THE EARTHWORKS STAGE BOUNDARY UNLESS AGREED WITH THE SUPERINTENDENT.
6. ALL CLEARED MATERIAL TO BE MULCHED AND STOCKPILED ON SITE WHERE INDICATED.
7. CONTRACTOR TO LOCATE ALL EXISTING SERVICES PRIOR TO COMMENCEMENT OF WORKS ON SITE.
8. CONTRACTOR TO GRADE EVENLY BETWEEN DESIGN CONTOURS AND MATCH INTO EXISTING SURFACE AT LIMIT OF EARTHWORKS BOUNDARY WHERE APPROPRIATE.
9. EXCESS CUT FROM EARTHWORKS SHALL BE PLACED ON SITE AS DIRECTED BY THE SUPERINTENDENT.
10. WHERE LIMESTONE IS WITHIN 600mm OF THE FINAL SURFACE LEVEL THE CONTRACTOR SHALL TREAT THE SITE IN ACCORDANCE WITH THE SPECIFICATION.
11. DESIGN LEVELS SHOWN SHALL BE ON THE FINISHED SURFACE INCLUDING TOPSOIL WHERE SPECIFIED.
12. THE CONTRACTOR SHALL LIMIT THE MOVEMENT OF EQUIPMENT AND MANPOWER TO THE MINIMUM AREA NECESSARY AND PROTECT ALL VEGETATION AND EXISTING SERVICES ON SITE.

LEGEND

- 37 — EXISTING CONTOUR
- 37 — DESIGN CONTOUR (1.0m)
- 36.5 — DESIGN CONTOUR (0.5m)
- 23.5 — DESIGN LOT LEVEL
- BUILDING SET BACK LINE
- PROPOSED RETAINING WALL
- EXISTING RETAINING WALL
- FUTURE RETAINING WALL
- EXTENT OF EXISTING CLEARING
- STAGE BOUNDARY
- 28.18 — PTA RAIL LEVELS
- 30.0 — EXISTING CONTOUR LEVELS

0m 40.0 80.0 120.0m
1:2000

REV	DATE	DRN	CKD	APP	AMENDMENT
F	01.03.17	DPM	-		SW SPLIT INTO TWO CATCHMENTS, NW CORNER AMENDED LAYOUT
E	17.02.17	DPM			ISSUED FOR COMMENT
D	07.02.17	DPM			ISSUED FOR COMMENT
C	17.01.17	DPM		R. TODD	LAYOUT AMENDED
B	16.12.16	DPM			PAD LEVELS ADDED
A	15.12.16	DPM			ISSUED FOR APPROVAL

Cossill & Webley CONSULTING ENGINEERS
Mailing Address: PO Box 680, Subiaco WA 6904
Street Address: B12 (Level 2) 431 Roberts Road, Subiaco WA 6008
T (08) 9422 5800 F (08) 9422 5801 E admin@cosweb.com.au

CLIENT: URBAN QUARTER
APPROVED: DPM
DESIGNED: DPM
SCALE: 1:2000
PROJECT: LOT 19 TARONGA PLACE, EGLINGTON
TITLE: EARTHWORKS CONCEPT PLAN
WAPC No.
DRAWING No.: 5826-00-SK07
REVISION: F
ORIGINAL SIZE: A1

Appendix B

CMW Preliminary Karst Landform Management Methodolgy

CMW Geosciences Pty Ltd
Chapman Morton Woodward

9 August 2016

LOT 19 TARONGA PLACE, CARABOODA

PRELIMINARY KARST LANDFORM MANAGEMENT METHODOLOGY

Urban Quarter WA

Ref. PER2016-0480AB Rev1

Unit 19 Wembley Green Offices,
127 Herdsman Parade, Wembley, WA 6014

www.cmwgeosciences.com

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Figures

Appendices

1 INTRODUCTION

This report outlines recommended development strategies to manage potential risks associated with karst landforms within Lot 19 Taronga Place, Carabooda. The work was commissioned by Mr Jason Wallis of Urban Quarter WA (Urban Quarter) on 2 August 2016.

It is understood that the 150ha site is proposed for urban development comprising a mixture of residential and commercial subdivision. The strategies in this report are aimed at providing an outline of tasks that will be performed as a precursor to development of a Karst Landform Management Strategy. It also outlines engineering design elements that can be adopted during construction of the subdivision in order to limit the risks associated with karst landforms to a level no greater than those acceptable for other developments on the Swan Coastal Plain. These strategies will be confirmed following detailed site investigations.

2 AVAILABLE INFORMATION

CMW has previously undertaken a desktop and reconnaissance study at the site. Information available for the previous study comprised the following:

- 1:50,000 scale geological mapping (Yanchep Sheet - 2034 IV) produced by the Geological Survey of Western Australia (GSWA) including 1:100,000 scale geomorphology mapping.
- A Western Australian Speleolgical Group field survey report dated 12 December 2007.
- Various project drawings including vegetation mapping, concept plan, existing ground surface contours and proposed finished levels.
- Observations of the site during a reconnaissance drive/walk over.

The available information has been incorporated with our experience of karst areas on the Swan Coastal Plain to allow consideration of development strategies with respect to potential karst ground conditions.

It is noted that the author has extensive knowledge and experience of urban development within areas of potential karst landform risk within the Swan Coastal Plain and has published technical papers on the subject including Mather P.J, 2013. Geotechnical Aspects of Karst within the Swan Coastal Plain, Western Australia. Australian Geomechanics, Vol. 48 No. 2, a copy of which is attached to this letter for reference.

3 DISCUSSION

The eastern part of the site is within a recognised zone of potential karst features as outlined by previous GSWA mapping. The location of the western extent of this potential karst zone has been slightly modified on the basis of local geomorphology observed during site reconnaissance. The inferred western extent of the potential karst zone is shown on the attached Figure 1. Within the areas west of the line shown in Figure 1, the risks associated with potential karst are considered to be very low and therefore can be managed by normal geotechnical investigation and design processes.

The hazards associated with development within areas of karst cannot be eliminated but geotechnical design strategies can be adopted to reduce and manage the risks to acceptable levels. The extent of remediation and modification of foundations to reduce the risk of karst is dependent on the severity of karst phenomenon and sensitivity of proposed development. By international standards karst occurrence on the Swan Coastal Plain is at the lower end of severity. Some internationally accepted design strategies to manage karst risk, in general order of increasing

severity, are as follows:

- Drainage control
- Grout/fill open fissures
- Stiffen footings (rafts or ground beams)
- Geogrids
- Driven piles to rock head
- Cap grouting at rock head
- Groundwater abstraction control
- Bored piles to rock head
- Combinations of the above techniques

The key trigger mechanisms for karst collapse on the Swan Coastal Plain is concentrated storm water runoff. The control and management of concentrated surface water discharge away from structures is considered to be the key factor in limiting the potential risks and impacts of sinkhole formation. Design recommendations for previous developments within karst areas of CoW (e.g. Lots 201 and 202 Breakwater Drive) have included the provision for domestic soak wells to be located no less than 10m from footings and road drainage basins to include a 30m development exclusion zone around their perimeter. Additional strategies that have been adopted locally include the stiffening of residential footings.

Other strategies that could be adopted to adequately reduce the risks in susceptible areas include large scale earthworks involving over excavation and replacement with a 2m thick layer of crushed limestone covered with a 1m thick surface layer of free draining sand. The 2m thick layer of compacted crushed limestone will act as a stiffened raft/geogrid layer in addition to attenuating concentrated stormwater inflows from the surface.

4 PROPOSED MEASURES TO MANAGE KARST

Subject to further, more detailed investigations, we believe the following measures or combination of measures would reduce the karst risk associated with this site to equal or less than that associated with other developments on the Swan Coastal Plain:

- Any exposed fissures should be over-excavated and backfilled in accordance with the geotechnical engineer's requirements;
- During cut-to-fill earthworks, areas in excess of 10m fill require no further mitigation, as the material above potential karst features will form an adequate raft to spread loads and dissipate stormwater infiltration;
- Areas of fill up to 3m thick should include a 2m thick crushed limestone layer as described in Section 3 above;
- Areas of fill less than 3m thick or areas of cut should be over-excavated to 3m below finished design levels, and backfilled to incorporate a 2m thick crushed limestone layer as described in Section 3 above; and,
- Further geotechnical investigations such as EFCPT probes should be undertaken upon completion to assess the presence of karst features at an inter-allotment scale prior to development

Some variation to the excavation and replacement option outlined above is likely to be appropriate based on the anticipated range of ground conditions. For example, in areas of cut which expose a limestone surface that is free of any indication of voids, the required thickness of crushed limestone could be reduced to 1m. Other variations such as backfilling exposed voids and heavy compaction of loose sand zones prior to fill placement may be appropriate depending on the local ground conditions and thickness of fill prosed within specific areas.

Prior to development, further geotechnical site investigation will be required to assess the extent of potential karst risk within the site and refine appropriate remediation options for urban development. It is likely that the results of detailed investigation will identify significant areas of very low risk within the potential karst risk zone, allowing remedial options to be targeted towards areas of higher potential risk.

It is anticipated that the adoption of a range of engineering design strategies as outlined above, targeted across the site on the basis of further detailed geotechnical investigation will result in the reduction of risks associated with karst to a level compatible with development outside of karst areas.

5 SUMMARY

Lot 19 Taronga Place, Carabooda is located partially across an area of the Swan Coastal Plain which has the potential for karst landforms. By international standards the karst risk is relatively low but will need to be addressed as part of the urban residential and commercial development proposed at the site. A range of engineering strategies are available to limit the risks associated with karst. Information obtained from further detailed geotechnical site investigation across the site can be incorporated into an assessment of suitable risk reduction strategies. Appropriate strategies will vary across the site depending on the severity of the ground conditions and proposed land uses. The aim of the design modifications will be to limit the risks associated with development at this site to those applicable to other developments on the Swan Coastal Plain that are outside the zone of potential karst.

6 CLOSURE

We trust this report meets your current project requirements. If you have any queries or require additional information please contact the undersigned.

For and on behalf of
CMW Geosciences Pty Ltd

Philip Mather

Principal

Distribution: 1 copy to Urban Quarter WA (electronic) Original held by CMW Geosciences Pty Ltd

Figures

LEGEND:

INFERRED WESTERN EDGE OF POTENTIAL KARST RISK ZONE

SITE BOUNDARY

NOTES:

1. BASE PLAN ADAPTED FROM: ROBERTS DAY CONCEPT PLAN, DRAWING NO. RD1 016, REV A, DATED 29.06.15

1:7500 0 75 150 225 300 375 m

CMW Geosciences Pty Ltd
Chapman Morton Woodward

CLIENT: URBAN QUARTER WA		DRAWN: DE	PROJECT: PER2016-0780
PROJECT: LOT 19 TARONGA PLACE, CARABOODA, WA		CHECKED: PJM	FIGURE: 01
		REVISION: 0	SCALE: 1:7500
TITLE: PRELIMINARY KARST LANDFORM MANAGEMENT		DATE: 09/08/2016	SHEET: A3 L

Appendix A

Geotechnical Aspects of Karst within the Swan Coastal Plain, Western Australia.

Geotechnical Aspects of Karst within the Swan Coastal Plain, Western Australia

Philip Mather

Coffey Geotechnics Pty Ltd – Perth, Western Australia

ABSTRACT

The occurrence of karst limestone conditions within Western Australia is not well recognised within the general community but can be of major engineering significance for developments that are impacted by it. The presence and engineering significance of karstic limestone on the Swan Coastal Plain has been recorded by local Engineering Geologists with the first officially published recognition presented in the 1:50,000 scale Environmental and Engineering Geology Series Yanchep Sheet in 1986. The Geological Survey of Western Australia (GSWA) mapping highlighted a significant, well defined zone of karst phenomena within Tamala Limestone extending from Joondalup to Two Rocks. Increasing pressure from urban development along Perth's northern corridor lead to several "near miss" incidents which precipitated the incorporation of a requirement for all development applications within the City of Wanneroo to include consideration of the potential for karst.

To date, the published literature relating to karst on the Swan Coastal Plain has been limited to geological descriptions of the phenomena. Although the potential karst hazard is now widely recognised within the geotechnical community there has been very little published information relating to geotechnical design considerations and strategies for urban development within areas affected by karstic limestone relating specifically to the Swan Coastal Plain. Considerable work has been completed over the past decade relating to the identification of karstic ground conditions and geotechnical design strategies to manage potential risks. In addition, the existence of additional areas of karstic limestone has been identified within the City of Cockburn and City of Mandurah.

1 INTRODUCTION

The occurrence of karst limestone conditions within Swan Coastal Plain of Western Australia is restricted to specific localised areas that, for many years, were of limited interest to those other than speleologists and caving enthusiasts. The coincidence of low lying swales with shallow groundwater and interdunal lakes resulted in karstic zones often being amongst areas of market garden and semi rural land uses. The pressure from urban expansion on the coastal plain has increasingly resulted in urban development encroaching into these previously less intensely developed areas. Although often not well recognised by property developers and the general public, the presence of karstic limestone can be of major engineering significance for developments that are impacted by it.

The occurrence of karst limestone was recognized by local Engineering Geologists such as Ray Gordon (2003) who was involved with local authorities to study and assess the potential risks/liabilities associated with this geohazard. These studies were greatly assisted by the work of local Speleologists such as Lex Bastion. Later work by Bob Gozzard with the resources of the Geological Survey of Western Australia (GSWA) resulted in the first official engineering recognition of the occurrence of karst within the Swan Coastal Plain presented on the 1:50,000 scale Environmental and Engineering Geology Series Yanchep Sheet published by the GSWA in 1982. The initial mapping highlighted a significant, well defined zone of karst phenomena within Tamala Limestone extending from Joondalup to Two Rocks.

Increasing pressure from urban development along Perth's northern corridor resulted in several sink hole occurrences associated with residential developments. In recognition of this potential hazard the City of Wanneroo has developed a draft of new requirements for all development applications to include consideration of the potential for karst.

Geotechnical investigations over the last decade have identified additional areas within the Swan Coastal Plain where karstic conditions occur and has focussed consideration of geotechnical design strategies to limit risks for developments.

The purpose of this paper is to provide an introduction to the geotechnical aspects of karst as follows:

- Case studies of karst collapse that have occurred within the Swan Coastal Plain that demonstrate the main features of sink holes and common trigger events.
- Updated geology map outlining two additional zones of significant karst, within the southern part of the Swan Coastal Plain and Mandurah that have never been published.

- Current geological/geomorphological hypotheses relating to the formation of karst environments within the Swan Coastal Plain.
- The effectiveness of various geotechnical investigation techniques available to identify the presence and significance of karstic limestone.
- Geotechnical design issues for development within areas of karst and potential options/solutions to limit associated risks.

2 CASE STUDIES

2.1 REGATTA DRIVE, EDGEWATER

Several sinkhole collapse features occurred within a road drainage basin following a significant rainfall event (Figure 1). The road basin is located within an urban residential development characterised by sand overlying pinnacled limestone at shallow depth. The collapses occurred in the mid 1990's and were investigated by Ray Gordon (2003) who has presented a schematic cross section of the site. No damage to the adjacent houses was reported. Remediation work included replacement of some sections of the boundary fences and precautionary underpinning of the foundations on one of the neighbouring residences.

Figure 1 – Road drainage basin at Regatta Drive, Edgewater showing sinkholes on left and at rear.

2.2 EMERALD DRIVE, CARABOODA

Sinkhole collapse occurred within a road runoff discharge area following winter rainfall soon after construction for a Special Rural subdivision (Figure 2). The collapse occurred in the early 2000's within an area of sand overlying shallow limestone between areas of scattered limestone outcrop. There was no damage reported, however, this example further highlights the potential risks associated with large volumes of concentrated runoff from road drainage basins triggering collapse events.

Figure 2 - Sinkhole within road drainage discharge area, Emerald Drive, Carabooda.

2.3 SWIMMING POOL COLLAPSE, WOODVALE

Undermining of a swimming pool due to sinkhole collapse occurred in March 2007 (Figure 3). The contribution of uncontrolled water discharge from a range of possible sources adjacent to the pool was suspected of contributing to progressive development of the sinkhole over many years which finally resulted in sudden collapse of the pool. Limited investigation at the site indicated a ground profile comprising sand overlying limestone at a depth of approximately 6 m.

Figure 3 - Woodvale swimming pool with bracing following collapse

2.4 BREAKWATER DRIVE, TWO ROCKS

Sinkhole collapse about 4 m wide and 3 m to 4 m deep occurred in December 2007 located approximately 12 m from the edge of a residence within a Special Rural subdivision (Figures 4a and 4b). The site is underlain by a 3 m to 6 m thick surface sand layer overlying limestone. A combination of CPT and air core borehole investigation identified loose

ground conditions within and overlying the limestone and the original building envelope was relocated away from an area within the Lot where numerous small voids had been encountered within the limestone at depths of between 11 m and 15 m.

The collapse occurred at the location of a bore water discharge point within the Lot. The bore discharge arrangement comprised of two child paddle pools. One pool received water from the bore which overflowed into the second pool. The bore was run for about an hour approximately 3 times per week. Water from the pools was bucketed out and distributed around the yard.

This arrangement had been in place for over a year prior to the collapse occurring. On the day of the collapse the owner had turned on the bore pump and then been distracted at the front of the property for between half to one hour with the pump running and pools overflowing. On his return to collect water from the pools they had "disappeared" down the sinkhole. One pool was completely gone and the corner of the second pool was visible at the base of the sinkhole.

Figure 4a – Breakwater Drive, Two Rocks. View of sinkhole from balcony of residence

Figure 4b - Breakwater Drive, Two Rocks. Close up view of sinkhole. Note tension crack around edge of failure zone

Common features with the case studies presented above include a surface layer of sand approximately 5 m thick and, more significantly, the action of concentrated surface water discharge providing a trigger mechanism for sudden sinkhole collapse.

3 GEOLOGY OF THE SWAN COASTAL PLAIN

A broad outline of the geology of the Swan Coastal Plain as presented by Davidson 1995 is shown in Figure 5. The existing 1:50,000 Geological Survey of Western Australia, Yanchep Sheet (Gozzard, 1982) outlines a zone referred to as "Interbarrier depression with prominent karst phenomena" extending between Joondalup and Two Rocks. This zone has been well documented and is well recognised throughout the geotechnical community and includes tourist features and cave systems within the Yanchep National Park.

Field experience from geotechnical site investigations and studies over the years has revealed additional, similar zones with karstic limestone conditions in the Lake Coogee – Munster area and further south along the western margins of the Peel Inlet at Dawesville and Mandurah. Additional isolated occurrences have also been encountered at Gwelup and Warwick. More localised occurrences are likely within similar geomorphological environments that have been revealed in the past and /or will be encountered in the future.

Figure 6 outlines a useful cross section presented by Grimes (2006) based on work by Lex Bastian in the Yanchep area. Meteoric water and groundwater undersaturated in $CaCO_3$ migrating west out of the Bassendean Sand dissolves the carbonate matrix to form "slots" within the limestone at the groundwater interface which enlarge over time through roof collapse to form caves.

Karst on the Swan Coastal Plain is considered to fit into Grimes's category of syngenetic karst which has formed within a soft, porous, soluble sediment at the same time as it has been cemented into a rock. This is quite different to the classical "hardrock" karst which involves dissolution of carbonate along pre-existing joints and fractures within a previously formed limestone or dolomite rock mass.

On the Swan Coastal Plain there appears to be a spatial association with low lying wetland areas where the water table is exposed at the surface and significant deposits of organic rich and peaty soils occur. The association with these wetlands introduces a possible influence of organic acids from peat deposits reducing the pH of groundwater and enhancing/"reinvigorating" the dissolution of carbonates within the adjacent or underlying limestone.

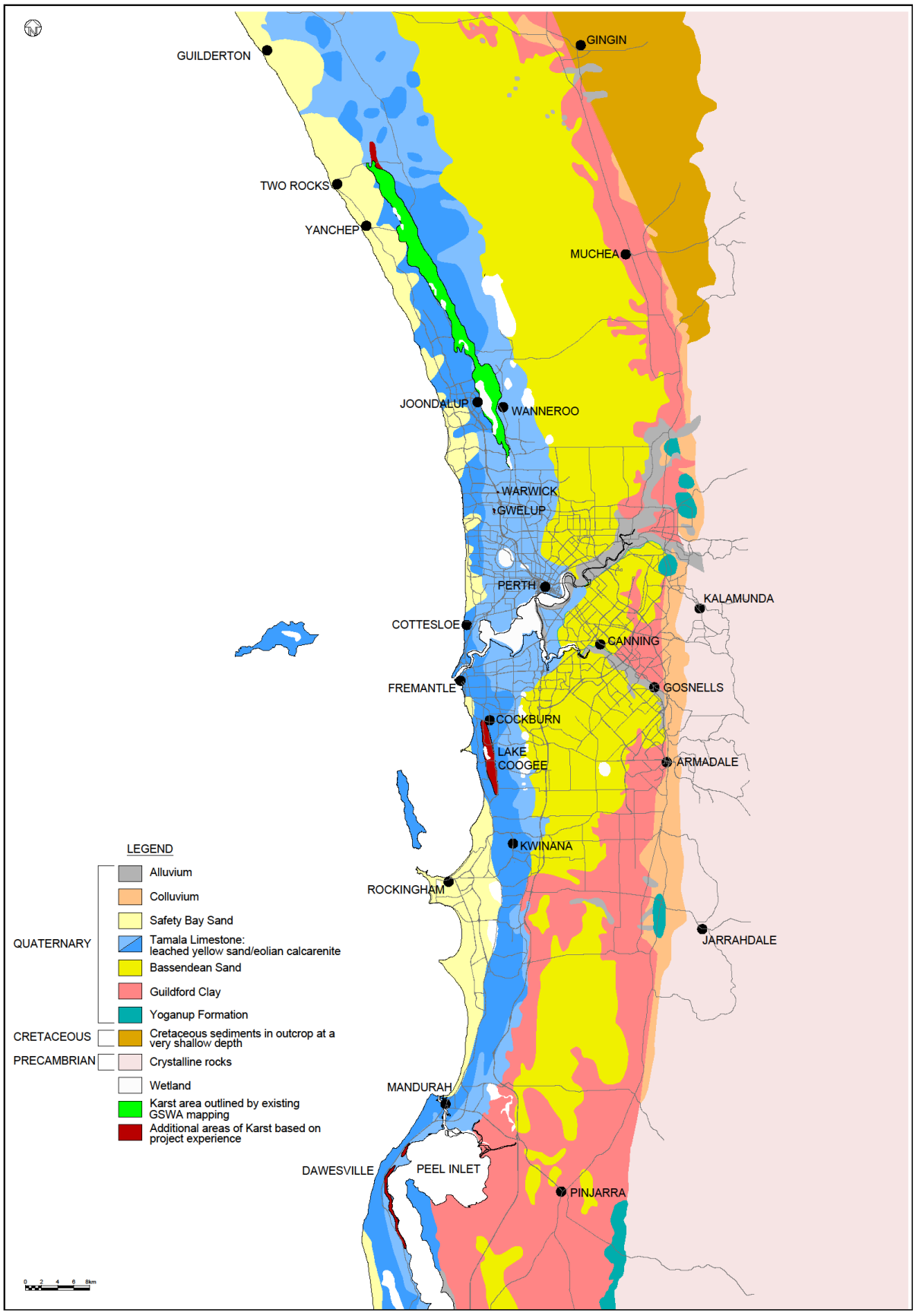

Figure 5 – Geology of the Swan Coastal Plain (from Davidson 1995)

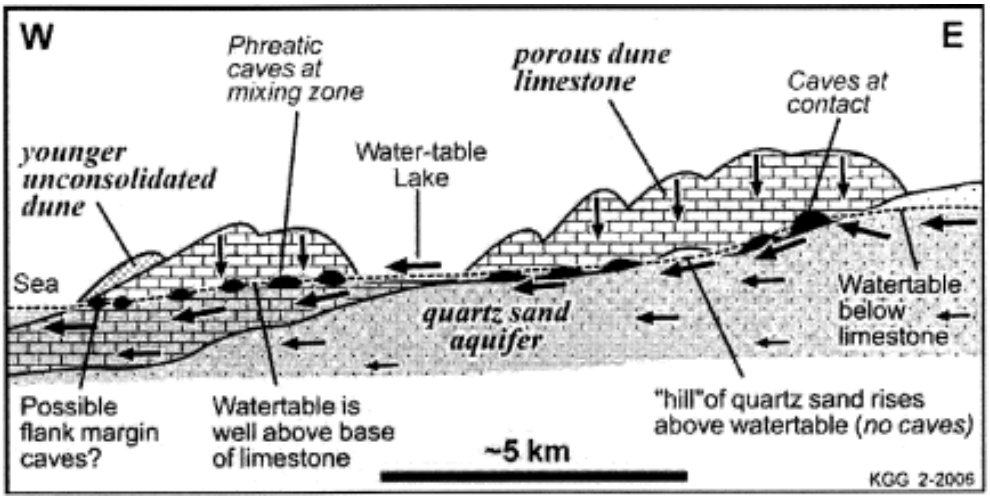

Figure 6 – Hydrology of the Yanchep Area (Grimes 2006 after Bastian)

Karst manifests itself as loose sand near the surface and cavities within the underlying limestone. Surface features include dolines, closed depressions and sinkholes. It is common to observe a characteristic topographic signature of closed depressions on surface contour maps and in particular from surface reconnaissance and field mapping within localised areas where the form of the ground surface appears inconsistent or disrupted within the broader landscape.

Waltham and Fookes (2003) present a classification of sinkholes as shown on Figure 7. Within the Swan Coastal Plain the occurrence of Waltham's Collapse sinkholes and Caprock sinkholes are rare. A more common occurrence highlighted by the case histories and author's experience are Buried sinkholes and Suffusion sinkholes which occur in areas of sand cover over the limestone.

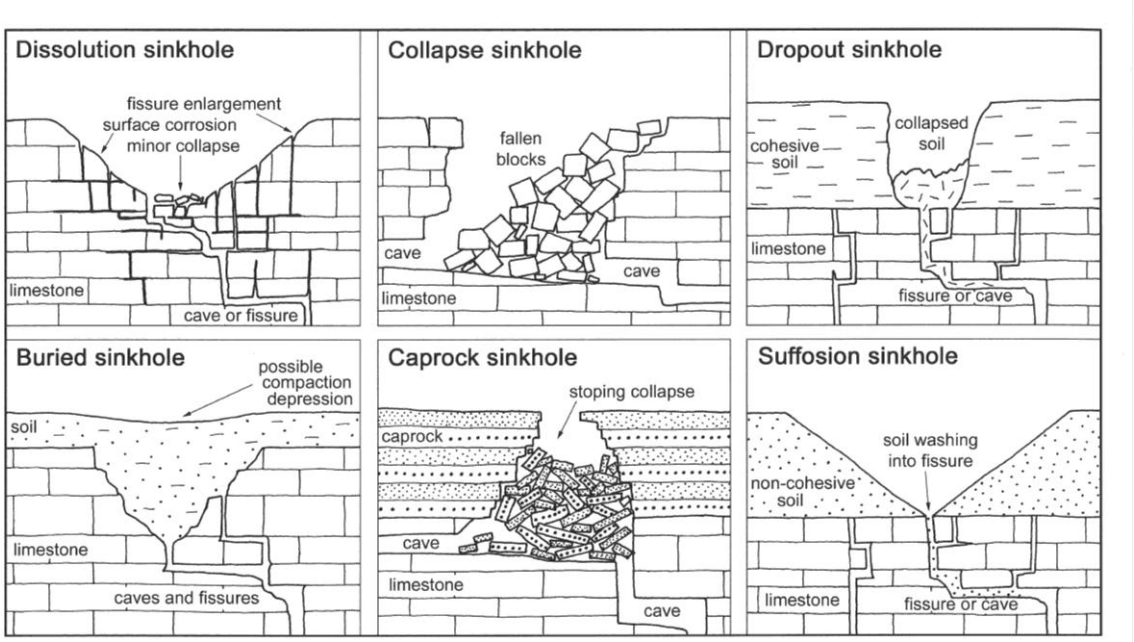

Figure 7 – Classification of Sinkholes via Mechanism of Ground Failure (Waltham and Fookes 2003).

Experience of sinkhole collapse on the Swan Coastal Plain suggests an increased hazard exists where the thickness of sand cover above limestone is in the order of 5 m. It is possible that when the thickness of sand cover exceeds 10m to 15 m it is sufficient to allow bridging of voids within the limestone and distribute any loss of ground over a broader soil zone thereby attenuating the magnitude and timing of ground movements experienced at the surface. In addition the influence of concentrated surface water infiltration is greatly diminished with depth. In areas where the thickness of sand cover is limited to a few metres it appears that the potentially significant sinkhole collapses have already occurred. In addition there is often clear surface evidence to alert the geologist to the presence of voids within the underlying limestone when it is at shallow depth.

Very loose zones within the overlying sand represent an additional hazard within areas of karst. Fortunately loose sand is relatively easy to identify and manage during development. The difficult hazard to manage results from "hidden" features where sudden collapse may be triggered by disturbance and/or changed conditions arising from new development.

4 GEOTECHNICAL INVESTIGATION TECHNIQUES

Extensive loose and very loose sand zones are a common feature of karst areas on the Swan Coastal Plain. Cone Penetrometer Testing (CPT) is an excellent technique to assess the condition of overlying sand and will sometimes penetrate the limestone to encounter voids at depth below the rock head. CPT is relatively quick and cost effective compared to drilling and provides continuous data about the ground conditions. A disadvantage of the CPT is that it can refuse on the limestone rock head. Drilling techniques are limited to the provision of less reliable data due to issues arising from ground disturbance at the bit face, core loss and discontinuous SPT test intervals. Drilling of all techniques is a relatively crude tool from which it is often difficult to distinguish between very loose sand, core loss and voids. However, within areas of very shallow limestone drilling to investigate the near surface ground conditions represents a method of overcoming early CPT refusal to obtain direct information.

Sinkholes are spectacular through their sudden and dramatic impact but are very isolated and, due to their association with concentrated surface water discharge, provide some scope to be managed through strict control of surface water drainage. Within areas of karst on the Swan Coastal Plain it is the loose sand zones overlying voided limestone that represents the significant risk to structures. These loose sand zones are inferred to have a general association with deeper voids and therefore can provide an indication of where hazards may exist within the underlying limestone. Individual voids within the limestone are extremely difficult to investigate. Drilling and probing is "hit and miss". A range of drilling techniques including auger, mud flush, diamond coring and air coring have been utilised. Despite careful observation of the drilling process it is often very difficult to distinguish reliably between air filled voids, sand filled voids, loose sand zones and very weakly cemented limestone. Compared to the crude data derived from drilling the use of intensive CPT testing to investigate the condition of the overlying sand, often penetrating the weaker and voided limestone at depth provides a valuable method to obtain reliable data on which to characterise the ground for input into geotechnical design.

Various geophysical techniques have been utilized with ground probing radar (GPR) typically being the most commonly adopted to assess karst on the Swan Coastal Plain. The author is not aware of any geophysical techniques that reliably indicate the presence, or not, of voids within limestone on the Swan Coastal Plain. Elsewhere surface and borehole seismic techniques have been used with some success to investigate voids at specific locations such as below a building foundation or for linear projects such as tunnel alignments (Whiteley, 2012). For larger areas geophysics can provide a generalised profile of ground conditions that may be useful to target more detailed investigation techniques, however, it provides very little useful information about the condition of the overlying sand which is often a more important factor for geotechnical design than knowing the specific location of voids. In the author's opinion, the use of geophysical techniques to conclusively demonstrate the absence of voids over large areas is unlikely to be practicable but they can provide complementary data for critical infrastructure at specific locations where investigation budgets allow.

5 GEOTECHNICAL DESIGN CONSIDERATIONS

The main considerations during geotechnical design within areas of potential karst are as follows:

- Excessive settlement within areas of loose sand under the load of structures.
- Sudden collapse of ground resulting from sinkholes.
- Concentrated surface and/or subsurface water flow which has been associated with every sinkhole occurrence observed by the author.
- Changes in land use which can concentrate surface water flows leading to a new generation of sinkholes to occur.
- The existence and effectiveness of geotechnical investigation guidelines. For example the City of Wanneroo has recently prepared a draft of new development guidelines for minimum geotechnical investigation requirements specifically related to karst. Other local Authorities are likely to follow.

6 CONCLUSIONS AND DESIGN STRATEGIES

The potential for sinkholes is a real and significant engineering issue within potential karst areas on the Swan Coastal Plain. The GSWA 1:50,000 mapping provides an excellent guide to the distribution of the potential karst zone north of Perth. Additional areas of karst have been encountered outside those shown on published geological mapping. Additional areas are likely to be revealed as urban development expands into areas of less intensive development. Investigation by drilling and probing is "hit and miss". The use of CPT has proved a reliable investigation technique on which to base engineering design within areas with a reasonable thickness of sand cover and can provide some indication of the strength of the underlying limestone sometimes penetrating the rock layer and intersecting voids to provide direct evidence of their existence. In the absence of any investigation techniques that can reliably detect the location of voids within limestone it is considered prudent that once karst conditions have been identified through surface mapping, drilling and probing, geotechnical design is based on the assumption that voids are present within the underlying limestone. For critical structures more specifically targeted techniques incorporating geophysics and intensive, close spaced drilling/probing may be justified.

The control and management of concentrated surface water discharge away from structures is considered to be the key factor in limiting the potential risks and impacts of sinkhole formation. Design recommendations for developments typically include the provision for soak wells to be located no less than 10m from footings. Road drainage basins are typically recommended to include a 30m development exclusion zone around their perimeter. Other design strategies include stiffening of footings to accommodate potential settlements associated with loose zones within sand and loss of ground above sinkholes. Structural assessments indicate that under typical loads associated with masonry residential structures a stiffened beam adopted for a site classification of M in accordance with AS2870-2011 will span a 1.8m wide void.

The hazards associated with development within areas of karst cannot be eliminated but geotechnical design strategies can be adopted to reduce the risks.

7 ACKNOWLEDGEMENTS

The author gratefully acknowledges the contribution and assistance from Geoff Cocks and Alan Moon during the preparation of this paper.

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