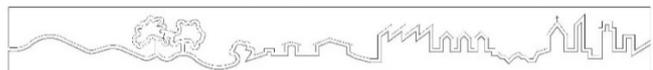


Sub-Precinct G2
Keirnan Street, Mundijong
Local Structure Plan



Prepared for DJM Mundijong Pty Ltd

PETER WEBB AND ASSOCIATES



CONSULTANTS IN TOWN PLANNING & URBAN DESIGN

Local Structure Plan

Sub-Precinct G2

Keirnan Street, Mundijong

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Version/Date: V2/August 2020

Prepared for:

DJM MUNDIJONG PTY LTD

This Structure Plan is prepared under the provisions of the Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2.

IT IS CERTIFIED THAT THIS STRUCTURE PLAN WAS APPROVED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON:

_____ *Date*

Signed for and on behalf of the Western Australian Planning Commission:

An officer of the Commission duly authorised by the Commission pursuant to Section 16 of the *Planning and Development Act 2005* for that purpose, in the presence of:

_____ *Witness*

_____ *Date*

_____ *Date of Expiry*

TABLE OF AMENDMENTS			
AMENDMENT NO.	SUMMARY OF THE AMENDMENT	AMENDMENT TYPE	DATE APPROVED BY WAPC

EXECUTIVE SUMMARY

This Local Structure Plan (**LSP**) has been prepared to facilitate the urban subdivision and development of the 'Sub-Precinct G2' LSP Area situated on the northern side of Kiernan Street, Mundijong.

The LSP Area is located at the north western corner of the intersection of Keirnan Street and Soldiers Road and extends to the west to encompass Lots 10 to 14 and 50 Keirnan Street. It extends to the north to include the adjoining section of the unmade road reservation of Lang Road and the eastern portion of Lot 101 Lang Road. The LSP Area is generally bound to the north by Manjedal Brook and the area contained within the adopted LSP for Sub-Precinct G1. (Refer to **Plan 1: Structure Plan Map.**)

Lots 11 to 14 Keirnan Street, Mundijong comprise of the landholdings within the LSP which are owned by *DJM Mundijong Pty Ltd (DJMM)*.

The section of the unmade road reserve of Lang Road together with the remaining landholdings including Lots 10 and 50 Keirnan Street and the eastern part of Lot 101 Lang Road are owned by external parties. These landholdings are included in the LSP to ensure an integrated approach to the planning of the sub-precincts of Precinct G, in accordance with the Shire of SJ Council resolution of 14 October 2019.

The LSP has been prepared in accordance with the requirements of *Schedule 2, Part 4 of the Planning and Development (Local Planning Scheme) Regulations 2015*.

The design of the LSP encompasses the fundamental principles and objectives of the endorsed *Mundijong-Whitby District Structure Plan* and the recently advertised *Mundijong District Structure Plan*, which documents provide the high-level strategic framework to guide the future land use and development of this location.

The design of the LSP ensures a strong sense of place and belonging is provided for the future residents of this urban community. This is to be achieved through design by creating a highly connected walkable neighbourhood which focuses on connecting the community with the natural beauty of this location.

The LSP is supported by the following technical assessments, which are detailed in *Part Two: Explanatory Information* of the LSP document, with complete copies of each assessment attached.

- Contour and Features Survey (*Vision Surveys*)
- Geotechnical Investigation (*Brown Geotechnical*)
- Landscape and Vegetation Strategy (*GHD*)
- Local Water Management Strategy (*Calibre*)
- Aboriginal Heritage Strategy (*Ethnoscience, Thomson Cultural Heritage Management*)
- Servicing and Infrastructure Strategy (*Calibre*)

- Stormwater Modelling Report (*Calibre*)
- Transport Impact Assessment (*Transcore*)
- Transportation Noise Assessment (*Lloyd George Acoustics*)
- Bushfire Management Plan (*Lush Fire and Planning*)
- Landscape Master Plan (*PWA*)

The technical assessments confirm the suitability of the land for urban development, as envisaged by *Perth and Peel@3.5million* and the *South Metropolitan Peel Sub-Regional Framework*.

The following **Executive Summary Table** provides a breakdown of the development outcome for the LSP Area.

EXECUTIVE SUMMARY TABLE		
ITEM	DATA	STRUCTURE PLAN REF (Section No.)
TOTAL AREA COVERED BY THE STRUCTURE PLAN	36.26 hectares	Part 2: Section 2.3 (pg. 10)
AREA OF EACH LAND USE PROPOSED:		Part 2: Section 5.0 (pg. 31)
- Residential	9.7 hectares	Part 2: Section 5.2 (pg. 33)
Reserves:		
- Co-located High School and District Playing Fields	15.64 hectares	Part 2: Section 5.3 (pg. 34)
- Public Open Space	3.95 hectares <i>(excluding the land set aside for the District Playing Fields, which area of open space is included in the Public Purposes Reserve)</i>	Part 2: Section 5.3 (pg. 34)
TOTAL ESTIMATED LOT YEILD		
ESTIMATED NUMBER OF DWELLINGS	approx. 230 dwellings	Part 2: Sections 5.1. and 5.2 (pgs. 31, 33)
ESTIMATED RESIDENTIAL SITE DENSITY	15 dwellings per gross ha of urban zoned land 24 dwellings per net residential site density <i>(excluding the land set aside for the District Playing Fields, which area of open space is included in the Public Purposes Reserve)</i>	Part 2: Section 5.2 (pg. 33)
ESTIMATED POPULATION <i>(based on the average of 2.95 persons per dwelling, as prescribed in the South Metropolitan Peel Sub-regional Planning Framework)</i>	679 people	Part 2: Section 5.2 (pg. 33)

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1.0 STRUCTURE PLAN AREA

This Structure Plan applies to Lots 10 to 14 and 50 Keirnan Street; the eastern portion 101 Lang Road; and the respective section of adjoining unmade road reservation of Lang Road, being the land contained within the inner edge of the line denoting the structure plan boundary on the Structure Plan Map. (Refer to **Plan 1**: Structure Plan Map.)

2.0 OPERATION

2.1	Operation	This Structure Plan commences operation on the date it is endorsed by the Western Australian Planning Commission pursuant to <i>cl. 22, Schedule 2, Part 4</i> of the <i>Planning and Development (Local Planning Schemes) Regulations 2015</i> .
2.2	Change or Departure from Structure Plan	Any change or departure from the Structure Plan is to be undertaken in accordance with <i>cl. 29, Schedule 2, Part 4</i> of the <i>Planning and Development (Local Planning Schemes) Regulations 2015</i> .

3.0 STAGING

The initial stage of subdivision and development will involve the landholdings under the ownership of DJMM. The staging therefore is proposed to commence in the eastern part of the LSP Area, being to the east of the High School and District Playing Fields Reserve.

The provision of essential infrastructure servicing for the LSP Area is designed for the initial stage of the development in the eastern portion of the site and is capable of being extended to service the future development of the High School and District Playing Fields Reserve.

4.0 SUBDIVISION AND DEVELOPMENT REQUIREMENTS

4.1	Structure Plan Map	The uses, subdivision and development of the land are to generally accord with the Structure Plan.
4.2	Residential	Residential densities applicable to the Structure Plan shall be those densities shown on the Structure Plan Map.

4.3	Public Purposes Local Scheme Reserve (High School and District Playing Field Reserve)	The area identified for the co-located High School and District Playing Fields requires the Shire of Serpentine-Jarrahdale and the Department of Education to enter into a long-term management agreement to ensure suitable sharing of the recreational facilities. This management agreement is to be prepared at the appropriate time in the future, prior to the land being developed.
4.4	Public Open Space	Public Open Space (POS) shall be provided generally in accordance with the Local Structure Plan Map. The development of the areas of POS are the responsibility of the developer, at subdivision stage.
4.5	Aboriginal Heritage	<p>(a) Lots 10, 11, 12, 13 and 14 Keirnan Street:</p> <p>Initial ground disturbance is to be monitored by one or two Gnaala Karla Booja representatives, as a precautionary measure. In the event that any suspected archaeological or cultural material is identified, all work must cease at that location until the representatives and an archaeologist have properly assessed the material. Contingency plans are to be developed, before ground disturbance occurs, to allow for culturally appropriate management of any such discoveries.</p> <p>(b) Lot 50 Keirnan Street (Department of Education):</p> <p>The newly recorded place, Sam Woods' Camp (MJ20-01) is likely to meet the requirements of sections 5 and 39(2) of the <i>Aboriginal Heritage Act 1972 (AHA)</i> and should be avoided and not impacted upon in any way without Ministerial consent under section 18 of the AHA.</p> <p>Further detailed recording and assessment of Sam Woods' Camp is to be undertaken by the owner of Lot 50 (Department of Education) prior to the lodgement of a section 18 application.</p> <p>An area is also identified on Lot 50 as having a potential archaeological subsurface deposit (PAD-01). This site is also required to be archaeologically tested and assessed by the</p>

		<p>Department of Education prior to the lodgement of a section 18 application.</p> <p>In the circumstance whereby Sam Woods' Camp cannot be avoided and will be impacted during future development, the Department of Education is to consult further with the representatives about any proposed section 18 application, mitigation and salvage strategies and the management of salvaged materials, and comply with any other undertakings given in respect to the section 18 process.</p> <p>The Department of Education is to implement suitable controls to prevent any impacts on Sam Woods' Camp during earthworks, including adequate physical demarcation of site boundaries and effective management processes such as ground disturbance permits and operator inductions.</p> <p>(c) Lot 101 Lang Road (eastern portion) and Lang Road Reserve:</p> <p>The scarred tree (Aboriginal Heritage Place (DPLH ID 37115)) is to be avoided and not impacted upon in anyway in anyway without Ministerial consent under section 18 of the AHA.</p> <p>A protective buffer of 30m radius is to be applied around the scarred tree during any ground disturbing works to ensure protection of the root system of the tree.</p> <p>In the circumstance whereby the scarred tree cannot be avoided and will be impacted during future development, the landowner of Lot 101 Lang Road is to consult further with the representatives about any proposed section 18 application, mitigation and salvaged strategies and the management of salvaged materials, and comply with any other undertakings given in respect to the section 18 process.</p> <p>The developer of the site is to implement suitable controls to prevent any impact during earthworks, including adequate physical demarcation of site boundaries and effective</p>
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		management processes such as ground disturbance permits and operator inductions.
4.6	Lang Road Reserve	<p>A section of the unmade existing local road reserve named 'Lang Road' contains mature vegetation to be protected. This land is currently gazetted as 'road reserve' and is to be transferred and dedicated for use as public open space, at subdivision stage.</p> <p>A new alignment for a portion of Lang Road Reserve, immediately to the south of the existing road reservation, is to be created in order to protect existing vegetation.</p> <p>The final alignment of the road reservation is subject to survey and shall be generally in accordance with the Local Structure Plan Map.</p> <p>The newly aligned sections of Lang Road are to be transferred to the Shire of Serpentine-Jarrahdale at subdivision stage, subject to payment of compensation to the affected landowner for the area of land required for the relocated road reservation. The payment amount is to be determined based on the market value of the total land area required to be transferred.</p>

5.0 LOCAL DEVELOPMENT PLANS

5.1	Local Development Plans	<p>Local Development Plans (LDP) are required to be prepared and implemented as a condition of subdivision approval, pursuant to <i>Schedule 2, Part 6 of the Planning and Development (Local Planning Schemes) Regulations 2015</i>, for the lots as identified on the Structure Plan Map as being:</p> <ol style="list-style-type: none"> 1. Lots identified in the <i>Transportation Noise Assessment</i> as requiring façade treatments to mitigate any noise impact. 2. Lots identified in the <i>Bushfire Management Plan</i> as requiring dwellings to maintain specific front setbacks to achieve a BAL 29 rating or lower.
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6.0 OTHER REQUIREMENTS

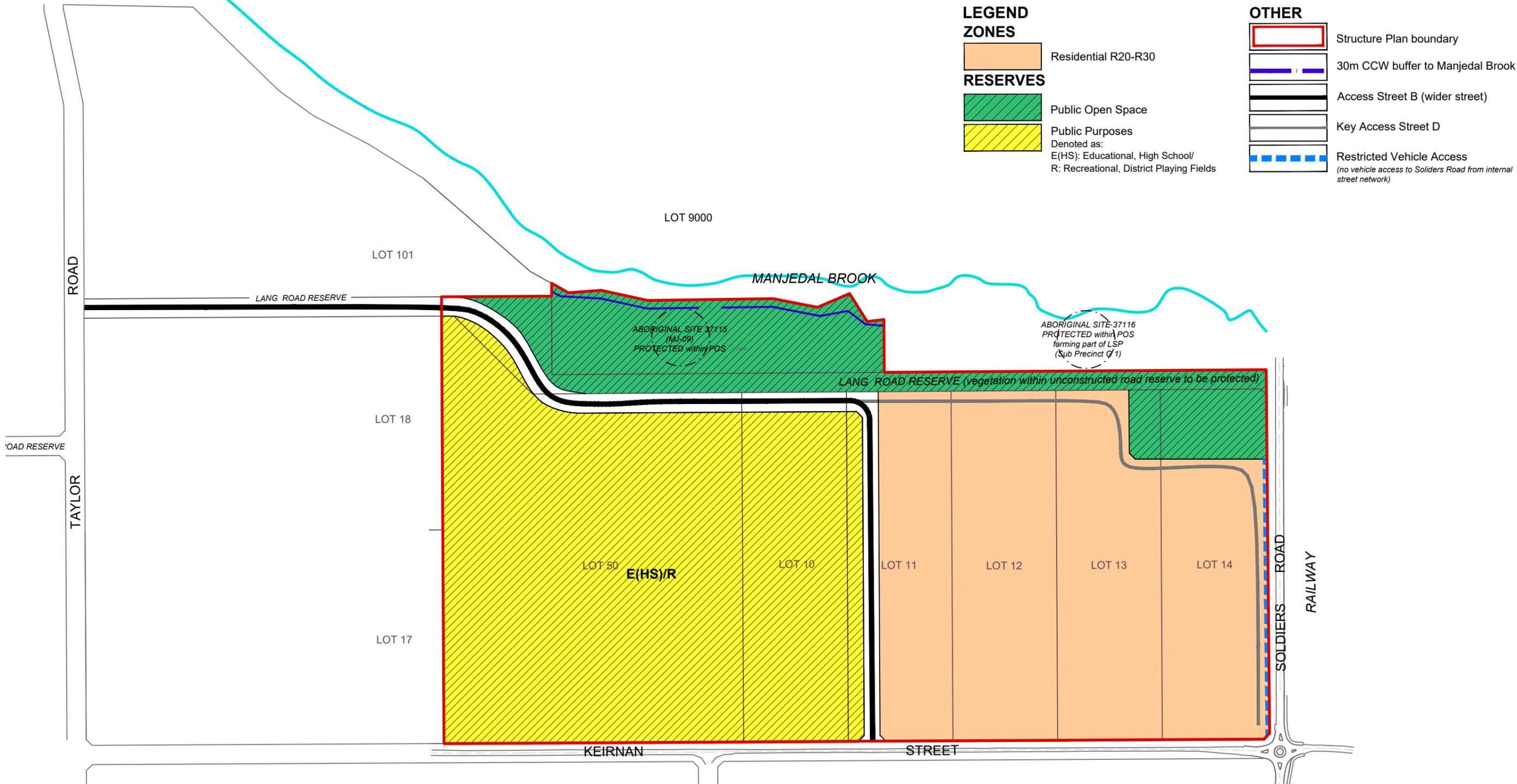
6.1	Notifications on Title	<ol style="list-style-type: none"> 1. Notification being included on the Certificates of Title for the lots identified in the <i>Bushfire Management Plan</i> as having a BAL 12.5 rating or higher, advising that the land is subject to a Bushfire Management Plan. 2. Notification being included on the Certificates of Title for the lots identified in the <i>Transportation Noise Assessment</i> as being above the target criteria, advising that the lot may be affected by transport noise and noting the relevant requirements for quiet housing design for the lot in order to achieve an acceptable level of noise reduction, as identified in the Transportation Noise Assessment.
6.2	Development Contribution	The Structure Plan will be subject to Community Infrastructure and Urban Development Contribution Plans (DCP), pursuant to Amendments 207 and 209 to <i>Town Planning Scheme No. 2</i> and in accordance with <i>State Planning Policy 3.6 – Development Contributions for Infrastructure</i> , following endorsement by the WAPC.

7.0 ADDITIONAL INFORMATION

7.1	Conditions of Subdivision Approval	<p>The Council shall recommend to the Western Australian Planning Commission that a condition be imposed on the granting of subdivision approval for each of the individual stages of development of the LSP to respond to the following as identified by the Structure Plan:</p> <ol style="list-style-type: none"> 1. Geotechnical Investigation. 2. Traffic Impact Assessment. 3. Bushfire Management Plan. 4. Flora and Fauna Survey. 5. Urban Water Management Plan. 6. Engineering Servicing Report. 7. Mosquito Management Plan. 8. Landscaping Management Plan.
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		<p>In addition to the above conditions, to the development of the co-located High School and District Playing Fields Reservation, the Department of Education and the Shire of Serpentine-Jarrahdale is to be subject to the following conditional requirement.</p> <p>9. Further assessment and archaeological testing at the newly recorded place, Sam Woods' Camp (MJ20-01) and the potential archaeological subsurface deposit (PAD-01) prior to any section 18 application being submitted.</p>
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PLAN 1
Local Structure Plan Map



LEGEND ZONES

Residential R20-R30

RESERVES

Public Open Space

Public Purposes
Denoted as:
E(HS): Educational, High School/
R: Recreational, District Playing Fields

OTHER

Structure Plan boundary

30m CCW buffer to Manjedal Brook

Access Street B (wider street)

Key Access Street D

Restricted Vehicle Access
(no vehicle access to Soldiers Road from internal street network)

- Notes**
1. The High School site and the District Playing Field facilities are proposed as a co-located public purpose reservation, as preferred by the Shire of Serpentine-Jarrahdale (SJ) and recommended in *Liveable Neighbourhoods*. The co-located facility is subject to further detailed design and a management arrangement being agreed between the Department of Education and the Shire of SJ, at the appropriate time in the future.
 2. Public Open Space areas are indicative only and subject to detailed design and drainage considerations, at subdivision stage.
 3. The key access streets are indicative only and subject to further detailed design at subdivision stage.
 4. The section of Lang Road Reserve to be transferred to public open space is required in order to retain the existing mature vegetation within that reservation, which may provide suitable habitat for the black cockatoo species.
 5. No direct vehicle access from the internal road network is permitted to Soldiers Road, due to the need to protect the significant vegetation existing within the road reservation.
 6. Acoustic noise mitigation is required to portion of the land to be developed within the LSP Area adjacent to Soldiers Road, to reduce the impact of noise exposure from the railway transportation to the east of Soldiers Road. The affected lots and the specific details of the dwelling treatment requirements are to be addressed at subdivision stage.

LOCAL STRUCTURE PLAN

Keirnan Street, Mundijong (LSP Area: Sub-Precinct G2)
DJM MUNDIJONG PTY LTD

1:2000 @ A3/P2284-24/03.08.2020



PETER WEBB AND ASSOCIATES

CONSULTANTS IN TOWN PLANNING & URBAN DESIGN

1.0 INTRODUCTION AND PURPOSE

This Local Structure Plan (**LSP**) has been prepared on behalf of *DJM Mundijong Pty Ltd (DJMM)* in order to facilitate the urban development of Lots 11 to 14 Keirnan Street, Mundijong.

The LSP incorporates the DJMM landholdings, together with the wider area (to be developed independently by others), which area is described as 'Sub-Precinct G2' in accordance with the *Mundijong-Whitby District Structure Plan* and the resolution of the Shire of Serpentine-Jarrahdale (**SJ**) Council decided at its Ordinary Meeting held on 14 October 2019.

The LSP Area is generally bound to the north by Manjedal Brook and the area of POS located just south east of the Manjedal Brook which forms part of the adopted LSP for Sub-Precinct G1. It is located at the north western corner of the intersection of Keirnan Street and Soldiers Road and extends to the west to include Lots 10 to 14 and 50 Keirnan Street. It also extends to the north to include the adjoining section of unmade road reservation of Lang Road and the eastern portion of Lot 101 Lang Road.

The LSP provides the framework for the future subdivision and development of Sub-Precinct G2.

The design of the LSP has been prepared to accord with the overarching objectives of the endorsed *Mundijong-Whitby District Structure Plan* (and taking into consideration the proposed (recently advertised) *Mundijong District Structure Plan*); *Perth and Peel@3.5million Planning Framework*; the *South Metropolitan Sub-Regional Planning Framework*; the requirements of the *Planning and Development (Local Planning Schemes) Regulations 2015*; and the Shire of SJ *Town Planning Scheme No. 2* (and taking into consideration the draft *Local Planning Scheme No. 3*).

The following technical documentation has been prepared in support of the LSP. The technical assessments cover the whole of the LSP Area. This provides certainty that the future development of those lots external to DJMM can proceed in an orderly and coordinated manner, to provide for a seamlessly connected urban development for the future residents of this locality.

- Contour and Features Survey (*Vision Surveys*)
- Geotechnical Investigation (*Brown Geotechnical*)
- Landscape and Vegetation Strategy (*GHD*)
- Local Water Management Strategy (*Calibre*)
- Aboriginal Heritage Strategy (*Ethnoscience/Thomson Cultural Heritage Management*)
- Servicing and Infrastructure Strategy (*Calibre*)
- Stormwater Modelling Report (*Calibre*)
- Transport Impact Assessment (*Transcore*)
- Transportation Noise Assessment (*Lloyd George Acoustics*)
- Bushfire Management Plan (*Lush Fire and Planning*)
- Landscape Master Plan (*PWA*)

2.0 LAND DESCRIPTION

The following section provides an overview of the location, land use and relevant ownership details of the landholdings contained within the LSP Area.

2.1 LOCATION

The LSP Area is located within the municipality of the Shire of SJ and in the locality of Mundijong. The area is located approximately 53 kilometres (km) south of the Perth Central Business District and 1.5km north of the Mundijong Town Centre. (Refer below to **Figure 1**: Regional Location Plan.)

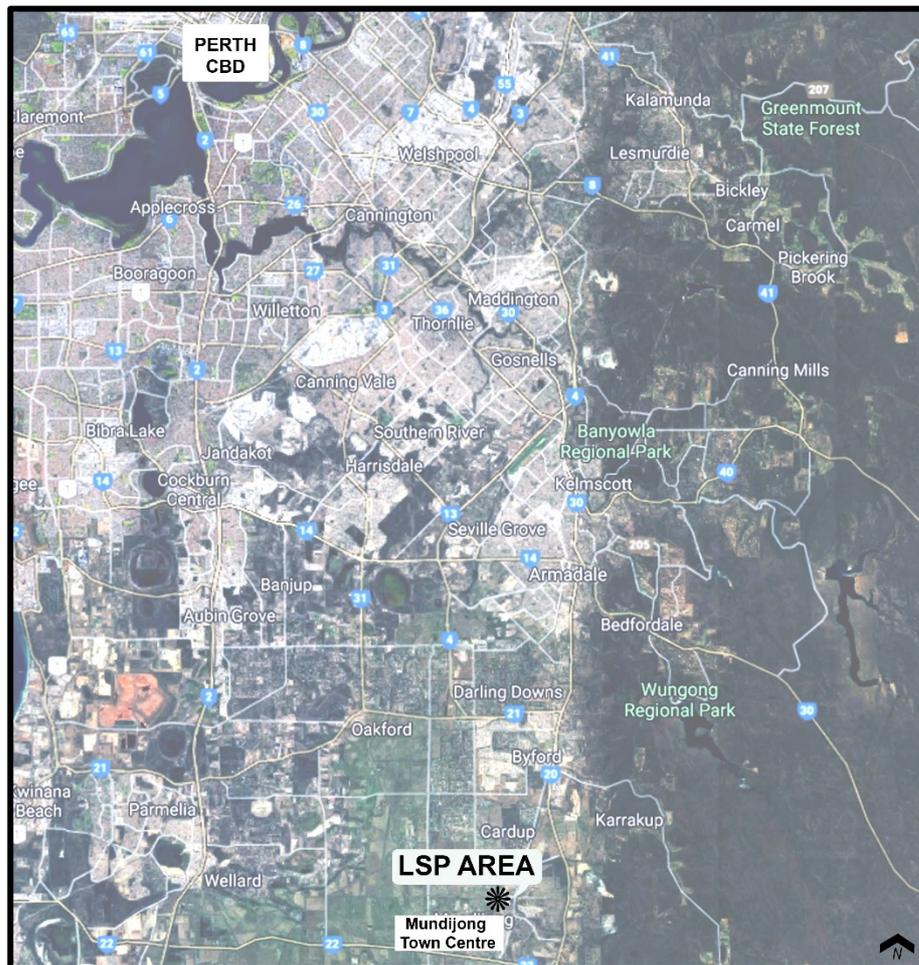


Figure 1: Regional Location Plan

(source: google maps)

The LSP Area is generally bound by Manjedal Brook and the land contained within the adopted LSP for 'Sub-Precinct G1' to the north of the Brook; Soldiers Road to the east, Keirnan Street to the south. The LSP Area extends west from Soldiers Road towards Taylor Road to include Lots 10 to 14 and 50 Keirnan Street. Passenger (Perth to Bunbury) and freight rail services run along the railway within the existing rail reservation, which extends in a north-south direction, parallel and to the east of Soldiers Road. (Refer to **Figure 2**: Location Plan.)



Figure 2: Location Plan (source: SLIP, 2020)

2.2 AREA AND LAND USE

The LSP Area has an approximate total land area of 36.26 hectares.

The LSP Area comprises mostly of vacant land, apart from Lot 10 Keirnan Street which contains a residential dwelling and associated outbuildings.

A review of historic aerial photographs confirms that the LSP Area has been cleared of native vegetation.

The land is generally flat and environmentally degraded due to the previous long term (70+ years) low intensity, grazing (farming) land use activities which have been undertaken across the area. (Refer to **Annexure 1: Contour and Features Survey.**)

2.3 LEGAL DESCRIPTION AND OWNERSHIP

The LSP Area contains a total of seven (7) freehold lots (including the portion of Lot 101) and a section of the unmade Lang Road reservation. The legal description of each lot is detailed in **Table 1.**

TABLE 1: LSP AREA LANDHOLDINGS			
LOT DETAILS	PLAN	OWNERSHIP	LAND AREA (HA)
10 Keirnan Street	P11881	owned by others	3.9334
11 Keirnan Street	P11881	DJM Mundijong Pty Ltd	3.9355
12 Keirnan Street	P11881	DJM Mundijong Pty Ltd	3.9376
13 Keirnan Street	P11881	DJM Mundijong Pty Ltd	3.9398
14 Keirnan Street	P11881	DJM Mundijong Pty Ltd	4.0140
50 Keirnan Street	D91562	Minister for Education	11.6706
101 Lang Road (eastern portion only)	P44318	owned by others	2.63ha (of total 11.8667ha)
Lang Road Reserve (eastern portion only) (unconstructed local road reserve)			2.21ha
TOTAL			36.26ha

The portion of the LSP Area owned by *DJM Mundijong Pty Ltd (DJMM)* is situated to the east of the proposed co-located High School and District Playing Fields Public Purposes Reserve and south of the unmade reserve of Lang Road. The LSP has been prepared over the land detailed in **Table 1** in accordance with the resolution of the Shire of SJ Council decided at its Ordinary Meeting held on 14 October 2019. The land outside of the ownership of DJMM includes the areas required by the Shire to be set aside for the future development of a High School and District Playing Fields Reservation and the areas to be protected due to the identification of an Aboriginal Heritage site and mature vegetation.

The landholdings owned by DJMM are detailed in **Table 2**. These landholdings are the area to be developed for residential development. Copies of the Certificates of Title are attached at **Annexure 2**.

TABLE 2: LSP AREA LANDHOLDINGS OWNED BY DJMM			
LOT DETAILS	CERTIFICATE OF TITLE	OWNERSHIP	LAND AREA (HA)
11 Keirnan Street	1460/743	DJM Mundijong Pty Ltd	3.9355
12 Keirnan Street	1460/744	DJM Mundijong Pty Ltd	3.9376
13 Keirnan Street	1460/745	DJM Mundijong Pty Ltd	3.9398
14 Keirnan Street	1460/746	DJM Mundijong Pty Ltd	4.0140
TOTAL			15.8269

2.4 SURROUNDING LAND USE AND CONTEXT

The boundary of the LSP defines the south eastern section of Precinct G (**Sub-Precinct G2**), which is described in the proposed revised *District Structure Plan (DSP)* for Mundijong as forming part of the area identified as 'Mundijong North'.

The surrounding land use and context is summarised below and illustrated at **Figure 3**:

1. The land to the immediate north, including the Manjedal Brook and a section of cleared land in the south eastern corner of the Brook and north of the Lang Road Reserve, is proceeding through a separate LSP assessment process, which LSP is described as 'Sub-Precinct G1'. This LSP was adopted by the Shire of SJ in September 2016 and remains with the WAPC for endorsement.
2. The nearby Manjedal Brook is a Conservation Category Wetland (UFI 15446) and recognised by the Shire of SJ as a 'Place of Natural Beauty' and an 'Ecological Linkage'. It is preserved and protected.
3. The land to the immediate west of Taylor Road is the subject of an WAPC endorsed LSP, which is identified as 'Precinct E1'. This LSP has been approved for urban development at a similar density range to the subject LSP. This area is yet to be developed.

4. The vegetation within the Soldiers Road reservation is preserved and protected. Soldiers Road is described as a 'Flora Road'. This road reserve together with the Bella Cumming Reserve located on the north eastern corner of the intersection of Keirnan Street and Soldiers Road form part of Bush Forever site 350/365.
5. The LSP Area is predominately cleared having been historically used for livestock farming. It is described as 'Parkland Cleared'. The vegetation condition across the LSP Area is identified as Degraded to Completely Degraded.
6. The eastern and central (unmade) sections of Lang Road Reserve contain mature vegetation over introduced grasses. There is no native understorey. The mature vegetation is to be protected as part of this LSP, as required by the Shire of SJ.
7. The existing freight rail (connecting to Kwinana) and the Australind passenger rail service between Perth and Bunbury both utilise the railway reservation which runs parallel to the eastern side of Soldiers Road, adjacent to the LSP Area. (It is recognised that the freight rail service is intended to be removed from this route and redirected along a new alignment to the east of the future West Mundijong Industrial area.)
8. To the south of Keirnan Street, the land is developed with residential dwellings at a low density. This area is identified in the DSP as forming part of the 'Mundijong Town Centre' and is suitable for urban development at a similar density to that proposed for this LSP Area.
9. The Mundijong Town Centre is located approximately 1.5 km to the south of the LSP Area, which is directly accessible via Soldiers Road/Paterson Street.
10. The emerging Whitby residential estate is situated in close proximity to the LSP Area, being located directly to the east of the railway reservation. The Whitby development forms the approved LSP for 'Precinct A', which incorporates a variety of residential densities, a future District Centre, Tertiary School, two (2) Primary Schools and a High School.
11. The future Tonkin Highway is to be extended, with government funding for that work having recently been secured and works scheduled to commence in 2020. The reservation for the extension of Tonkin Highway is situated to the west of the LSP at a distance of approximately 600 metres.
12. South West Highway is located to the east, currently accessed via the Keirnan Street 'at grade' rail crossing, which intersects with South West Highway at a distance of approximately 2.5 km.
13. The future West Mundijong Industrial area is located approximately 2.3 km (to the west) from the intersection of Keirnan Street and Taylor Road.

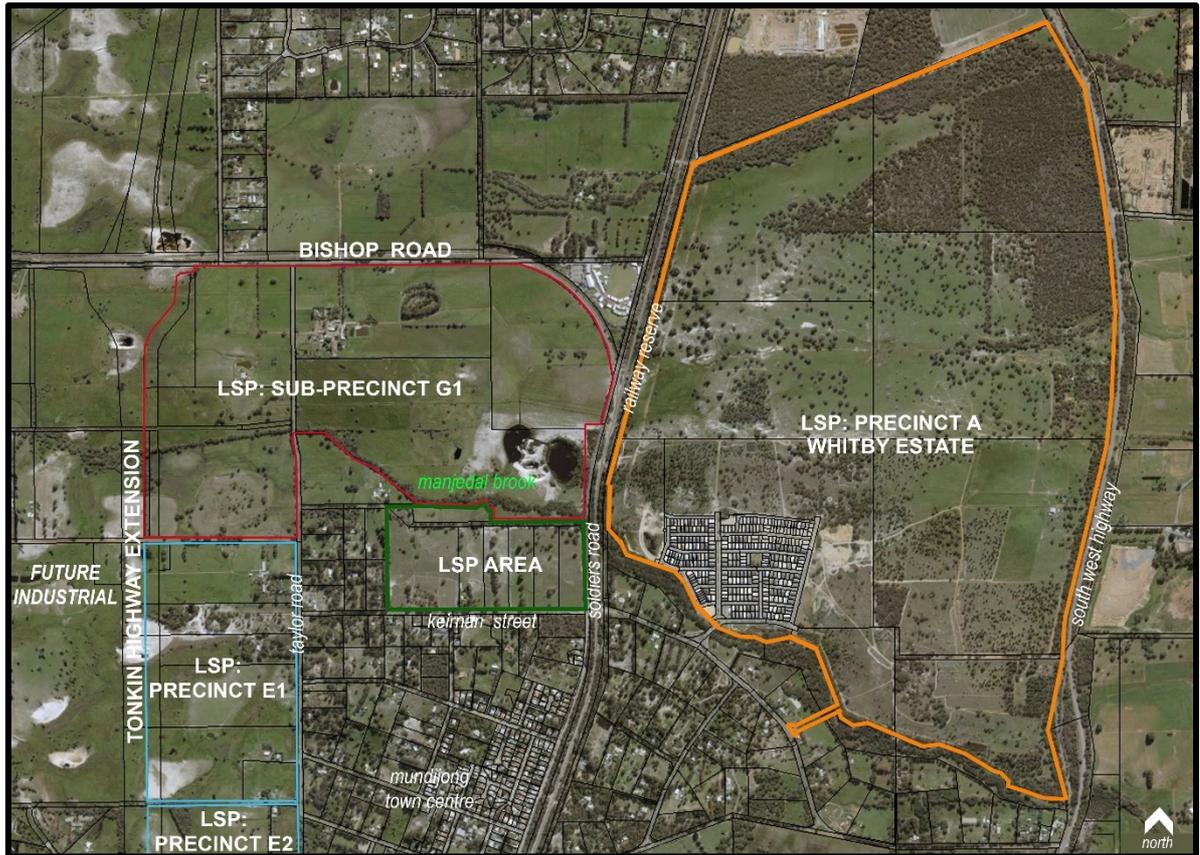


Figure 3: Land Use and Context

(source: slip, 2020)

3.0 PLANNING FRAMEWORK

PLANNING AND DEVELOPMENT (LOCAL PLANNING SCHEMES) REGULATIONS 2015

The LSP has been prepared in accordance with the requirements set out in the deemed provisions at *cl. 16, Part 4, Schedule 2*, of the *Planning and Development (Local Planning Scheme) Regulations 2015*.

3.1 ZONING AND RESERVATIONS

METROPOLITAN REGION SCHEME

The LSP Area is zoned 'Urban', pursuant to the Metropolitan Region Scheme (MRS).

(Refer to **Figure 4: MRS Zoning**.)

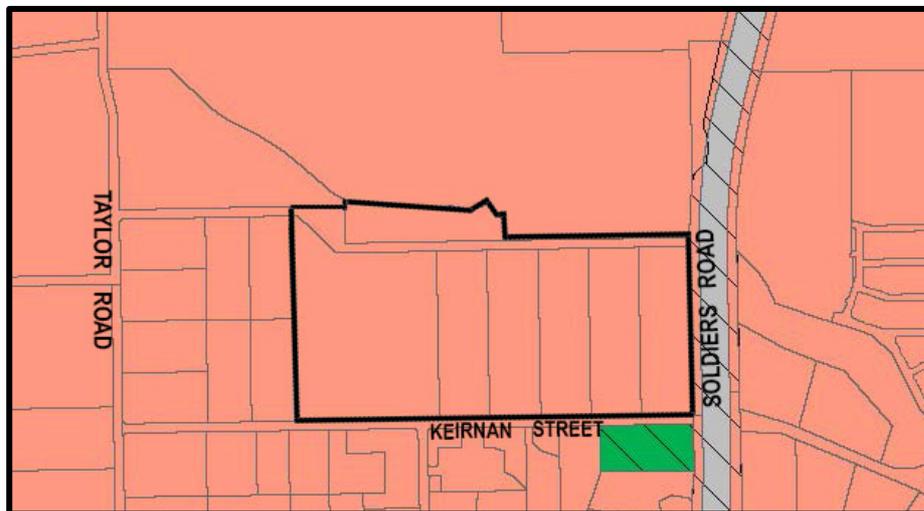


Figure 4: MRS Zoning

SHIRE OF SERPENTINE JARRAHDALE TOWN PLANNING SCHEME 2

The LSP Area is zoned 'Urban Development' (Development Area 1), pursuant to the Shire of Serpentine-Jarrahdale *Town Planning Scheme No. 2 (TPS 2)*.

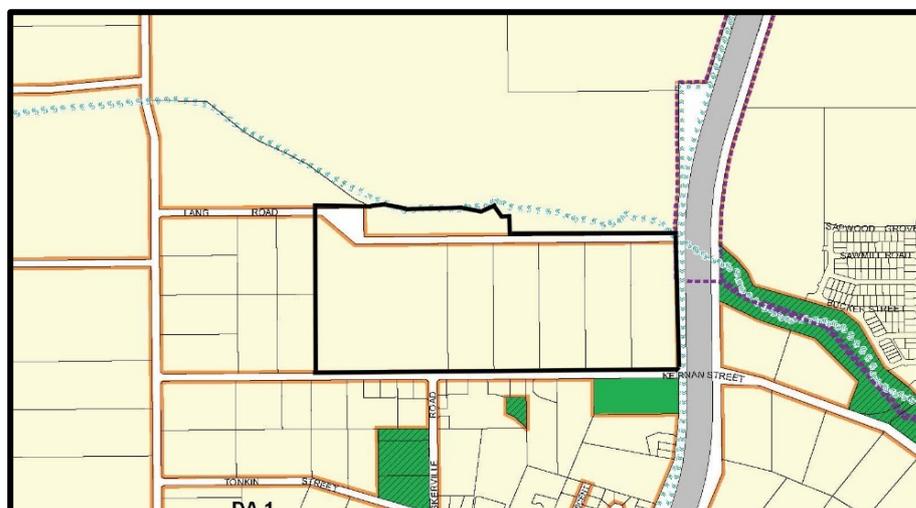


Figure 5: TPS 2 Zoning

The LSP is submitted as required by Clause 5.19.1.1 of TPS 2, which states that no new development or use of land is to commence on land zoned 'Urban Development' until a Structure Plan has been approved.

DRAFT LOCAL PLANNING SCHEME 3

The advertising process for draft *Local Planning Scheme No. 3 (LPS 3)* has concluded and the outcome of that consultation was considered by Council at a Special Meeting held on 22 June 2020. The Council resolved to support the modified LPS 3. The documentation has now been sent to the WAPC in accordance with Section 25 (3), Division 2, Part 4; and Section 28 (1), Division 2, Part 4 of the *Planning and Development (Local Planning Schemes) Regulations 2015*.

The draft LPS 3 retains the same zoning of 'Urban Development' as the currently operative TPS 2.

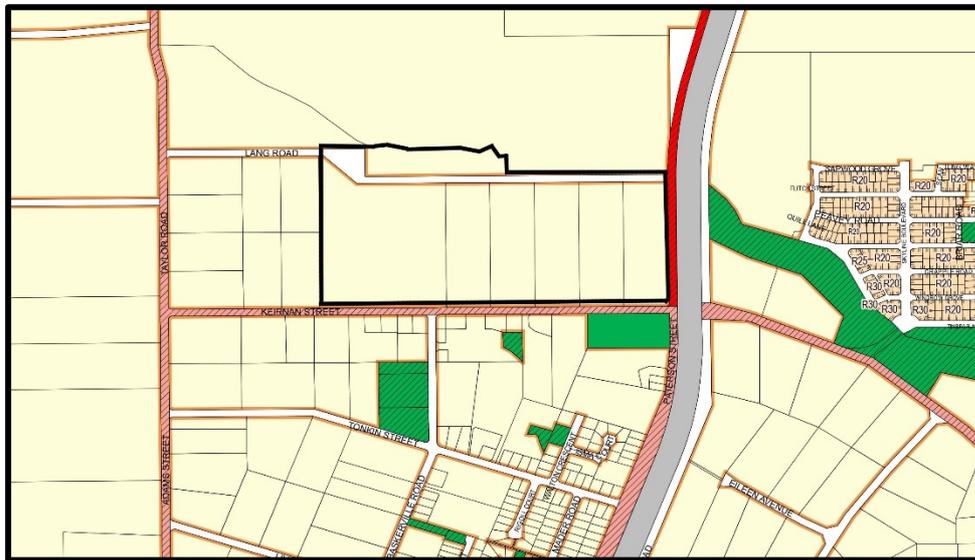


Figure 6: Draft Local Planning Scheme No. 3 (as advertised)

3.2 REGIONAL AND SUB-REGIONAL STRUCTURE PLAN

MUNDIJONG-WHITBY DISTRICT STRUCTURE PLAN

The endorsed *Mundijong-Whitby District Structure Plan (DSP)* (2011), together with the draft revised DSP for Mundijong (adopted by Council in December 2018 for the purpose of advertising and now currently being advertised for public comment until 20 July 2020), provides the district level strategic direction for the urban development of the Mundijong-Whitby area and guidance for the preparation of the detailed Local Structure Plans by developers.

The revised DSP proposes to consolidate the endorsed DSPs for Mundijong-Whitby and West Mundijong into a single strategic document. (Refer to **Figure 7: Endorsed DSP** and **Figure 8: Proposed Revised DSP**)



Figure 7: Endorsed DSP (2011)

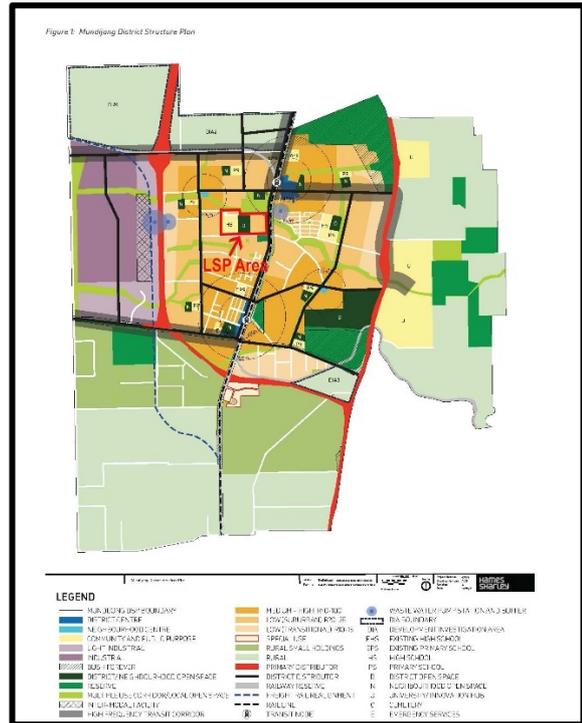


Figure 8: Proposed Revised DSP (2018)

The endorsed DSP and the revised DSP identifies twelve (12) LSP Precinct Areas for the purpose of identifying the extent of land required to be included in the detailed LSPs.

The endorsed DSP identifies the LSP Area as being contained within *Precinct G* and the revised DSP identifies the subject land as being contained within *LSP Area G – Mundijong North*. It is noted in the revised DSP that an LSP can be prepared for all or portion of the LSP Area, with the extent of the LSP to be determined in liaison with the Shire.

An LSP for Taylor and Bishop Roads has been adopted by the Shire for the section of Area G located to the north of Manjedal Brook, and west of Taylor Road. The Shire describes the LSP to the north of Manjedal Brook as ‘Sub Precinct G1’, which proposal is currently being held at the WAPC awaiting endorsement.

The Shire resolved at its Ordinary Meeting of Council held on 14 October 2019 to approve the LSP to include a portion of the remaining area of Precinct G, comprising of the south-eastern area of the precinct and formally titled as ‘Sub-Precinct G2’.

The LSP is consistent with the DSP (both the endorsed and revised draft version); the advice provided by the Shire’s Technical Officers during the pre-lodgement consultation process to ensure compliance with the overarching objectives of the district level strategic plan for Mundijong; and the Shire Council decision of 14 October 2019.

In particular, the following key elements of the DSP are implemented through the proposed LSP:

1. The land use distribution is consistent with the land uses identified for this sub-precinct of Area G.

2. The Shire's preferred outcome for a co-located High School and District Playing Field Public Purposes Reserve is realised in the LSP. The Public Purposes Reserve contains sufficient land area (and suitable dimensions) to provide for the future High School building footprint and two (2) District Playing Fields, to meet the Shire and the Department of Education's requirements. In particular, Lot 50; Lot 10 and a portion of Lot 11 Keirnan Street are set aside for future amalgamation into a single reservation to ensure adequate land is provided to accommodate the co-located facilities.
3. The urban development provides a strong, legible road network, which bounds the future High School and District Playing Fields Reserve and POS areas adjacent to the Manjedal Brook.
4. The native mature vegetation which exists within the section of the unmade Lang Road reservation is proposed to be retained and protected, with a new alignment for the east-west orientated road being proposed to be shifted just south of the existing road reserve, to within the adjoining private landholdings.
5. The small pocket of mature native trees in the north eastern corner of Lot 14 are to be protected within POS.
6. No vehicle access from the internal road network is to be proposed directly to Soldiers Road, to ensure the protection of the mature vegetation within the road reservation. This vegetation forms part of Bush Forever Site 350/365, which includes the Bella Cumming Reserve to the south of Keirnan Street and extends along the Soldiers Road and railway reservations.
7. The design of the LSP ensures a strong sense of place and belonging is able to be achieved for the future residents of this community through the creation of a highly connected walkable neighbourhood which ensures a strong focus and visual connection is maintained to the natural beauty of this location.

3.3 PLANNING STRATEGIES

PERTH AND PEEL@3.5MILLION & SOUTH METROPOLITAN PEEL SUB-REGIONAL PLANNING FRAMEWORK

Perth and Peel@3.5million outlines the Planning framework for the future growth of the Perth and Peel Regions of Western Australia to accommodate a population of 3.5 million by 2050.

The proposed LSP Area is identified in the *Perth and Peel@3.5million* as forming part of the *South Metropolitan Peel Sub-regional Planning Framework*.

The LSP Area is identified in the *Sub-regional Planning Framework* as 'Urban (undeveloped)' land, which is consistent with the MRS zoning of the location.

This Sub-region is identified as being expected to have relatively strong population growth. The specific attracting features of the area are highlighted as including affordable housing options, as well as employment and lifestyle opportunities. The Framework predicts a growth in this South Metropolitan Peel Sub-region to 1,264,450 people by 2050.

This LSP is consistent with the strategic direction for the South Metropolitan Peel Sub-Region as it will assist in providing affordable housing for the anticipated population expected to be residing in this location in the short to medium term.

SHIRE OF SERPENTINE JARRADHALE DRAFT LOCAL PLANNING STRATEGY

The advertising process for draft *Local Planning Strategy (LPS)* has concluded and the outcome of that consultation was considered by Council at a Special Meeting held on 22 June 2020. The Council resolved to support the LPS with the modifications as proposed. The documentation has now been sent to the WAPC in accordance with Section 14 (2) and (3), Part 3 of the *Planning and Development (Local Planning Schemes) Regulations 2015*.

The SJ2050 Spatial Framework of the LPS identifies the LSP Area as forming part of the Urban Settlement area, which is designated for ‘Medium Density’ residential development.

The LPS identifies Mundijong as potentially reaching an anticipated population of 50,000/1850 ha, with a gross housing density of 9.4, by 2050.

The LSP Map has been designed to ensure consistency with the overarching objectives and strategies outlined in the LPS. The following **Table 3** describes the ways in which the LSP design complies with the LPS.

TABLE 3: COMPLIANCE WITH THE LPS STRATEGY REQUIREMENTS FOR MUNDIJONG	
<i>a. Ensure that local structure plans prepared for each precinct identify appropriate opportunities for increased residential densities.</i>	The LSP proposes residential densities to comply with the densities specified for this location in both the endorsed and proposed revised DSP for Mundijong.
<i>b. Ensure that structure plans and subdivision plans for urban development are prepared in a responsive manner to existing and planned centres, facilities and natural features.</i>	The LSP is designed to appropriately respond to the existing area and the nearby facilities as well as ensure connection to the future facilities planned for this area. The LSP similarly responds to the need to preserve and connect to the natural features of the area through the design.
<i>c. Ensure that the future urban development of the existing Mundijong townsite and surrounding area responds to historic settlement patterns and preserves the character and heritage of Mundijong.</i>	The LSP responds and seeks to preserve the rural character and heritage of Mundijong.
<i>d. Ensure that local structure plans and subdivision plans include a diversity of lot sizes to accommodate a range of housing types and sizes.</i>	The LSP is able to accommodate a range of lot sizes to provide for different housing typologies, as illustrated on the Concept Plan included at Figure 9 .
<i>e. Require applicants to demonstrate how housing diversity will be achieved, which may include incorporation and retention of a range of housing types and tenures in new residential developments.</i>	Housing diversity is able to comfortably be achieved to meet market demand for affordable housing and accords with the density range specified in the endorsed and draft DSP for Mundijong.

(cont.) TABLE 3: COMPLIANCE WITH THE LPS STRATEGY REQUIREMENTS FOR MUNDIJONG	
<i>f. Encourage built form, particularly dwellings, to be capable of being adapted in response to changing needs over time.</i>	The LSP design will allow for a diverse range of dwelling developments, as needs change over time.
<i>g. Encourage housing to conform to universal and sustainable design principles.</i>	The road and perimeter block design of the LSP ensures sustainable housing design principles will be able to be achieved, at development application stage.
<i>h. Investigate the potential for urban expansion within the consolidated land parcels north of the Mundijong urban area and Bishop Road, with the potential to extend Norman Road to the west as a potential boundary to the urban expansion.</i>	Not applicable.
<i>i. Investigate the potential for urban expansion in the area between the existing southern boundary of the Mundijong urban area and north of the proposed Tonkin Highway extension to the South Western Highway.</i>	Not applicable.

The LSP Map is designed in a manner which addresses and responds to the key features of the location as identified in the draft LPS. These features include both protecting and preserving the historical and natural elements of Mundijong. In particular, the design addresses and protects the Manjedal Brook by providing POS to stretch along the northern boundary of the LSP Area with appropriate physical separation from the urban development by a road reservation. This feature of the design not only creates a suitable separation distance between the Brook and the urban development front. It also maximises access for the local community by designing POS adjacent to the Brook, offering opportunities for people to visit and recreate along the banks of the watercourse. The LSP is also designed to protect the Regional Green Linkage and Bush Forever site contained within the road reservation of Soldiers Road.

The LSP ensures the protection of the identified Aboriginal heritage site (scarred tree on the eastern portion of Lot 101) within a designated public open space reserve, similar to the Aboriginal heritage site located to the north east of the LSP Area and adjacent to Soldiers Road. In addition, the LSP references the Aboriginal heritage sites identified on Lot 50 Keirnan Street, which are required to be protected following further assessment to be undertaken by the Department of Education, in the future as part of its further development considerations for that site.

In addition, the LSP provides the required land area for the future development of the District Playing Field facilities which are to be co-located with the proposed future High School as a single Public Purposes Reserve. The co-located High School and Playing Fields Reserve is the preferred approach of the Shire as it will create a multi-use facility which will maximise use efficiency of the facilities provided. This proposal aligns with the principles of the *Community Infrastructure and Public Open Space Strategy* and *Community Infrastructure Implementation Plan*.

3.4 PLANNING POLICIES

SPP 2.8 – BUSHLAND POLICY FOR THE PERTH METROPOLITAN REGION

The LSP Area does not contain any regionally significant bushland within a Bush Forever area.

There are two (2) Bush Forever sites adjacent to the LSP area, including: the Bella Cumming Reserve situated at the south eastern corner of the intersection of Keirnan Street and Soldiers Road which is reserved in the MRS as 'Parks and Recreation'; and the vegetation within the Soldiers Road and the Railway Reservations.

The design of the LSP ensures the bushland within these protected areas will not in any way be adversely impacted by the urban development of this site.

SPP 3.1 – RESIDENTIAL DESIGN CODES

The LSP Map is designed to incorporate a range of densities to meet the demands of the main demographic choosing to reside in Mundijong.

The LSP design allows for densities including: Residential R20 (450m² average); R25 (350m² average); and R30 (300m² average).

The design ensures that each perimeter block is able to facilitate the subdivision of lots with sufficient widths and depths for project housing development.

SPP 3.6 – DEVELOPMENT CONTRIBUTIONS FOR INFRASTRUCTURE

The proposed development contributions for the LSP Area are detailed in proposed Amendment No. 209 to the Shire of SJ TPS 2 and accompanying draft Mundijong Urban Development Contribution Plan (DCP) for Mundijong.

Amendment No. 209 and the draft DCP are currently progressing through the advertising process, which is scheduled to conclude on 10 August 2020.

The proposed community infrastructure development contributions for the LSP Area are detailed in proposed Amendment No. 207 and the accompanying draft Community Infrastructure Development Contribution Plan (**CIDCP**). The advertising process for this Amendment (with the CIDCP) has concluded. The documents were presented to the Ordinary Meeting of Council on 18 May 2020, and supported with modifications. The documentation has now been forwarded to the WAPC, in accordance with Regulation 37 (2) of the *Planning and Development (Local Planning Schemes) Regulations 2015*.

SPP 3.7 – PLANNING FOR BUSHFIRE MANAGEMENT AND GUIDELINES

The LSP Area is wholly identified as being within a 'Bushfire Prone Area' and accordingly, the LSP Map has been prepared in consultation with a bushfire management expert and is supported by a comprehensive *Bushfire Management Plan*, which meets with the requirements of SPP 3.7.

The whole LSP Area has been considered in the BMP, with particular (site specific) focus given to the landholdings owned by DJMM. The specific requirements of the BMP are summarised in **Section 5.4** of this report and a complete copy of the BMP document is attached at **Annexure 3**.

SPP 5.4 – ROAD AND RAIL TRANSPORT NOISE AND FRIEGHT CONSIDERATIONS IN LAND USE PLANNING

An existing railway reservation runs in a north-south direction along the eastern side of Soldiers Road, which is located to the immediate east of the LSP Area. The railway is currently used for freight transport and passenger services between Perth and Bunbury (Australind service).

The draft LPS (and DSP) indicate the planned realignment of the freight rail service from this route to run along the extended Tonkin Highway, adjacent to the future Mundijong Industrial Area.

The long-term plan for the existing railway reserve is to continue its service between Perth and Bunbury, with further investigation identified in the LPS for improved operational efficiency of this passenger rail service through better integration with the metropolitan rail service.

In accordance with the requirements of SPP 5.4, to ensure noise from the rail is mitigated to achieve acceptable noise levels for the dwellings to be created on the affected lots, a *Transportation Noise Assessment* has been prepared by *Lloyd George Acoustics*. The details of this assessment are summarised at **Section 4.6** of this report and explained further in the Assessment document attached at **Annexure 4**.

SPP 7.0 – DESIGN OF THE BUILT ENVIRONMENT

The LSP design addresses each of the overarching design principles of SPP 7.0 – Design of the Built Environment, as summarised in the following **Table 4**.

TABLE 4: COMPLIANCE WITH DESIGN PRINCIPLES OF SPP 7.0	
<p>1. Context and character <i>Good design responds to and enhances the distinctive characteristics of a local area, contributing to a sense of place.</i></p>	<p>The LSP is designed to achieve a highly connected walkable neighbourhood which focuses on creating a strong community connection to the distinctive characteristics of the natural environment in Mundijong.</p> <p>The design seeks to protect the natural environment within areas of public open space as a way of retaining and enhancing the strong sense of place which already exists in this location. In order to achieve this, the design focuses on the natural beauty of the adjacent Manjedal Brook through the placement of public open space areas and connecting road and path network, which will encourage the local community to connect with the natural beauty of this area.</p> <p>The few existing mature native trees which are scattered across the landscape are to be protected where possible, to encourage the resting of native species.</p> <p>Importantly, the Aboriginal cultural heritage values of this location are to be protected and sensitively interpreted in order to educate the community on the strong association of the local area with the Aboriginal history of the country.</p>

(cont.) TABLE 4: COMPLIANCE WITH DESIGN PRINCIPLES OF SPP 7.0	
<p>2. Landscape quality <i>Good design recognises that together landscape and buildings operate as an integrated and sustainable system, within a broader ecological context.</i></p>	<p>The protection and enhancement of the natural landscape of this local area is ensured by this LSP.</p> <p>The Landscape Master Plan identifies the overarching principles to guide the development of the more detailed Landscape Management Plans to be prepared as part of the subdivision application process.</p> <p>The Landscape Management Plans are to detail the design requirements for the open space areas in consultation with the Shire, which will focus on the protection of the existing environmental features and ecosystems in order to create engaging spaces which contribute to the local identity and streetscape character as well as provide for equitable access and ease of long term management and maintenance.</p>
<p>3. Built form and scale <i>Good design ensures that the massing and height of development is appropriate to its setting and successfully negotiates between existing built form and the intended future character of the local area.</i></p>	<p>The design of the LSP provides for views and vistas of the Manjedal Brook and proposed areas of POS (both internally and externally to the LSP Area), from the future residential and high school sites. The ability to maintain the visual connection to these areas as part of the built form outcome is essential to achieving the future character of the local area, which is to draw on the distinctive natural beauty of this location.</p> <p>The road network and proposed density layout illustrated on the concept design at Figure 9 demonstrates the design focus on the native attributes of the area.</p>
<p>4. Functionality and build quality <i>Good design meets the needs of users efficiently and effectively, balancing functional requirements to perform well and deliver optimum benefit over the full life-cycle.</i></p>	<p>The LSP is designed to provide a functional environment with spaces suited for their intended land uses and ensuring maximum flexibility for built form design which can connect and engage with the surrounding environment.</p> <p>The LSP Map is designed to allow for the more detailed subdivision layout of the residential area to appropriately respond and connect with to the other uses of the LSP Area, including the areas of open space and the co-located High School and District Playing Fields reserve. The concept layout for the design of the residential area demonstrates that the design is able to seamlessly connect with these other land uses within the LSP Area when they are developed in the future, without any need for major modification to the layout.</p> <p>The regular shape and size of the land area set aside for the co-located High School and District Playing Fields and the bounding road network similarly provides flexibility and adaptability for its future development to integrate in a highly connected manner with the surrounding built and natural environment.</p>
<p>5. Sustainability <i>Good design optimises the sustainability of the built environment, delivering positive environmental, social and economic outcomes.</i></p>	<p>Sustainable landscape and urban design is to be established through the water sensitive design principles as detailed in the <i>Local Water Management Strategy</i> attached at Annexure 8. The main practices to be adopted include: stormwater management that incorporates the latest water sensitive urban design practices, groundwater resource management; the protection and enhancement of ecosystems which are dependent on water resources from the land; and sustainable water servicing. These practices combine to ensure the urban development in this location will not adversely impact on the existing natural features and ecological processes of this location.</p>

(cont.) TABLE 4: COMPLIANCE WITH DESIGN PRINCIPLES OF SPP 7.0	
<p>6. Amenity <i>Good design provides successful places that offer a variety of uses and activities while optimising internal and external amenity for occupants, visitors and neighbours, providing environments that are comfortable, productive and healthy.</i></p>	<p>The LSP includes a suitable mix of land uses to create a viable, thriving and diverse urban environment. The land uses include residential, recreation and a co-located High School and District Playing Field reserve. An appropriate range of densities are proposed to provide for housing best suited to the main demographic (families) choosing to reside in this location, with a direct connection to the future High School and District Playing Fields intended to be developed in the long term, once the population has significantly increased to a level which necessitates the need for these additional community facilities in Mundijong.</p> <p>The concept design (at Figure 9) demonstrates that the land is capable of being developed with regular sized lots which can be orientated towards the road network and adjacent areas of public open space and the future High School site. The Public Purposes Reserve (for development of the co-located High School and District Playing Fields) is similarly regular shaped and allows for flexible design and the ability for the design to achieve maximum orientation and interaction with the surrounding environs.</p>
<p>7. Legibility <i>Good design results in buildings and places that are legible, with clear connections and easily identifiable elements to help people find their way around.</i></p>	<p>The LSP design ensures a highly legible place will be created. This is achieved through the road and path network, which provides for a clear movement system. The main intersecting road reserve with Keirnan Street which extends along the eastern side of the Public Purpose Reserve has an increased width and visually connects to the area of public open space adjacent to the Manjedal Brook, external to the LSP Area. This main road connection and connecting footpath to the proposed dual use path on Keirnan Street provides for easy movement of vehicles, cyclists and pedestrians to the future community and high school facilities to be provided at the Public Purposes Reserve and the recreational opportunities within areas of POS along the banks of Manjedal Brook.</p>
<p>8. Safety <i>Good design optimises safety and security, minimising the risk of personal harm and supporting safe behaviour and use.</i></p>	<p>The LSP design ensures the subsequent subdivision is capable of responding to the need to maximise the opportunities for passive surveillance of the public open space areas and future high school development. Further, that the road network is capable of being designed to incorporate street lighting for the optimal safety and security of the future residents of this local area.</p>
<p>9. Community <i>Good design responds to local community needs as well as the wider social context, providing environments that support a diverse range of people and facilitate social interaction.</i></p>	<p>The LSP design proposes a density mix of R20-R30 in accordance with the District Structure Plan. This density mix will allow for a suitable range of dwelling types to provide housing choice for the main demographic sectors choosing to reside in this location. The regular shaped lots ensure the land is capable of adapting to different demographics and changes to housing needs, including housing affordability options and accommodating all age groups and abilities.</p>
<p>10. Aesthetics <i>Good design is the product of a skilled, judicious design process that results in attractive and inviting buildings and places that engage the senses.</i></p>	<p>The LSP seeks to ensure the main cultural and natural attributes of this location are sensitively protected in a way which will allow for these elements of the landscape to be protected as natural landmark features of the local area.</p> <p>The arrangement of the land uses and the protection of the Aboriginal heritage values, native mature trees and focus on the conservation of the adjacent Manjedal Brook provides the essential foundation for the development of this new urban location into a highly aesthetic and inviting place to live, learn and recreate.</p>

LIVEABLE NEIGHBOURHOODS (WAPC 2009 and draft 2015)

The LSP Map is designed to respond to the principle aims, objectives and relevant requirements of *Liveable Neighbourhoods (WAPC, 2009 and draft 2015)*.

In particular, the LSP incorporates the design element requirements of *Liveable Neighbourhoods* in regard to road network design, lot density range and public open space. Further detail on the compliance of the LSP design with the relevant elements of *Liveable Neighbourhoods* is detailed in **Section 5.0** of this report.

3.5 PRE-LODGE MENT CONSULTATION

Pre-lodgement consultation involved the presentation of the initial concept design for the LSP at the *Design SJ Technical Advisory Group Meeting* held on September 13, 2018. Following that meeting, a detailed schedule of the items discussed at the meeting was submitted to the Shire and additional information and comments were provided by the Shire's Technical Officers to address specific matters and determine the detail required to be provided in the LSP. The LSP was submitted on 12 June 2019 for formal assessment addressing all of the matters raised during the preliminary consultation process.

The Shire advising in writing on 9 July 2019 that further detail was required. Further consultation was undertaken and a formal request to confirm the required boundary of the LSP was presented to the Ordinary Meeting of Council held on 14 October 2019. The Council resolved to support the revised boundary for the LSP Area. The Shire confirmed the decision in correspondence dated 23 October 2019 and reiterated that the requested additional information listed in the correspondence dated 9 July 2019 was to be provided to cover the area of the defined boundary for Sub-Precinct G2, prior to the acceptance and advertising of the LSP. This information is now provided, as required.

4.0 SITE CONDITIONS AND CONSTRAINTS

4.1 BIODIVERSITY AND NATURAL AREA ASSETS

A *Landscape and Vegetation Strategy* including a Level 1 Fauna Survey and targeted Black Cockatoo Site Assessment has been undertaken by GHD for the landholdings contained within the LSP Area. A complete copy of the *Landscape and Vegetation Strategy* is attached at **Annexure 5**.

FLORA AND FAUNA

The findings of the analysis are listed below.

1. The site is predominantly cleared and completely degraded. The land has been historically used for livestock farming and is described as 'Parkland Cleared'.
2. The site has been highly modified, with the vegetation structure no longer intact. There is no native understorey remaining on the land. The vegetation that remains consists of scattered *Eucalyptus* trees (both native and planted) over introduced grasses and herbs.
3. There are some scattered remnant trees in the northern section of the land and two (2) rows of introduced Eucalypt species planted on Lots 11 and 12. The remnant trees in the north eastern corner of the site comprising of jarrah and marri are to be protected within a proposed area of POS, as potential habitat for the Black Cockatoo and to strengthen the creation of a sense of place and belonging for the future residential community, through connection to the natural beauty of this area.
4. Three (3) vegetation types are present within the Lang Road Reserve, located between the lots the subject of the LSP. The majority of the vegetation consisting of Jarrah/Marri/Sheoak woodland, *Melaleuca* closed woodland and marri woodland. There is no native understorey.
5. A small pool of water was identified in the far-east corner of Lot 14 during the 2018 spring flora survey. This area was dry during the 2020 survey. This area is therefore identified as being seasonally inundated and is situated adjacent to the Manjedal Brook (Conservation Category wetland UFI 15446) that flows in a westerly direction, located to the north of the LSP Area.
6. The area is intersected by Environmentally Sensitive Areas (ESAs) extending along Soldiers Road and Manjedal Brook and is located partly within a regional ecological linkage and is adjacent to Bush Forever Site No. 350, along its eastern boundary and part of its southern boundary. The remnant vegetation associated with the ecological linkage extends along the Soldiers Road reserve and the railway reserve, which is outside of the LSP Area.

7. There is no declared rare flora; priority species or threatened ecological communities in or near (within 1.0 km) of the site.
8. No breeding activity or roosting sites of the Black Cockatoo were recorded during the survey.
9. The completely degraded and cleared site has resulted in the site being declared by GHD as having low habitat value.

4.2 LANDFORM AND SOILS

LANDSCAPE AND TOPOGRAPHY

The topography of the LSP Area has a gradual fall from east to west, with the site levels grading from 40.5m AHD in the south eastern corner of the site (at the intersection of Keirnan Street and Soldiers Road) and 39.0m AHD in the north eastern corner of the site; to 31.0m AHD at the western boundary of the LSP Area (being the western side boundary of Lot 50 and the western most point of the section of Lot 101 included in Sub-Precinct G2).

The highest groundwater level is 38.4m AHD in the south-eastern corner of the LSP Area, at a depth of 1.5m (below ground level). Groundwater levels decrease to the north and north west, with much of the ground in the western part of the LSP Area being dry to over 2.0 metres.

The hydraulic gradient slopes in a west-north-west direction.

The geotechnical investigation confirms that the land comprises of four (4) subsurface conditions including topsoil; medium grained; sand with moderate to low slit content, very dense, fine to medium grained sandy gravel with clay and clayey sand with gravel. Further, the site is confirmed to contain good drainage characteristics in all areas, including the sites identified for the drainage basins. A complete copy of the *Geotechnical Investigation* prepared by *Brown Geotechnical* is attached at **Annexure 6**.

ACID SULFATE SOILS

The soil mapping identifies the LSP area as being at 'low risk' of Acid Sulfate Soil occurrence.

CONTAMINATION

GHD have confirmed that, following a review of the *Contamination Sites Database* on June 25, 2018, the landholdings within the LSP Area are not known to be contaminated.

4.3 HYDROLOGY

The management of ground and surface water is detailed in the comprehensive *Stormwater Modelling Report* and *Local Water Management Strategy* (LWMS) prepared by *Calibre*.

The existing hydrology of the site and surrounds is summarised below and detailed in the *Stormwater Modelling Report* at **Annexure 7** and the LWMS attached at **Annexure 8**.

GROUNDWATER

Pre-development monitoring was carried out between 2016 and 2017.

Winter groundwater levels at the site are approximately 1.5m below the surface in an average year and fluctuating to the surface in a high rainfall year.

A minimum separation of 1.5m to the estimated pre-development groundwater level or impermeable clay layer will be maintained post-development. Where this separation does not already exist, imported fill and subsoil pipe network will be utilised.

SURFACE WATER

The pre-development modelling has confirmed that there are no significant waterways or wetlands within the land. As such, it has not been necessary to undertake surface water quality monitoring.

A degraded surface channel extends across the southern portion of the land, which is confirmed through the stormwater modelling to be insignificant in terms of stormwater management. The *Department of Environment and Water Regulation* has confirmed that filling of the degraded channel is able to be supported, following geotechnical investigation and flood modelling to confirm no adverse impact on the downstream environment.

The *Stormwater Modelling Report* prepared by Calibre confirms no impact. Therefore, it is considered suitable for the slight depression in the surface of the land to be filled using clean imported fill; and the redundant culvert on Soldiers Road to be blocked. The detailed modelling undertaken to confirm the design approach for this part of the land is contained in the *Stormwater Modelling Report* attached at **Annexure 7**.

Stormwater modelling of the nearby Manjedal Brook completed in 2015 indicates that peak flood levels within the Brook fall in a westerly direction from 38.5m AHD to 34.0m AHD.

WETLANDS

The findings of the *Landscape and Vegetation Strategy* by GHD confirms that there are no RAMSAR or Wetlands of National Significance within 5.0 km of the LSP Area.

A single Geomorphic Wetland intersects the LSP Area, being identified as a Multiple Use wetland (UFI 16021). However, no riparian vegetation was found. This indicates that the MU wetland is underneath the ground. In addition to this, GHD found no evidence of waterlogging or swamp vegetation species growing within the LSP Area.

A small portion of the Conservation Category Wetland buffer to Manjedal Brook extends into the LSP Area. This buffer is identified on the LSP Map and the area is retained within the area of POS.

WATERCOURSES

No creek lines are located within the LSP Area.

The closest waterbody is the Manjedal Brook which flows east-west and is located to the east of the LSP Area.

A small depression exists in the north eastern corner of the LSP Area, adjacent to Manjedal Brook. This depression is likely to be seasonally inundated and is to be retained within an area of POS.

4.4 HERITAGE

ABORIGINAL

The LSP Area is located within the Gnaala Karla Booja country.

An *Aboriginal Heritage Ethnographic Survey* and *Archaeological Assessment* have been undertaken over the LSP Area. A complete copy of both the Aboriginal Heritage Survey is attached at **Annexure 9**.

The Survey was conducted on 27 March 2020 and involved eight (8) Aboriginal consultants drawn from the Bilya and Winjan groups.

The findings and recommendations of the Survey are summarised below, which includes specific requirements for the individual landholdings contained within the LSP Area. This is particularly important as an Aboriginal site has been identified on the Department of Education landholding which will require further assessment by the Department prior to the land being designed for development as a High School, at the appropriate time in the future.

- **Lot 50 Kiernan Street, Mundijong (owned by the Department of Education)**

A newly identified Aboriginal site has been identified on the *Department of Education* landholding at Lot 50.

This site is known as *Sam Woods Camp (MJ20-01)*. Details of the significance of the site are contained in the assessment reporting attached to the LSP.

The Assessment states that this newly recorded place is likely to meet the requirements of Sections 5 and 39(2) of the *Aboriginal Heritage Act 1972 (AHA)* and should be avoided and not impacted upon in any way without Ministerial consent under section 18 of the AHA.

The *Department of Education* will be required to undertake further assessment in consultation with the Aboriginal consultants, who have requested that the site be preserved or at least commemorated (through such means as interpretative signage). It is also recognised that this site could play an important role, with its integration into the design of the future school providing an opportunity to educate the school children on the Aboriginal history of the Mundijong area.

In addition, the Aboriginal consultants have identified a potential subsurface archaeological material site at the site of an elevated sand dune on Lot 50. This site is noted as having 'moderate potential' of containing an archaeological subsurface deposit and is required to be further investigation by the Department of Education, prior to any site disturbance.

- Eastern portion of Lot 101 Lang Road (privately owned landholding)

The existing Heritage place (scarred tree) on the eastern portion of Lot 101 Lang Road is to be protected. The Assessment has confirmed that it is likely to meet the requirements of Sections 5 and 39(2) of the *Aboriginal Heritage Act 1972* (AHA) and should be avoided and not impacted upon in any way without Ministerial consent under section 18 of the AHA.

It is recommended that a 30-metre protective buffer be applied around the tree during any ground disturbing works to ensure the root system is not damaged.

**- Lot 10 Keirnan Street (privately owned landholding); and
Lots 11 to 14 Keirnan Street (DJMM landholding)**

The Survey concludes that the isolated stone artefacts observed within the lot boundaries of Lots 10 to 14 Keirnan Street are considered not to constitute Aboriginal archaeological sites.

Notwithstanding this, it is noted that there is some potential for subsurface archaeological material to be present. It is therefore recommended that initial ground disturbance on these landholdings be monitored by one (1) or two (2) Gnaala Karala Booja representatives. Contingency plans will be required to be developed at subdivision stage, to allow for culturally appropriate management of such discoveries.

EUROPEAN

There are no listed European Heritage sites within the boundaries of the LSP Area identified on the *State Heritage Council* database.

The Shire of SJ does however identify the Manjedal Brook on its Municipal Inventory as being a place of significance for its natural landscape and historic relevance to the pattern of settlement. In recognition of the importance of the nearby Brook to the local community, the LSP design proposes the development of public open space along the length of the northern boundary of the LSP Area. The designation of public open space along the Brook will assist in creating a buffer to protect and preserve the natural beauty of the Brook.

4.5 BUSHFIRE MANAGEMENT

A *Bushfire Management Plan* (BMP) has been prepared by *Lush Fire and Planning* for the LSP Area, which demonstrates compliance with objectives and the relevant Bushfire Protection Criteria of SPP 3.7.

The BMP concludes that post-development the land is able to achieve a BAL 29 rating or lower; and notes that access to the LSP Area is provided through multiple locations. The specific design attributes of the LSP which address matters of bushfire management are detailed at **Section 5.0** of this report.

Further detail of the conclusions of the BMP are provided in the copy of the BMP attached at **Annexure 3**.

4.6 RAIL TRANSPORT NOISE

A *Transportation Noise Assessment* has been prepared for the DJMM landholdings within the LSP Area by *Lloyd George Acoustics*. The affected lots are those closest to the railway and therefore consideration of the degree of exposure to freight train noise on the future residents is required.

It is recognised that both the existing DSP and the proposed revised DSP for Mundijong identify the planned relocation of the freight rail service to run along the western side of the future Tonkin Highway extension, and to the east of the future West Mundijong Industrial area.

Notwithstanding the likely relocation of freight rail and noting that the Australind passenger rail service will still utilise the existing rail line within the reserve, a conservative assessment has been undertaken based on the current situation. It is therefore considered that the findings presented are the worst-case scenario.

The assessment has concluded that the closest lots to the eastern boundary will require noise mitigation measures. A noise wall is not proposed as part of the requirements to reduce the impact of noise from the existing rail operations, so as to ensure the development remains open and visually connected with the Soldiers Road frontage of the LSP Area. Further, the construction of a noise wall may result in adverse impact on the protected vegetation within the Soldiers Road reservation and therefore should be avoided.

Instead of a noise wall, façade protection packages for the ground and first floors of dwellings are proposed for the affected lots, together with other mitigation measures including notifications on the relevant Certificates of Title. A complete copy of the *Transportation Noise Assessment* is attached at **Annexure 4**.

5.0 LOCAL STRUCTURE PLAN

5.1 LAND USE

The LSP proposes a robust and legible urban structure for the future residential community of this location of Mundijong. The design encourages a strong connection and association with the natural beauty and historic landscape attributes of the surrounding locality. In this way, the LSP design creates a strong sense of place and belonging for the community of this part of Mundijong North. A **Concept Plan** illustrating a possible option for the subdivision and development of the LSP Area in accordance with the key principles and requirements of the Planning Framework is included at **Figure 9**. This detailed concept layout of the LSP Map is a ‘non-statutory’ version of the LSP Map and is not to be interpreted as the approved subdivision design. The detailed design of the relevant stages will be further refined and developed at subdivision stage.

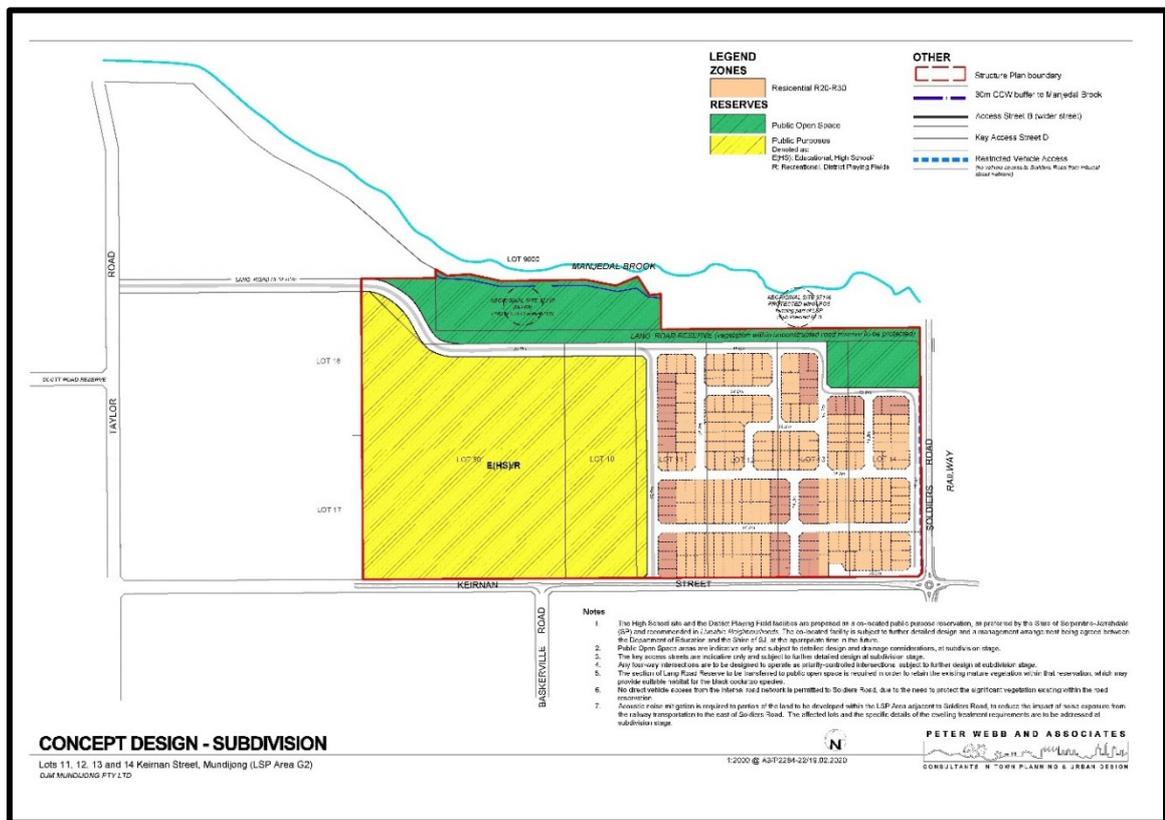


Figure 9: Development Concept Layout

The overarching principles and requirements of the LSP, which are demonstrated in the Concept Plan are listed below.

1. Creating a strong sense of place and belonging by responding to and protecting the important natural and historic features of the immediate area and ensuring a highly connected walkable neighbourhood, focusing on pathway connections to the recreational areas adjacent to Manjedal Brook and a strong connection to the future High School and District Playing Fields Reserve.

2. Ensuring the Aboriginal heritage sites identified within the LSP Area on Lot 50 and the eastern part of Lot 101 are sensitively protected and appropriately interpreted.
3. Responding to the local context by designing an urban structure which seamlessly integrates with endorsed and adopted neighbouring Local Structure Plan designs and the wider strategic plan for Mundijong, as detailed in the endorsed and revised DSP.
4. Applying urban water management techniques to ensure the efficient and sensitive management of water, with careful consideration being to ensure the protection of Manjedal Brook to the north of the LSP Area.
5. Incorporating an appropriate mix of residential densities and lot sizes, offering a range of housing types to cater for the main demographic choosing to reside in this area.
6. Providing sufficient land area for the future development of a co-located High School and District Playing Fields Public Purposes Reserve, to accord with the requirements of the endorsed and proposed revisions to the DSP for Mundijong. The co-located facility will provide for the efficient use of the district level sporting facilities through a shared arrangement between the Shire of SJ and the *Department of Education*.
7. Ensuring the development of a variety of public open space areas to offer both active and passive recreational opportunities (as well as focusing on conservation of the natural environment and Aboriginal heritage values of identified sites) for the enjoyment of the community.
8. Creating a permeable and well-connected road and path network, which implements the road network of the DSP and integrates with the approved local networks of neighbouring LSPs. In particular, noting the future proposal to close the 'at grade' rail crossing at Keirnan Street.
9. Delivering a development which has a strong visual connection to the natural beauty of the area, including Manjedal Brook and the landscape corridor of Soldiers Road.
10. Protecting the limited remaining mature remnant vegetation within the LSP Area, where possible.
11. Providing sufficient setbacks to ensure adequate separation from vegetation for the purposes of bushfire management.
12. Providing for the extension of infrastructure and services in a coordinated and orderly manner to facilitate the urban development of this location.

A summary of the design attributes of the Concept Plan (indicatively illustrated at **Figure 9**), resulting from the application of these overarching principles, is provided below.

1. An approximate lot yield of 230 residential lots, at a density range of R20-R30.

2. The higher density lots are concentrated on the section of the road network fronting the High School and District Playing Field Reserve; and the sections of access road which front onto the area of POS in the south eastern corner of the site.
3. An approximate overall open space area of 3.95 hectares is distributed throughout the LSP area to offer appropriate recreational areas for the enjoyment of the community. The eastern portion of Lot 101 Lang Road is included in this area, which provides an opportunity for recreational pursuits as well as the protection of the Aboriginal Heritage site. This open space area calculation does not take into account the land set aside for the District Playing Fields which area of open space is included in the Public Purposes Reserve and the section of Lang Road which contains mature trees. This area of the public open space will form part of the restricted area public open space component of the development, to be defined as part of the subsequent subdivision application.
4. A strong permeable road network, with a bounding road to the future High School and District Playing Fields Public Purposes Reserve, the Manjedal Brook and along the frontage to Soldiers Road.
5. A shared path network extending along Keirnan Street to connect with the existing path running along the eastern side of Soldiers Road, which extends south along Paterson Road to connect to the existing Mundijong Town Centre (and future connection to the future Activity Centre forming part of Precinct A).

5.2 RESIDENTIAL

The main land use of the LSP is Residential. The assigned Residential Density Codes accord with the revised DSP for Mundijong which identifies the area on the DSP Map as 'Low (Suburban): R20-R35'.

The design incorporates densities of Residential R20-R30, which will offer a variety of lot sizes and housing types appropriate to suit the needs of the main demographic sectors of the residential community choosing to reside in this locality.

The density range is identified on the LSP Map. A Concept Plan is also included at **Figure 9** to illustrate a possible option for the subdivisional development of the land. The design allows for regular shaped lots and consistent lot dimensions for efficient lot layout, minimising civil engineering and building construction costs. This will ensure housing affordability options are able to be offered to this community.

Dwelling Yields and Density Targets

The LSP is able to achieve approximately 230 dwelling lots, at a density code range of R20-R30.

The higher density lots are proposed to be concentrated adjacent to the areas of amenity including the future High School and District Playing Fields Public Purposes Reserve and the areas of public open space.

Perth and Peel@3.5million identifies a **residential density target** of 15 dwellings per gross hectare of urban zoned land. The LSP Area has the potential to create approximately 230 lots, which reaches a residential density target of six (6) dwellings per gross hectare of urban zoned land. The reason the urban density target is not reached is due to the significant amount of land area required to be set aside for the future High School and District Playing Fields Public Purposes Reserve and the preservation of the mature trees in the Lang Road reserve. Should this land not be included in the density target calculation and only the area proposed for residential development is included, the LSP meets the requirement, achieving exactly 15 dwellings per hectare.

The **residential site density target** identified is 26 dwellings per residential site hectare, pursuant to *Perth and Peel@3.5 million*. The LSP achieves close to this target, with it being anticipated that the development will have the ability to create approximately 24 dwellings per net residential site density.

Community Gardens

The Shire of SJ recognises the importance of supporting community connectiveness in its local government area. This initiative of the Shire is encouraged through the use of community gardens as detailed in the *Council Policy 5.2.3 – Community Gardens*. This particular aspect of community development is not typically addressed at the broader structure planning stage. This is due to such initiatives being community-based programs which are to be established in consultation with the Shire on land under its management and control. The importance of establishing such programs as a way to encourage the interaction of the community in a shared space is however recognised and encouraged.

5.3 PUBLIC OPEN SPACE

The LSP provides an extensive range of public open space (POS) to cater for a wide variety of recreational pursuits, including active and passive areas at local and district level, as well as ensuring a strong focus is achieved on the importance of conservation of the natural environment.

The LSP proposes a total of 3.95 hectares of public open space. This calculation does not include the land set aside for the District Playing Field which is proposed to be developed as part of a single Public Purposes Reservation with the High School. The co-location of these facilities is the preferred arrangement of the Shire of SJ to ensure land efficiency. This approach to the provision of playing fields shared with schools is supported by *Liveable Neighbourhoods* (WAPC).

A summary of the proposed public open space provided in the LSP is provided below and detailed at **Table 5: Public Open Space Schedule**:

1. 3.9 ha of gross public open space is designed across the LSP Area, which equates to 13.62% of the total net site area of the LSP Area, excluding the land set aside for the Public Purposes Reservation. This amount of POS exceeds the required 10% contribution of the WAPC. The additional POS is provided to ensure the adjacent Manjedal Brook, the identified Aboriginal site (scarred tree) on Lot 101 and the mature vegetation within the unmade Lang Road reserve and at the north eastern corner of the site are protected in perpetuity within areas of recreation for the benefit of the local community. (This calculation does not include the two (2) District Playing Fields identified within the area of Public Purposes Reserve.)
2. The District Playing Fields are proposed to be shared with the High School and therefore form part of the Public Purposes Reserve.
3. A lineal POS is proposed to follow Manjedal Brook to the north of the LSP Area, which includes a portion of the Conservation Category Wetland (CCW) buffer to the Brook and ensures the protection of the identified Aboriginal sites, including the site identified on Lot 101 as part of this LSP and the site identified as forming part of the POS proposed for the LSP for 'Sub-Precinct G1'.
4. Two (2) small drainage basins are proposed within POS areas in the eastern extents of the LSP Area (as part of the DJMM urban development). These drainage basins are designed for stormwater management associated with the development of the residential area to the east of the co-located High School and District Playing Fields Public Purposes Reserve.

TABLE 5: PUBLIC OPEN SPACE SCHEDULE		
Total Site Area (ha)		36.26
Deductions		
High School and District Playing Fields Reservation	15.64	
Drainage Basins (refer to Notes 1 and 2)	0.0041	
Surplus restricted Public Open Space ¹	1.41	
Total Deductions		17.05
Net Site Area		19.21
Required Public Open Space (10%)		
Min 8% unrestricted POS	1.54	
Max 2% restricted POS	0.38	
Breakdown of POS Provided		
	Unrestricted	Restricted
POS 1: Manjedal Brook	2.05 ha	1.71 ha
POS 2: Local Park (N/E corner)	0.9246 ha ²	0.0774 ha
POS 3: District Playing Fields	N/A	N/A
Total	2.97 ha (14%)	1.7874 ha Credited Restricted POS: 0.38 ha (2%) Surplus Restricted POS: 1.41ha
Total POS (credited)		3.35 (17%)

- Note 1: In accordance with R26 of Liveable Neighbourhoods, drainage basins are proposed within areas of POS for stormwater drainage purposes, as part of the proposed development of the DJMM landholdings within the LSP Area.*
- Note 2: In accordance with R25 and R33 of Liveable Neighbourhoods, the area of POS 2 which is subject to 1:1-year inundation is deducted from the net site area. It is also noted that the drainage basin proposed within POS 3 forms part of the shared use High School and District Playing Field reservation. This drainage basin on POS 3 is included as a full deduction and therefore the small portion of the basin which is subject to a 1:1-year inundation is not included as a separate deduction.*
- Note 3: In accordance with R33 of Liveable Neighbourhoods, the encroachment of the CCW buffer to the Manjedal Brook into the area of POS 1 is calculated as 'restricted POS'.*
- Note 4: In accordance with R43 of Liveable Neighbourhoods, the surplus area of restricted POS is included as a deduction to the site area.*
- Note 5: In accordance with R43 and the objectives of Element 8 of Liveable Neighbourhoods, the District Playing Fields are to form part of a co-located reserve with the future High School, to improve land use efficiency of the playing fields. The District Playing Fields are therefore identified as a full deduction to the total site area.*
- Note 6: Drainage areas are based on the Calibre LWMS prepared to facilitate the subdivision of the DJMM landholdings in the eastern part of the LSP Area. The drainage proposed for this area ensures sufficient capacity it provided to allow for unhindered and progressive development in the western part of the development and to accommodate the future High School.*
- Note 7: The public open space illustrated on the LSP Map and the areas calculated are indicative only and subject to further refinement and design at subdivision stage.*

LANDSCAPE CHARACTER STATEMENT - PUBLIC OPEN SPACE AREAS

The LSP defines the **landscape character** as maintaining a strong connection to the natural environment of Mundijong and focusing on the preservation and protection of the Aboriginal heritage values of this location within the proposed parkland areas.

A *Landscape Master Plan* has been prepared which defines the intended landscape character for the area, which is attached at **Annexure 10**. Further detail on the design of the landscaping for the open space areas is required to be undertaken in the form of a Landscape Management Plan, for each respective subdivision application. The requirement for a detailed Landscape Management Plan is referenced at *Part One: Implementation, Section 7.0* of the LSP and further detailed in the following section titled: *Landscape Master Plan*.

The overarching principles detailed in the attached *Landscape Master Plan* are to be taken into consideration at the more detailed Landscape Management Plan stage.

POS 1: Manjedal Brook Reserve

1. The proposed area of public open space identified on the *Landscape Management Plan* as POS 1 has a total area of approximately 2.05 ha.
2. The **landscaping theme** for POS 1 is focused on conservation and protection of the existing matures trees and adjacent Manjedal Brook.
3. POS 1 holds an important Aboriginal heritage site (scarred tree) which is to be protected and commemorated, in a culturally sensitive manner.
4. A 30m buffer to the Brook and around the scarred tree on Lot 101 is to form part of the landscaping management of this open space.
5. The unmade Lang Road reservation forms part of this area of POS. The existing mature trees within the reserve are to be protected.
6. The remaining area of POS 1 is to be maintained in its existing parkland cleared state, providing the community with an active and passive recreational area adjacent to Manjedal Brook. The creation of open space adjacent to the Brook will encourage the community to form strong connections with the natural environment and the Aboriginal history of this location.
7. POS 1 includes a small portion of the buffer to the Conservation Category Wetland (Manjedal Brook) which is mostly contained within the adopted LSP for Sub-Precinct G1. The buffer extent which encroaches into the LSP Area is indicative only and subject to further refinement at subdivision stage.
8. POS 1 extends to include and protect the existing mature vegetation contained within the unmade Lang Road Reservation. It provides a continuous link to POS 2.

9. POS 1 protects the Aboriginal site ('Other Heritage Place' (ID: 37115)) recorded on Lot 101 within the LSP Area and ensures a seamless connection to the area of POS contained within the LSP Area for Sub-Precinct G1, which contains the other identified Aboriginal site ('Other Heritage Place' (ID: 37116)) on this southern side of the Manjedal Brook. This offers an opportunity to sensitively commemorate and educate the community on the Aboriginal history of Mundijong.
10. POS 1 seeks to encourage recreation at a fundamental level with the *Landscape Master Plan* recommending sensitively located nature play elements and picnic facilities, to be detailed in the Landscape Management Plan, as part of the subdivision application processes.
11. An integrated footpath is to be designed to encourage pedestrian movement, as part of the Landscape Management Plans.

POS 2: Local Park

1. POS 2 is a local park with an approximate area of 1.03 ha.
2. The **landscaping theme** for POS 2 is a continuation of the conservation of the native vegetation and providing the seamless connection, through nature, to POS 1.
3. This local park is to retain the existing mature (jarrah and marri) trees as 'potential habitat trees', which trees are identified in the *Landscape and Vegetation Strategy* as providing possible roosting opportunities for the Black Cockatoo.
4. The retention of the significant mature trees within POS 2 has the additional benefit of creating a strong sense of place and belonging for the future residents, as it retains the few remaining natural landscape attributes of this historically cleared farming land.
5. POS 2 will provide some nature play elements and opportunities for picnic facilities, to encourage the use of the area for active and passive recreational pursuits.
6. An integrated footpath is to be designed to facilitate pedestrian movement to connect to the external areas of open space, when developed in the future.

POS 3: District Playing Fields

1. The District Playing Fields adjacent to the future High School are identified in this location in the endorsed and revised DSP for Mundijong.
2. The Playing Fields and the High School site are proposed as a co-located Public Purposes Reserve. A management agreement will be required to be arranged between the *Department of Education* and the Shire of SJ to guarantee exclusive use rights for the High School to the Playing Fields during school hours, and that the facilities will remain available to the public in the long term.
3. The total Public Purposes Reserve has an indicative land area of 15.64 hectares.

4. The Reserve includes Lot 50 and Lot 10 Keirnan Street, together with a small portion of Lot 11 Keirnan Street.
5. The recent Aboriginal Heritage Strategy prepared to support the LSP has identified a new Aboriginal Heritage site on Lot 50, which land is owned by the *Department of Education*. This newly located site (Sam Wood's Camp) is identified on the attached *Landscape Master Plan* and further detailed in the Aboriginal Heritage Strategy documentation attached at **Annexure 9**.
6. The newly identified Aboriginal Heritage site and a possible sub-surface archaeological site found on Lot 50 requires further investigation and assessment by the *Department of Education* in consultation with the Gnaala Karla Booja representatives, in the future when the site is proposed for development.
7. The area set aside for the Public Purpose Reserve is sufficient to accommodate both the High School and two (2) District Playing Fields, for shared use with the community, and the regular shape of the landholding allows for the future High School and Districts Playing Fields to be developed in a manner which ensures the newly identified Aboriginal site of Sam Woods' camp are able to be sensitively protected and commemorated.
8. The area allows for a High School development and one (1) playing field over an approximate land area of 11.6 hectares. This land area meets with the requirements of R9 of *Liveable Neighbourhoods*, which states that the size of government secondary schools should generally provide 10 hectares.
9. The remaining land area is provided to allow for the future development of the second District Playing Field. This area has an approximate size of 3.88 hectares, which is more than sufficient to accommodate this facility.
10. Both Playing Fields are to be orientated 15 degrees east of north and have a minimum area (per field) of 205m x 175m (3.587ha each) and designed to allow for the remaining few mature trees to be retained and the Aboriginal heritage place to be protected.
11. Integrated footpaths to encourage pedestrian activity around the Public Purposes Reserve, with strong connections to POS 1 and POS 2, are to be provided throughout the LSP Area, which design will be detailed as part of the Landscape Management Plan requirements, at subdivision stage.

LANDSCAPE MASTER PLAN

A *Landscape Master Plan (LMP)* has been prepared to support the LSP.

The LMP details the following **guiding principles** for establishing the landscape character and theme for the LSP Area in the development of the public open space areas and within the road reserves, in accordance with the Landscape Design Guidelines contained in the endorsed DSP.

1. The landscaping design is to provide a balance between conservation of the natural environment and the protection of the Aboriginal history in this location, with the active and passive recreational needs of the future community to reside in this area.
2. The main objective for the landscaping design of each open space area is to enhance and protect the distinctive native (visual) historical landscape character and amenity of Mundijong.

In order to achieve this vision, the detailed landscaping plans to be prepared at subdivision stage are to retain the existing mature vegetation (where possible) particularly within street verges and along Manjedal Brook.
3. The existing natural 'green' linkages within and extending along the road reserves of Soldiers Road and within the unmade section of the Lang Road reserve are protected, providing a link between the POS areas.
4. Perimeter roads bounding all areas of proposed recreational reservations are necessary to ensure sufficient separation distance to vegetation, for the purposes of bushfire management.
5. Landscaping within the areas of POS are to be selected with reference to the plant species identified in the Shire's *Low Flammability Local Native Species*.
6. Street trees are to be planted at a rate of one (1) tree per residential lot, where possible. The trees are to be placed central to the lot frontage and set back to allow for crossovers, utility services including street lighting, and footpaths.
7. The tree species are to be chosen from the Shire's preferred tree species list and will be identified in the site specific, detailed Landscape Management Plans, which are required to be prepared at the subdivision application stage and approved by the Shire.
8. Tree planting specifications (including species and density) must take into consideration the assigned BAL rating for the nearby residential lots and ensure that the proposed landscaping will not result in any increase to the prescribed BAL rating.
9. The drainage basins contained within POS 2 and POS 3 will contain planting suitable for seasonal inundation, e.g. reed and sedge species. While it is not expected that the basins will retain standing water during the summer months, it is likely that the soil profile will remain moist. As a result, the vegetation will not completely dry out and therefore, is classified as low threat vegetation.

10. Footpath connections are to be provided internally within the recreational areas and will connect with the shared paths and footpaths along the internal road network.

11. The control mechanisms for weeds, feral animals and plant disease are to be detailed in the Landscape Management Plans at subdivision stage.

12. Public access and the need to ensure the protection of the Aboriginal Heritage sites within POS 1 and POS 3 is to be addressed and management details included in the site-specific Landscape Management Plans, at the stage that these areas of the LSP are developed.

These principles are to be further refined as part of the site-specific Landscape Management Plans to be prepared at subdivision stage.

A copy of the LMP is attached at **Annexure 10**.

5.4 BUSHFIRE MANAGEMENT

A Bushfire Management Plan (BMP) has been prepared by *Lush Fire and Planning*.

The Bushfire Hazard Level assessment over the LSP Area concludes that the LSP Area will have either a 'moderate' or 'low' bushfire hazard level.

The principle bushfire hazards are identified as being the vegetation to be protected within the Lang Road Reserve; the public open space in the north eastern corner of the site; Soldiers Road; the Railway Reserve; and the Bella Cumming Reserve.

A BAL Contour Map has been prepared for the landholdings owned by DJMM, being the section of the LSP Area proposed for residential lot development. This BAL Contour Map indicates that the majority of the site will have a BAL-LOW or a BAL-12.5 rating. Some lots around the periphery of the site will comprise of a BAL-29 rating or lower. The concept design illustrates that the LSP Map is able to be developed in a manner which ensures compliance with SPP 3.7. This particular design demonstrates that the higher BAL-29 rating is mostly contained within the front setback area of the dwelling lot, with the majority of the built form being able to be located in the lower BAL-19 and BAL-12.5 rating components of the affected lots.

The BMP confirms that the LSP design complies with the objectives of SPP 3.7.

A complete copy of the BMP is attached at **Annexure 3**.

5.5 MOVEMENT NETWORKS

The LSP is supported by a detailed *Transport Impact Assessment* (TIA) prepared by Transcore.

The TIA concludes that the LSP design is consistent with the Planning Framework for the locality, including the endorsed and proposed revised DSP.

The road network provides a robust and permeable layout which is highly interconnected and incorporates a comprehensive network of paths to encourage pedestrian and cycling use and to create a strong sense of place and belonging for the community.

The following sections provide a summary of the detail of the TIA. A complete copy of the assessment is attached at **Annexure 11**.

EXISTING MOVEMENT NETWORK

Regional Roads

The **South Western Highway** provides the main regional road connection for the LSP Area.

The South Western Highway can currently be accessed via Keirnan Street, which street extends east over the railway reserve (at grade rail crossing) to intersect with the South Western Highway. The long-term strategic plan recommends the closure of the Keirnan Street rail crossing, with a new rail crossing intended to be constructed further north on Soldiers Road (approximately 800m from the intersection of Keirnan Street and Soldiers Road) and a re-established crossing being provided approximately 1.2km to the south near the Mundijong Train Station. The LSP Area will therefore retain direct linkages to the South Western Highway with both of the alternative crossings being directly accessible from the LSP Area by Soldiers Road.

The South West Highway also provides connections to other significant roads within the network, including Albany Highway and Tonkin Highway.

Land is reserved for **Tonkin Highway** which is to be extended further south, to the west of the LSP Area.

District and Local Roads

Soldiers Road is identified as a Local Distributor Road. It is approximately 7.8m wide, a single carriageway, two-lane road with kerbing on the eastern edge and a wide gravel shoulder on the western edge of the road. The current traffic data provided by the Shire of SJ indicates that this road carries approximately 2020vpd during a typical weekday (April 2015).

A 2.5m wide shared path is constructed along the eastern side of Soldiers Road up to the rail crossing at Keirnan Street. An existing roundabout provides for controlled traffic movements at the intersection of Keirnan Street and Soldiers Road.

No internal roads are proposed to intersect with Soldiers Road, to ensure that the vegetation landscape values contained within the road reservation are protected and not adversely impacted as a result of urban development.

Keirnan Street is identified as a Local Distributor Road, providing an east-west connection over the railway and connecting to the South Western Highway. It is constructed to a width of 4.5m-5.0m and is a single carriageway with gravel shoulders. The most recent traffic data provided by the Shire of SJ for Keirnan Street indicates that this road carries approximately 280vpd to the west of Soldiers Road and 1200vpd to the east of Soldiers Road and the railway on a typical weekday (November 2016).

The existing at grade rail crossing at Keirnan Street is identified in the existing and revised DSP for Mundijong as being closed in the future. A new crossing will be established approximately 1.2km to the south (to reconnect Richardson and Evelyn Streets) and a new connection is identified to the north, and just south of the Bishop Road intersection with Soldiers Road, which east-west link is to be constructed as part of the proposed LSP for Sub-Precinct G1. This new crossing will provide a direct connection to the future Whitby District Centre, in accordance with the revised DSP.

Taylor Road and **Adams Street** are both classified as Local Distributor Roads. Both are single carriageway rural roads with approximate shoulder widths of 6.5m and 7.2m. Based on the most recent traffic counts, Taylor Road carries approximately 1110vpd during a typical weekday (November 2016). Adams Street carries around 870vpd on a typical weekday (July 2016).

Lang Road is currently unconstructed, with only a small western section of the reservation having been constructed to provide access to private properties, at its intersection with Taylor Road. The LSP proposes the construction of the road to urban standard along its current reservation alignment until the point in which the vegetation within the reservation becomes dense and is required to be protected.

The LSP Map indicatively illustrates the proposal to retain and protect the mature vegetation in the central and eastern sections of the road reserve. The design proposes the realignment of the existing road reserve of Lang Road immediately to the south, within the southern boundary of the private landholdings. The existing reserve containing the vegetation will be preserved to form part of the public open space adjacent to the Manjedal Brook. Given land has already been set aside for the Lang Road Reservation, the Shire of SJ requirement for the road not to be constructed within the current alignment and instead this road be shifted south, with land being taken from the adjoining landowners for the realigned Lang Road Reserve, payment of compensation for the land required is to be provided to the respective landowner. (Refer to *Section 4.6 of Part One: Implementation* of the LSP, which details the subdivision and development requirements for the realignment of Lang Road and the transfer of the existing road

reservation for dedication as part of the public open space reservation, recognising the compensation rights of the landowners.)

Pedestrian Network and Cycling

A 2.5m wide shared path has been constructed along the eastern side of Soldiers Road, which connects to Mundijong Town Centre, to the south, and north for approximately 1.0km from the intersection of Soldiers Road with Kiernan Street. Other than this shared path and the developing pedestrian and cyclist network in the Whitby residential estate to the east of the railway reserve, there is a limited pedestrian and cycle network in the immediate surrounds of the LSP Area.

PROPOSED MOVEMENT NETWORK

Road Network

The TIA classifies the proposed internal road network of the LSP based on the indicative concept design proposal for the subsequent subdivision application. The proposed road hierarchy based on this concept design layout includes:

- Access Street B
- Access Street D
- Laneway

Refer to **Figure 10** which illustrates the Road Hierarchy Plan.

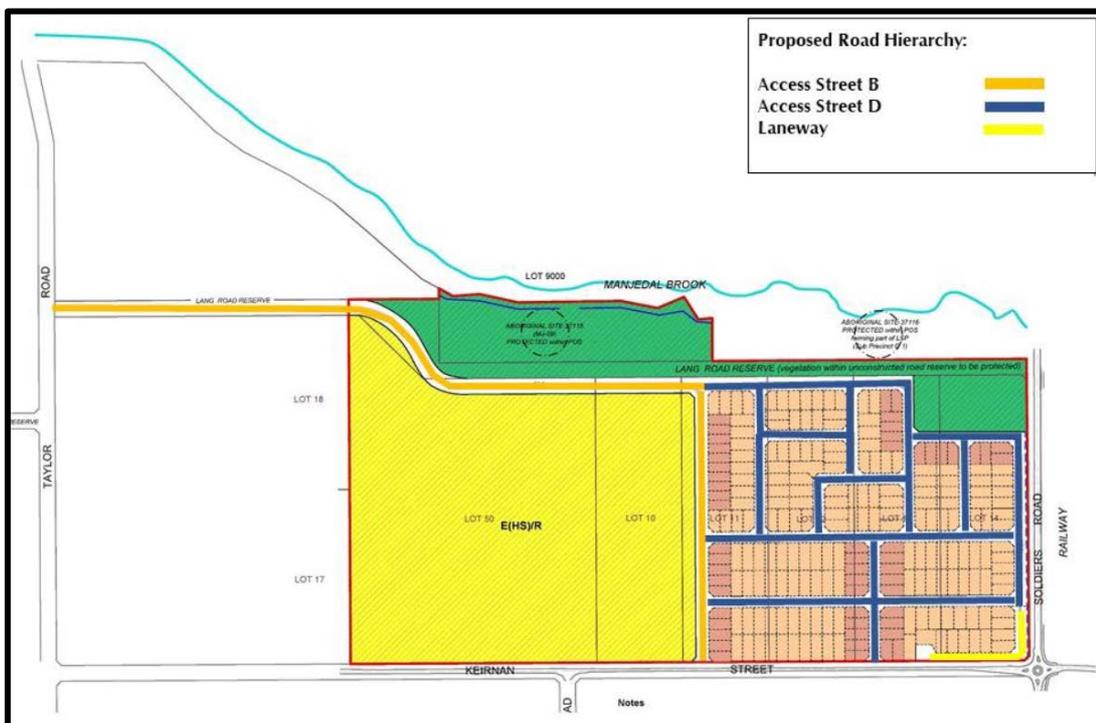


Figure 10: Road Hierarchy Plan

The main elements of the road network proposal are summarised below:

- **Access Street B** is proposed for the road network bounding the High School and District Playing Field Public Purposes Reserve along the eastern and northern boundaries. This road is proposed to intersect with both Keirnan Street and Taylor Road. These roads are proposed with varying reservation widths and provide for traffic volumes of up to 3000vpd, being common for areas with high parking activity, i.e. in close proximity to school facilities.
- **Access Street D** is proposed for the remaining internal road network (except for the service lane), which will allow for 6.0m wide carriageways and 4.1m wide verges. The Access Street D road reserve extending along the section of the open space areas adjacent to the south of Manjedal Brook is proposed with a wider reserve to ensure sufficient separation distance to vegetation, to ensure compliance with the bushfire guidelines (SPP 3.7).
- A **service lane** with a cul-de-sac head is proposed for the lots fronting Keirnan Street, in the south eastern corner of the LSP Area. This is a laneway road reserve allowing for a 6.0 wide carriageway. The section of this lane which runs north-south is proposed at an increased width of 18.0m to address bushfire management requirements in accordance with SPP 3.7.

Pedestrian and Cyclist Network

The LSP is proposed to introduce an extensive pedestrian and cyclist network, as detailed below and illustrated on **Figure 11**.

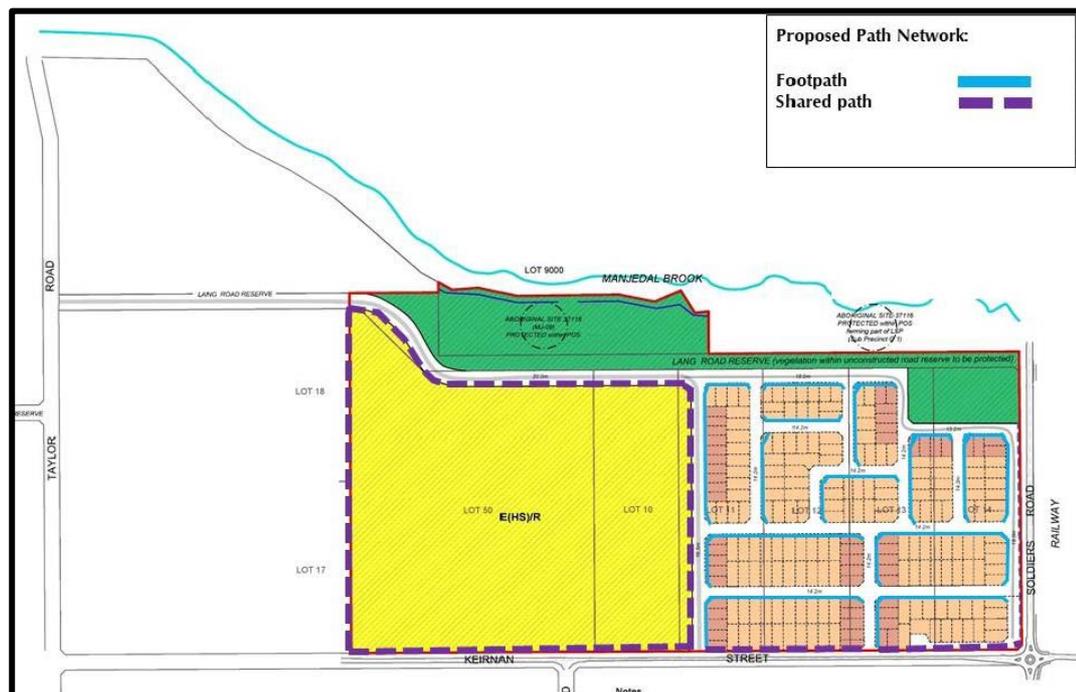


Figure 11: Pedestrian and Cyclist Network

- Strong pedestrian and cyclist linkages are to be created throughout the LSP Area and the future High School Site.
- Footpaths are to be required on one (1) side of each internal residential street.
- Footpaths on both sides of the street are to be provided on the roads which bound the High School and District Playing Field site.
- A shared path network is required to be constructed along Keirnan Street to connect to the existing shared path along Soldiers Road. This shared path link will facilitate direct pedestrian and cyclist links between the residential area and the future High School and District Playing Fields facilities. It will also assist in providing a strong pedestrian and cyclist links to the existing and future planned activity nodes for Mundijong. Further detail on the integration of the LSP Area with the surrounding area of Mundijong is detailed in the TIA attached at **Annexure 11**.
- A shared path network will be designed to run along the southern boundary of the Manjedal Brook (to the north).

Public Transport

The land is located approximately 1.4km from the Mundijong Train Station.

The locality is serviced by two (2) existing bus routes on Soldiers Road/Paterson Street, which operate daily and regularly (one to two-hour intervals). An existing bus stop is located immediately south of the Keirnan Street intersection with Soldiers Road. The bus routes provide direct connections to Armadale Station, Byford Town Centre, Mundijong Town Centre and Jarrahdale.

Multiple Use Trail

The Shire's Local Planning Policy 1.17 – Multiple Use Trails (**LPP 1.17**) identifies a potential multiple use trail extending along the length of Keirnan Street to connect with Taylor Road. The potential location for a trail is identified in the LPP 1.17 as being located within the road reserve.

The protection of the Manjedal Brook with a buffer area of public open space and the mature vegetation within unmade Lang Road Reservation lends itself to further opportunities for the Shire to strength the multiple use corridor linkages through Mundijong. The land is therefore provided to ensure these connections are able to be developed. The detailed design of the trail and corridor and its linkage to wider area is to be developed as part of the detailed Landscape Management Plans, at subdivision stage.

5.6 WATER MANAGEMENT

A *Local Water Management Strategy* (LWMS) prepared by *Calibre* in accordance with best management practices of *Better Water Urban Management* (WAPC, 2008).

This involves managing, protecting and conserving the total water cycle of the local environment and the greater catchment.

The management principles of the LWMS are to be implemented and refined in the Urban Water Management Plans prepared at subdivision stage.

The water management strategies follow the best practice water sensitive urban design, integrating sustainability and the provision of attractive communities. The key elements of the strategies are summarised below and further detailed in the LWMS, attached at **Annexure 8**.

- All dwellings are to be serviced with reticulated water and sewer.
- Rainwater tanks to provide a non-potable water source are to be encouraged.
- Stormwater detention systems combined with treatment systems are to capture and treat stormwater flows.
- Soakwells are to be provided on each individual lot created to detain stormwater up to 15mm, to meet the standards of the Shire.
- Finished lot levels are to ensure sufficient clearance to flood events through sub-soil drainage and imported clean fill. The specifics will be determined in the Urban Water Management Plans to be prepared at subdivision stage.
- Water Sensitive Urban Design elements will be used on site to treat stormwater and groundwater, improving the water quality prior to it entering downstream ecosystem of the Manjedal Brook.
- Flows from the Brook will be managed to pre-development rates.

A **mosquito management plan** is included in the statutory section of the LSP as a conditional requirement of the subdivision approval. The plan will include recommended management actions to minimise the likelihood of excessive mosquito numbers during the construction and post-construction phases of the proposed land development.

5.7 EDUCATION

The LSP Area includes a co-located High School and District Playing Fields Public Purposes Reserve, in accordance with the endorsed and proposed revised DSP and addresses the advice provided during the pre-lodgement consultation process with the Shire of SJ.

The *Department of Education* has indicated that the development of the High School is a long-term proposition and therefore it is not in a position to provide a current design layout concept.

The LSP sets aside a sufficient amount of land is for future development as a High School, with the co-located District Playing Fields, in accordance with the land requirements stated in *Liveable Neighbourhoods (WAPC)*.

The concept plan illustrating a possible design for the residential development component of the LSP Area includes a bounding road network to ensure safe access and on-street parking is able to be accommodated for the co-located Public Purpose Reserve.

The LSP design ensures the site can be developed with an appropriate interface with the surrounding residential community as well as Manjedal Brook to the north. Further, it ensures a robust path network is provided to promote walkability, cycling and access to public transport on Keirnan Street and Soldiers Road.

The Shire of SJ and the *Department of Education* will be required to enter into a long-term management agreement to ensure appropriate sharing of the recreational facilities.

5.8 ACTIVITY CENTRES AND EMPLOYMENT

The LSP is located in relatively close proximity to the Mundijong Town Centre, being situated approximately 1.5km to the south of the intersection of Keirnan Street and Soldiers Road. This offers immediate access to essential retail and community services for the future residents.

In addition, new Activity Centres are identified in the DSP, including the Whitby District Centre to the east of Soldiers Road and the railway reservation; and a Neighbourhood Centre in the LSP for 'Sub-Precinct G1' further north on Taylor Road.

The existing and planned activity centres provide employment opportunities for residents of this future community as well as ensuring all commercial needs will be met as the area continues to grow into a vibrant and self-sufficient residential community.

5.9 INFRASTRUCTURE COORDINATION, SERVICING

An *Engineering Servicing Report* has been prepared by *Calibre* to consider the subdivision and development of the LSP, with a focus on the initial development stage of the DJMM landholdings in the eastern extent of the LSP. A summary of the findings is provided below. A complete copy of the report is attached at **Annexure 12**.

- The highest groundwater level is located in the south eastern corner of the LSP Area, 1.5m below ground level.
- Groundwater levels decrease to the north and north west.
- The approximate hydraulic gradient is 'west north west'.
- The finished levels of the DJMM landholdings will consider the site work controls and clean fill will be imported to ensure adequate site levels are provided.

- A traditional pit and underground pipe system is proposed to collect surface runoff within the road reserves.
- The stormwater will be conveyed via the pipe system to drainage basins proposed in the POS area in the north east and within part of the land of Lot 11 which is to form part of the Public Purposes Reserve.
- Groundwater levels will be managed via a subsoil drainage system which utilises and connects to the stormwater drainage pit system. This will ensure a minimum 1.5m clearance to the finished lot levels.
- The road network as proposed in the concept development layout and detailed in the TIA allows adequate width to accommodate all utility services, parking, paths and drainage.
- A reticulated wastewater network (DN150 gravity sewer main) will connect to each lot.
- The fall of the gravity sewer is south-east to north-west and is to be designed to meet with the Water Corporation standard DS50. The sewer will connect to the designated connection point within the Lang Road Reserve at a proposed invert level of 33.0m AHD. Ultimately wastewater is to convey to the future Mundijong wastewater pumping station located west of the LSP Area on Scott Road.
- Potable water is available via the existing 315PE water main on Soldiers Road and the existing 150PE water main on the southern side of Keirnan Street. The internal water reticulation will be via a reticulated 150PE water main.
- The development will be provided with underground power.
- Gas services are able to be extended to the LSP Area, via the existing ATCO Gas supply which extends along Soldiers Road.
- Both Telstra and NBN supply service the area.

5.10 DEVELOPMENT CONTRIBUTIONS

The proposed development contributions for the LSP Area are detailed in proposed Amendment No. 209 to the Shire of SJ TPS 2 and accompanying draft Mundijong Urban Development Contribution Plan (DCP) for Mundijong. Amendment No. 209 and the draft DCP are currently progressing through the advertising process, which is scheduled to conclude on 20 July 2020.

The proposed community infrastructure development contributions for the LSP Area are detailed in proposed Amendment No. 207 and the accompanying draft Community Infrastructure Development Contribution Plan (**CIDCP**). This Amendment and the CIDCP have already been advertised for public comment. The documents were presented to the Ordinary Meeting of Council on 18 May 2020, and supported with modifications. The documentation has now been

forwarded to the WAPC, in accordance with Regulation 37 (2) of the *Planning and Development (Local Planning Schemes) Regulations 2015*.

The DCP incorporates the area covered by the proposed revised DSP for Mundijong. Once it is finalised, it will provide a shared costing arrangement for a variety of traditional and community infrastructure needs to support the emerging urban community.

ANNEXURES

ANNEXURE 1
Contour and Features Survey
Vision Surveys Consulting

FEATURE SURVEY

STREET NAME : KEIRNAN STREET LOT # : HOUSE # : SUBURB : MUNDIJONG LOCAL AUTHORITY : SHIRE OF SERPENTINE-JARRAHDALE LOT AREA : R CODE : SURVEY DATE : SCALE AT A1 SIZE : 1:1000

LEGEND

☉ TREE (TO SCALE)

****ALL OTHER FEATURES ARE AS LABELLED****

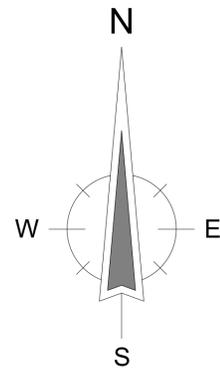
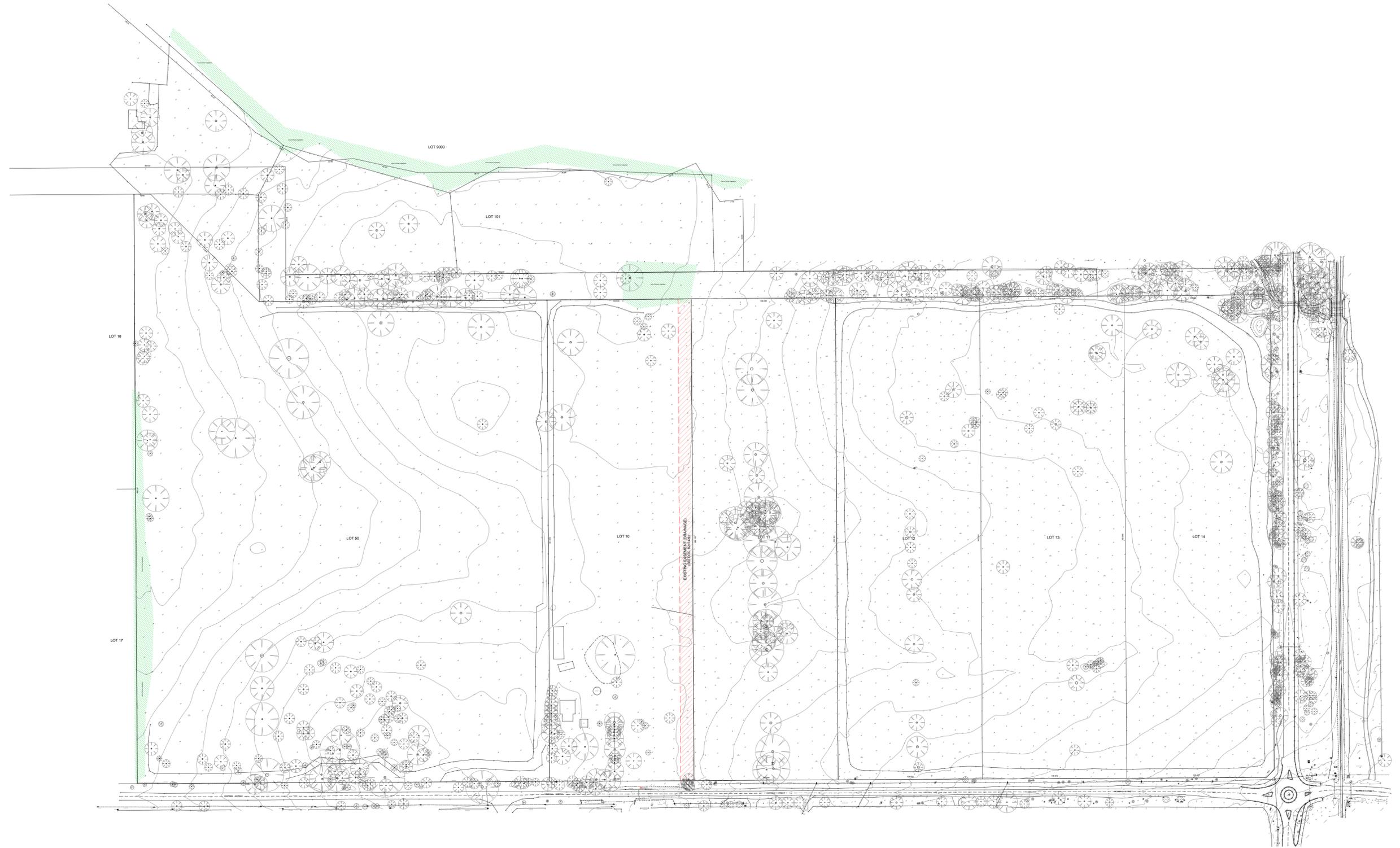
CLIENTS DETAILS :
DJM MUNDIJONG PTY LTD

LEVEL DATUM : AHD (Approx.) DWG REF : Keiman L10-14, 50, 101 F - v1.0

Survey of Lots 11-14 (02/05/2018)
Survey of Lots 10,50 & 101 (12/12/2019)

Calculated Total Area = 31.4114ha.

AHD, PCG94



T: (08) 6144 0000 F: (08) 6144 0099
59 SCARBOROUGH BEACH RD,
SCARBOROUGH WA 6019
Email: info@visionsc.com.au
www.visionsurveys.com.au

SCALE 1:1500 @ A1



PLAN / DIAG / SP	P 11881 & D 91562
ELECTRICITY	OVERHEAD
WATER	IN AREA
GAS	IN AREA

TELSTRA	IN AREA
SEWERAGE	NO
DRAINAGE	GOOD
VEG. / SOIL	AS DESCRIBED

IMPORTANT NOTES:

BEFORE ANY WORK IS STARTED ON SITE OR PLANS ARE PRODUCED BY DESIGNERS/ ARCHITECTS, THE BOUNDARIES MUST BE REPEGGED AND EXACT OFFSETS MEASURED TO EXISTING STRUCTURES AND FENCING. VISION SURVEYS ACCEPTS NO RESPONSIBILITY FOR ANY CHANGES TO THE PARCEL OR PORTION OF THE PARCEL OF LAND SHOWN ON THIS SURVEY INCLUDING BUT NOT LIMITED TO ANY ADJOINING NEIGHBOURS LEVELS AND FEATURES THAT HAVE OCCURRED AFTER THE DATE ON THIS SURVEY.

THIS PLAN IS INTENDED FOR THE DEPT OF PLANNING & INFRASTRUCTURE ONLY.

SEWER / DRAINAGE MAY VARY FROM SCHEMATIC PRESENTATION / CHECK WITH APPROPRIATE AUTHORITY BEFORE ADOPTION OF POSITION.

CHECK TITLE FOR EASEMENTS / COVENANTS ETC.



ANNEXURE 2

Certificates of Title

WESTERN



AUSTRALIA

REGISTER NUMBER 11/P11881	
DUPLICATE EDITION 2	DATE DUPLICATE ISSUED 23/3/2018

RECORD OF CERTIFICATE OF TITLE
UNDER THE TRANSFER OF LAND ACT 1893

VOLUME 1460 FOLIO 743

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

LAND DESCRIPTION:

LOT 11 ON PLAN 11881

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

DJM MUNDIJONG PTY LTD OF GROUND FLOOR 200 ADELAIDE TCE, EAST PERTH WA 6004
(T N854422) REGISTERED 19/3/2018

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

1. *N979480 MORTGAGE TO COMMONWEALTH BANK OF AUSTRALIA REGISTERED 4/9/2018.

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: 1460-743 (11/P11881)
PREVIOUS TITLE: 1460-732
PROPERTY STREET ADDRESS: NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY: SHIRE OF SERPENTINE-JARRAHDAL

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING N979480

WESTERN



AUSTRALIA

REGISTER NUMBER 12/P11881	
DUPLICATE EDITION 2	DATE DUPLICATE ISSUED 23/3/2018

RECORD OF CERTIFICATE OF TITLE
UNDER THE TRANSFER OF LAND ACT 1893

VOLUME 1460 FOLIO 744

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

LAND DESCRIPTION:

LOT 12 ON PLAN 11881

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

DJM MUNDIJONG PTY LTD OF GROUND FLOOR 200 ADELAIDE TCE, EAST PERTH WA 6004
(T N854422) REGISTERED 19/3/2018

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

1. *N979480 MORTGAGE TO COMMONWEALTH BANK OF AUSTRALIA REGISTERED 4/9/2018.

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

STATEMENTS:

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SKETCH OF LAND: 1460-744 (12/P11881)
PREVIOUS TITLE: 1460-732
PROPERTY STREET ADDRESS: NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY: SHIRE OF SERPENTINE-JARRAHDAL

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING N979480

WESTERN



AUSTRALIA

REGISTER NUMBER 13/P11881	
DUPLICATE EDITION 2	DATE DUPLICATE ISSUED 23/3/2018

RECORD OF CERTIFICATE OF TITLE
UNDER THE TRANSFER OF LAND ACT 1893

VOLUME 1460 FOLIO 745

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

LAND DESCRIPTION:

LOT 13 ON PLAN 11881

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

DJM MUNDIJONG PTY LTD OF GROUND FLOOR 200 ADELAIDE TCE, EAST PERTH WA 6004
(T N854422) REGISTERED 19/3/2018

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

1. *N979480 MORTGAGE TO COMMONWEALTH BANK OF AUSTRALIA REGISTERED 4/9/2018.

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.
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-----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: 1460-745 (13/P11881)
PREVIOUS TITLE: 1460-732
PROPERTY STREET ADDRESS: NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY: SHIRE OF SERPENTINE-JARRAHDAL

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING N979480

WESTERN



AUSTRALIA

REGISTER NUMBER 14/P11881	
DUPLICATE EDITION 2	DATE DUPLICATE ISSUED 23/3/2018

RECORD OF CERTIFICATE OF TITLE
UNDER THE TRANSFER OF LAND ACT 1893

VOLUME 1460 FOLIO 746

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

LAND DESCRIPTION:

LOT 14 ON PLAN 11881

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

DJM MUNDIJONG PTY LTD OF GROUND FLOOR 200 ADELAIDE TCE, EAST PERTH WA 6004
(T N854422) REGISTERED 19/3/2018

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

1. *N979480 MORTGAGE TO COMMONWEALTH BANK OF AUSTRALIA REGISTERED 4/9/2018.

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: 1460-746 (14/P11881)
PREVIOUS TITLE: 1460-732
PROPERTY STREET ADDRESS: NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY: SHIRE OF SERPENTINE-JARRAHDALE

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING N979480

ANNEXURE 3
Bushfire Management Plan
Lush Fire and Planning



Bushfire Management Plan

(Local Structure Plan - Sub Precinct G2)

Keirnan Street, Mundijong

Ref 18-040
Ver D
April 2020



LUSH FIRE & PLANNING
3 Paterson Rd
Pinjarra WA 6208
0418 954 873
ABN 74 232 678 543

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:	Lots 11 - 14 DP11881 Keirnan Street		
Suburb:	Mundijong	State:	WA
		P/code:	6123
Local government area:	Serpentine Jarrahdale		
Description of the planning proposal:	Residential subdivision		
BMP Plan / Reference Number:	18-040	Version:	D
		Date of Issue:	30/04/2020
Client / Business Name:	DJM Mundijong Pty Ltd		

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 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.)?

Local Structure Plan

Note: The decision maker (e.g. the 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
Geoffrey Lush	Level 2	BPAD 27682	28/02/2021
Company		Contact No.	
Lush Fire & Planning		0418 954 873	

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

Signature of Practitioner



Date

30/04/2020

This bushfire management plan is prepared for a proposed local structure plan (Sub Precinct G(2), and specifically for the subdivision and development of Lots 11, 12, 13 & 14 Keirnan Street Mundijong which are owned by DJM Mundijong Pty Ltd (DJMM). The subject land is located approximately 2.0 kilometres north of Mundijong townsite

The local structure plan (LSP) has an overall area of approximately 36 hectares. The subject land, owned by DJMM has an area of 15.8121 hectares of the local structure plan areas and is comprised of four lots. It is situated on the north western corner of Keirnan Street and Soldiers Road. The site is vacant with some minor areas of remnant vegetation / windbreaks. There is remnant vegetation along Soldiers Road, the unconstructed Lang Road reserve and Manjedal Brook.

Access to the site is from Paterson Street/Soldiers Road which provides a district connection between Mundijong and Byford. Keirnan Street also extends to the east connecting from Taylor Street to the South Western Highway.

All of the LSP area is designated on the Map of Bush Fire Prone Areas as being bushfire prone.

The LSP is estimated to be able to be developed into a total of 230 residential lots. The site owned by DJMM will be developed for 200 plus residential lots with R20 (average lot size of 500sqm) or an R25 coding (average lot size of 350sqm). The remaining LSP area comprises of a future co-located High School and District Playing Fields, the respective portion of the Lang Road unmade road reserve, and the eastern portion of Lot 101 Lang Road which contains an listed Aboriginal Heritage site.

The subject land and surrounding area is designated as an Environmentally Sensitive Area (ESA) and this extends along Paterson/Soldiers Road and Manjedal Brook. Bush forever site 350 is located within the Soldiers Road reserve; which is designated as a Flora Road. Both Soldiers Road and Manjedal Brook are designated as an area of Natural Beauty under Town Planning Scheme No 2.

The existing paddock trees and windbreaks within the subject land will be cleared for the development. A group of trees in the north eastern corner of the site will be retained within a local POS reserve. The existing vegetation in Lang Road will be protected and potentially enhanced over time.

A bushfire hazard level assessment has been undertaken for the LSP area. This confirms that when developed the LSP area will have either a moderate or low bushfire hazard levels. The moderate hazard areas are predominantly the 100m buffer from the external hazard vegetation. In accordance with Section 6.2(b) of SPP3.7 Planning in Bushfire Prone Areas, land with a moderate or low bushfire hazard level assessment is suitable for development.

A BAL Contour Map has been prepared for the DJMM land holdings and this indicates that the majority of the site will have either a BAL-12.5 or Bal-Low rating. In some instance that there is a minor encroachment of BAL-40/FZ into the front setback of some lots on the periphery of the subdivision. This will only be 3m which accords the minimum front setback provided in the R Codes when the averaging provisions are used. The BAL ratings for individual lots will be confirmed when the BMP is updated to reflect the final subdivision design.

Ultimately the LSP area will form part of the expanded Mundijong urban area which will extend over Manjedal Brook, north to Bishop Road and west to the extension of Tonkin Highway. The subject land owned by DJMM is an independent urban cell separated from the balance of the structure plan area by the proposed high school and co-located district playing field reserve.

The principal bushfire hazard is the bushland on the Lang Road reserve, Soldiers Road, the railway line and also the Bella Cumming nature reserve. These are external to the site but require specific management of the hazard interface.

The proposed local structure plan complies with the objectives of State Planning Policy 3.7 as:

1. It avoids any increase in the threat of bushfire to people, property and infrastructure.

Development with a maximum BAL-29 rating it does not increase the threat of bushfire. The proposed subdivision design does not increase the bushfire threat as it complies with the Bushfire Protection Criteria and provides for the management of vegetation hazards, suitable road access and appropriate separation distances.

2. It reduces vulnerability to bushfire through the identification and consideration of bushfire risks in the design of the development and the decision-making process.

The bushfire hazard and risks have been identified and assessed in this report. It also documents the measures and issues to be addressed at the subsequent stages of the planning process.

3. The design of the subdivision and the development takes into account bushfire protection requirements and includes specific bushfire protection measures.

The proposed development will comply with the Bushfire Protection Criteria.

4. Achieves an appropriate balance between bushfire risk management measures and biodiversity, conservation values, and environmental protection.

The vegetation clearing relates to the proposed development and is internal paddock trees which are predominantly windbreaks.

The recommendations in this report should not be construed to assure total bush fire protection and do not guarantee that a building will not be damaged in a bush fire. The severity of a bush fire will depend upon the vegetation fuel loadings; the prevailing weather conditions and the implementation of appropriate fire management measures.

Document Reference

Property Details

Street No	Lot No's	Plan	Street Name
	11 - 14	11881	Keirnan Street
Locality	Mundijong	State	WA
		Postcode	6123
Local Government Area	Serpentine Jarrahdale		
Description of the building or works	Residential subdivision		

Report Details

Revision	Date	Job No 18-040
A	16 April 2019	Final
B	15 May 2019	Landscape master plan
C	22 April 2020	Revised structure plan area
D	30 April 2020	Edits and landscape plan

Practitioner Details

BPAD	Level 2 Practitioner	Accreditation No	27682
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Disclaimer

The measures contained in this report do not guarantee that a building will not be damaged in a bushfire. The ultimate level of protection will be dependent upon the design and construction of the dwelling and the level of fire preparedness and maintenance under taken by the landowner. The severity of a bushfire will depend upon the vegetation fuel loadings; the prevailing weather conditions and the implementation of appropriate fire management measures.



Geoffrey Lush
30 April 2020
geoffrey@lushfire.com.au



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APPENDICES

Appendix 1	Landscape Master Plan
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1.0 PROPOSAL DETAILS

1.1 Introduction

This bushfire management plan has been prepared on behalf of *DJM Mundijong Pty Ltd (DJMM)* to facilitate the urban development of Lots 11 to 14 Keirnan Street, Mundijong. The subject land is located approximately 2.0 kilometres north of Mundijong townsite as shown in Figure 1.

The Local Structure Plan (LSP) is described as 'Sub-Precinct G2'. The LSP incorporates the DJMM landholdings together with Lot 50 and Lot 10 Keirnan Street, which are identified by the Shire as set aside for future development as a co-located High School and District Playing Field, the respective portion of the unmade Lang Road road reservation and the eastern portion of Lot 101 Lang Road, which includes a scarred tree identified as a Aboriginal Heritage site.

This bushfire management plan focusses on the development of the DJMM landholdings while having regard to the overall context of the LSP.

This report has been prepared to demonstrate that:

- a) the objectives of State Planning Policy 3.7 Planning in Bushfire Prone Areas are met; and
- b) the Bushfire Protection Criteria in the Guidelines can be achieved now or in subsequent planning stages.

1.2 Existing Conditions

The LSP area has an area of 36 hectares containing 6 freehold lots, 1 portion of a freehold lot and a section of unmade road reserve. The LSP Area (Sub-Precinct G2) is bounded by Keirnan Street to the south, Manjedal Brook to the north, Soldiers Road to the east and extends to the west to include Lot 50 Keirnan Street. The existing conditions are shown in Figure 2.

The land owned by DJMM has an area of 15.8121 hectares and is comprised of four lots as documented in Table 1. It is situated on the north western corner of Keirnan Street and Soldiers Road with Lang Road, being an unconstructed road reserve, on its northern boundary. It has a frontage of 435m to Keirnan Road and a depth of 362m. It is illustrated on the LSP as the urban cell, located to the east of the area set aside as a Reserve for the future development a co-located High School and District Playing Field.

The existing conditions for the land owned by DJMM is shown in Figure 3. The subject land is vacant with some minor areas of remnant vegetation / windbreaks. The subject land has an elevation of approximately 45m AHD and a gentle slope from west to east of approximately 1.5 percent.

The land to the south and east is serviced with reticulated water and fire hydrants as shown in Figure 2. The land to the south has been developed for rural residential and residential purposes with a variety of lots sizes. The Bella Cumming nature reserve is located opposite the site on the southern side of Keirnan Road. There is remnant vegetation along Soldiers Road, the unconstructed Lang Road reserve and Manjedal Brook.

To the east of Paterson Street/Soldiers Road is the South West Main railway extending from Kwinana to Bunbury. East of this is the Whitby residential estate. North of the site is Manjedal Brook and larger rural properties used for broad acre farming.

Access to the site is from Paterson Street/Soldiers Road provides a district connection between Mundijong and Byford. Keirnan Road also extends to the east connecting from Taylor Street to the South Western Highway.



SUBJECT LAND 

RAILWAY LINE 

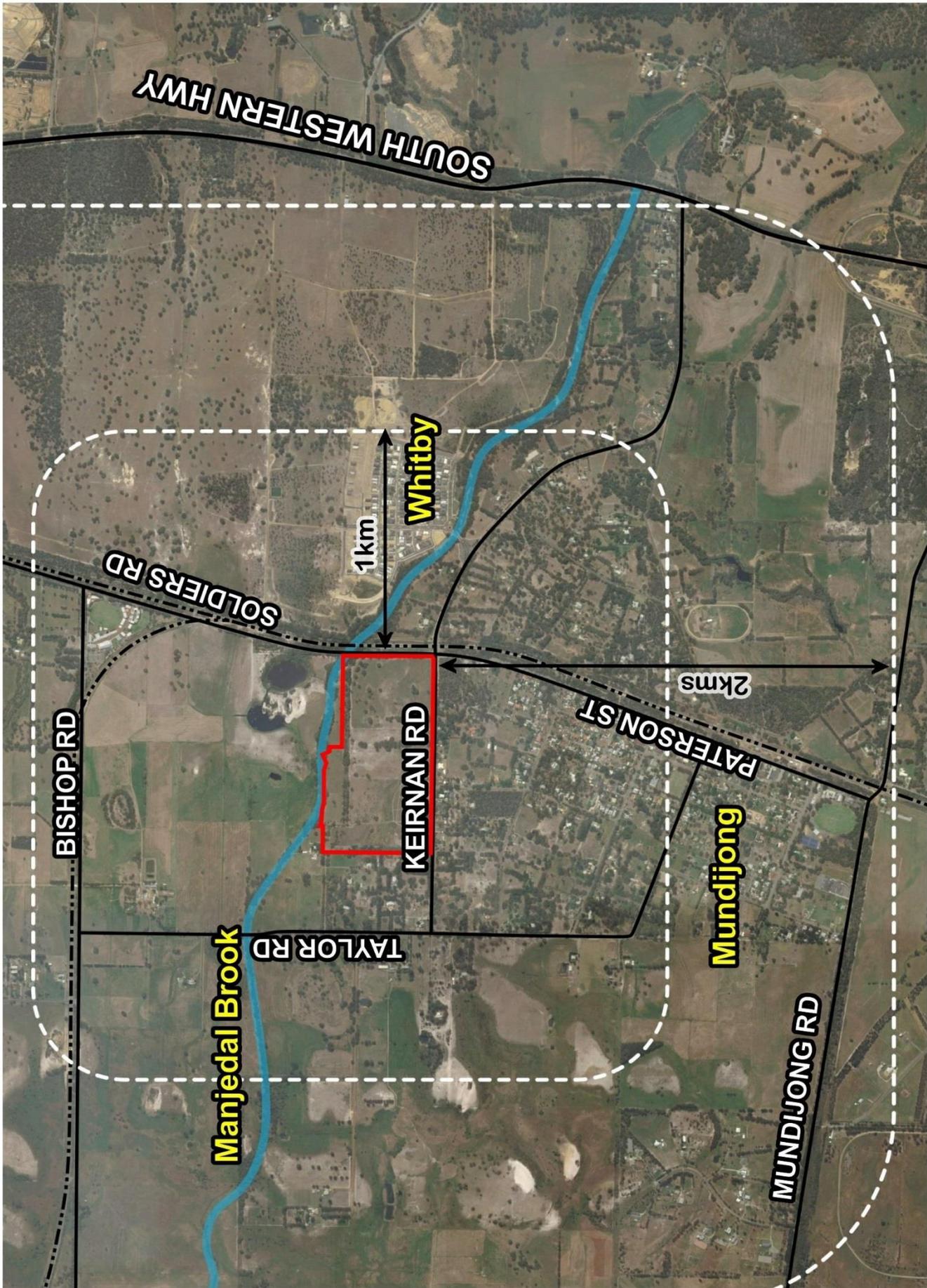


FIGURE 1
LOCATION & CONTEXT

LEGEND

LSP BOUNDARY

DJMM HOLDINGS

GEO MAP REFERENCE



FIGURE 2
LSP EXISTING CONDITIONS



Job No 18-040
Rev Description
A Preliminary
B SP Revisions

Date
10/04/2019
16/04/2020

- LEGEND**
- DJMM LANDHOLDING —
 - 2m CONTOUR —
 - WATER MAIN & HYDRANT ●
 - GEO MAP REFERENCE +



Job No 18-040
 Rev Description
 A Preliminary
 Date 15/02/2019



FIGURE 3
 DJMM EXISTING CONDITIONS

Table 1 Land Details

No	Lot	Plan	Vol	Folio	Registered Proprietor	Area(ha)
	11	11881	1460	743	DJM Mundijong Pty Ltd	3.9355
	12	11881	1460	744	DJM Mundijong Pty Ltd	3.9376
	13	11881	1460	745	DJM Mundijong Pty Ltd	3.9398
	14	11881	1460	746	DJM Mundijong Pty Ltd	4.0140

1.3 Bushfire Prone Land

All of the LSP area is designated on the Map of Bush Fire Prone Areas as being bushfire prone. Bushfire prone areas are comprised of (1):

- Bushfire prone vegetation; and
- A 100m wide bushfire prone buffer.

The designation of bushfire prone areas triggers:

- The application of Australian Standard AS3959 Construction of Buildings in Bushfire Prone Areas under the Building Code of Australia;
- The provisions of the Planning and Development (Local Planning Schemes) Regulations 2015; and
- The application of SPP3.7 Planning in Bushfire Prone Areas.

1.4 Fire Break Notice

Council's Firebreak Notice and Fuel Hazard Reduction Notice 2018 - 2019 requires that:

1. All land 4047m² (one acre) or less
 - Cut all grass to less than 25mm in height.
 - Trim all trees and bushes that overhang driveways, access ways and firebreaks to leave a 4 metre wide clearance and a clear vertical axis.

OR

Install firebreaks that are:

- Immediately inside all external boundaries.
- Immediately surrounding all agricultural buildings, sheds or group of buildings.
- A minimum of 3 metres wide, but not wider than 5 metres.
- Trim all trees and bushes that overhang driveways, access ways and firebreaks to leave a 4 metre wide clearance and a clear vertical axis.

Dwellings are to:

- Maintain 20m asset protection zones or as per an approved BAL/FMP assessment.
- Trim back all trees overhanging buildings.

2. All land greater than 4047m² (one acre)
 - Keep grasses short.

1 DFES (2015) Mapping Standard for Bush Fire Prone Areas.

- Trim all trees and bushes that overhang driveways, access ways and firebreaks to leave a 4 metre wide clearance and a clear vertical axis.
- Install firebreaks that are:
 - Immediately inside all external boundaries.
 - Immediately surrounding all agricultural buildings, sheds or group of buildings.
 - A minimum of 3 metres wide, but not wider than 5 metres.

Dwellings are to:

- Maintain 20m asset protection zones or as per an approved BAL/FMP assessment.
- Trim back all trees overhanging buildings.

Compliance with the general provisions of the Firebreak Order is required on or before 30th November and maintained up to and including the 31st May each and every year. Compliance with an approved bushfire management plan is required all year.

1.5 Proposed Development

The proposed structure plan is shown in Figure 4.

The area to the west of the subject land includes the High School and District Playing Fields. A POS reserve is proposed along the extent of Manjedal Brook including the buffer to the brook and a parkland cleared recreational area. The conceptual subdivision design for the urban cell to the east of the future High School and District Playing Fields Reserve proposes two access roads to Keirnan Street and future access to Taylor Road.

The land owned by DJMM will be developed for 200 plus residential lots with R20 (average lot size of 500sqm) or an R25 coding (average lot size of 350sqm). The front setback requirements in the R Codes are 6m for both R20 and R25 lots.

A POS reserve of 1.02 hectares will be provided in the north eastern corner of the site to protect potential habitat trees for Black Cockatoos. A high school is proposed on the land to the west.

There will be two access connections from Keirnan Road with a future connection to Taylor Road. Lang Road on the northern boundary will not be constructed so as to protect the existing vegetation. The internal subdivision roads are generally 14.2m wide with the perimeter roads having an 18m wide road reserve.



LEGEND ZONES	RESERVES	OTHER
Residential R20-R30	Public Open Space	Structure Plan boundary
Public Purposes	Public Purposes	30m CCW buffer to Manjedal Brook
Detached lot	Detached lot	Access Street B (wider street)
E(HS): Educational, High School/ District	E(HS): Educational, High School/ District	Key/ Access Street D
R: Recreational, District Playing Fields	R: Recreational, District Playing Fields	Restricted Vehicle Access (no vehicle access to Soldiers Road from internal street network)



DJMM LAND HOLDINGS - - - - -

FIGURE 4
STRUCTURE PLAN

2.0 ENVIRONMENTAL CONSIDERATIONS

2.1 General

A Threatened Ecological Community is located in the railway reserve just south of the Manjedal Brook; Buffers boundaries and ESA status extend over the subject land and the vegetated area of the unmade Lang Road reserve.

The subject land and surrounding area is designated as an Environmentally Sensitive Area (ESA). This extends along Paterson/Soldiers Road and Manjedal Brook. The ESA is declared in the Environmental Protection (Environmentally Sensitive Areas) Notice 2005, which was gazetted on 8 April 2005. Exemptions for low impact routine land management practices are prescribed in the Environmental Protection (Clearing of Native Vegetation) Regulations 2004. These exemptions do not apply in ESAs and a clearing permit is required.

Bush forever site 350 is located within the Soldiers Road reserve; which is designated as a Flora Road. Both Soldiers Road and Manjedal Brook are designated as an area of Natural Beauty under Town Planning Scheme No 2.

The Bella Cumming nature reserve (Reserve 6168) is a C class reserve for 'Parks and Recreation'. It has an area of 2.0234 hectares and is managed by the Shire.

2.2 Native Vegetation Modification and Clearing

The existing paddock trees and windbreaks within the subject land will be cleared for the development of the subdivision. A group of trees in the north eastern corner of the site will be retained within a local POS reserve.

2.3 Re-vegetation / Landscape Plans

The proposed landscaping master plan is contained in Appendix 1.

The main objective for the landscaping design of each open space area is to enhance and protect the distinctive rural (visual) historical landscape character and amenity of Mundijong. Tree planting specifications (including species and density) must take into consideration the assigned BAL rating for the nearby residential lots and ensure that the proposed landscaping will not result in any increase to the prescribed BAL rating.

The Manjedal Brook Reserve is to retain remnant vegetation and will include revegetation with waterwise, native shrub species, to be determined as part of the detailed Landscape Management Plan for each respective stage of development, at subdivision application stage.

For the purpose of the BAL Contour Map is also assumed that the existing vegetation in the Lang Road reserve may be enhanced over time and hence be classified as Forest.

The design for the local park is to ensure retention of the remnant vegetation and to provide for passive recreational opportunities for local residents. The habitat trees within this POS area are to be protected for roosting opportunities for the black cockatoo and to provide for identify and a sense of place for the residential community.

The above vegetation modifications are shown in Figure 5.

LEGEND

-  LSP BOUNDARY
-  DJMM HOLDINGS
-  GEO MAP REFERENCE
-  VEGETATION TO BE MODIFIED TO LOW THREAT STATE
-  POTENTIAL REVEGETATION AREAS



Job No 18-040
 Rev Description
 A Preliminary
 B SP Revisions



Date
 10/04/2019
 16/04/2020

FIGURE 5
 LSP VEGETATION MODIFICATION

3.0 BUSHFIRE ASSESSMENT RESULTS

3.1 Assessment Inputs - Vegetation Classification

The general classification of the vegetation for the LSP area is shown in Figure 6 noting that there was no right of access to the private land within the LSP area.

The vegetation classification for the land owned by DHJMM is shown in Figure 7 and the following photographs. The vegetation has been classified in accordance with:

- Australian Standard AS3959 Construction of Buildings in Bushfire Prone Areas;
- The Visual Guide for Bushfire Risk Assessment in Western Australia; and
- Applicable Fire Protection Australia BPAD Practice Notes.

The details of the vegetation plots for the land owned by DJMM is summarised in Table 2 below.

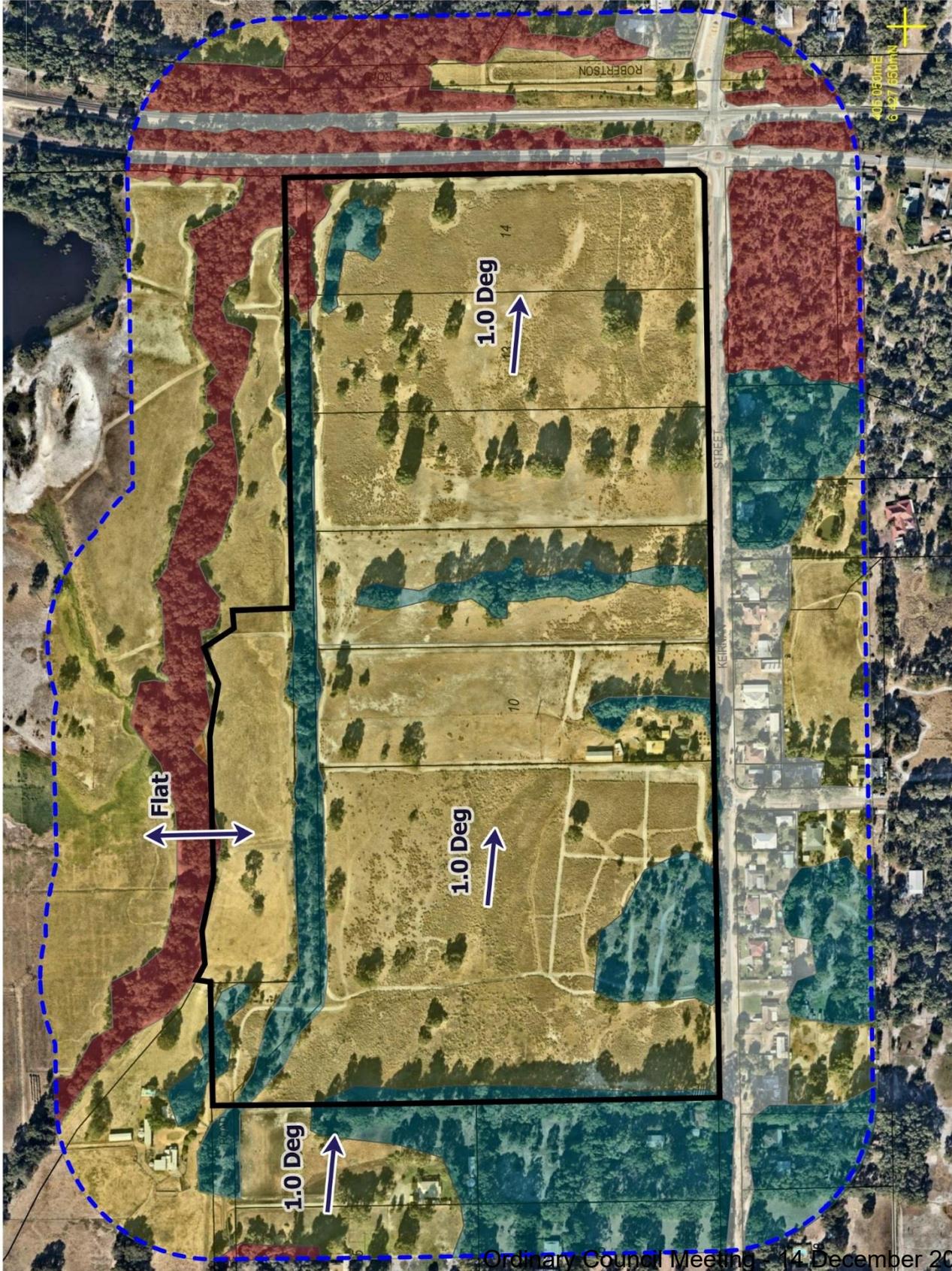
Table 2 DJMM Vegetation Summary

Plot No	Class	Comment
1	Class A Forest - Open forest A-03	Vegetation along Manjedal Brook with both Eucalypts and Melaleuca
2	Class G Grassland – Sown pasture G-26	Paddock broad acre grazing on the adjoining land to 750mm in height.
3	Class A Forest - Low open forest A-04	Vegetation along both sides of Soldiers Road
4	Class B Woodland - Woodland B-05	Vegetation along Lang Road reserve. Generally, Marri with other species in the western portion.
5	Class B Woodland - Woodland B-05	Small area of Marri trees within the subject land.
6	Class G Grassland – Open tussock G-23	Grazing pasture / tussocks in the adjoining land
7	Class B Woodland - Woodland B-05	Eucalypt windbreak within the subject land.
8	Class G Grassland – Sown pasture G-26	Ungrazed pasture within the subject land
9	Class G Grassland – Tussock grassland G-22	Unmanaged grassland along the railway reserve to 500mm.
10	Excludable - 2.2.3.2(f) Low Threat Vegetation	Existing residential development with managed gardens.
11	Class B Woodland - Woodland B-05	Larger semi residential lots containing mature gums over pasture and gardens.
12	Class A Forest - Open forest A-03	Primarily the vegetation within Bella Cumming Reserve. Mixed Marri, Banksia, Sheoak with Grasstree and shrub understorey.

LEGEND

- LSP BOUNDARY
- - - VEGETATION ASSESSMENT AREA (150m from the external boundary of the subject site)
- ↑ UPSLOPE
- ⊕ GEO REFERENCE
- VEGETATION CLASS
- A FOREST
- B WOODLAND
- G GRASSLAND
- EXCLUDED VEGETATION
- Low Threat (2.2.3.2(f))

Location: Keirnan Street, Mundijong
 Assessment Date: 21/01/2019
 Prepared by: G Lush
 Accreditation Level: Level 2
 Accreditation No: BPAD 276820
 Expiry Date: February 2022
 Aerial Photo Date: December 2018



Job No 18-040
 Rev Description
 A Preliminary

BPAD
 Bushfire Planning & Design
 Accredited Practitioner
 Level 2

FIGURE 6
 LSP VEGETATION CLASSIFICATIONS

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 0418 954873

Date: 10/04/2019



LEGEND

- DJMM LAND HOLDING
- VEGETATION ASSESSMENT AREA (150m from the external boundary of the subject site)
- ↑ UPSLOPE
- ↗ **3** PHOTO POINT
- VEGETATION CLASS
 - A FOREST
 - B WOODLAND
 - G GRASSLAND
 - EXCLUDED VEGETATION
- Low Threat (2.2.3.2(f))

Location Details: Lot 11, 12, 13, & 14
Keirnan Street Mundijong

Assessment Date: 21/01/2019

Prepared by: G Lush

Accreditation Level: Level 2

Accreditation No: BPAD 27682

Expiry Date: February 2020

Aerial Photo Date: December 2018

BPAD
Bushfire Planning & Design
Accredited Practitioner
Level 2

N

Job No 18-040

Rev A

Description Preliminary

Date 15/02/2019

LUSHfire
and planning

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0418 954873

FIGURE 7
DJMM VEGETATION CLASSIFICATIONS

Photo No 1 Plot No 1

Vegetation Classification

Class A Forest - Open forest A-03

Description

Vegetation along Manjedal Brook with both Eucalypts and Melaleuca to 18m height canopy more than 50% limited middle understorey due to grazing, typically grass and fallen material, high fuel loads. Plot 2 Grassland in the foreground.



Photo No 2 Plot No 2

Vegetation Classification

Class G Grassland – Sown pasture G-26

Description

Grazing pasture in the adjoining land variable height and coverage. Plot 1 in the background.



Photo No 3 Plot No 3

Vegetation Classification

Class A Forest - Low open forest A-04

Description

Vegetation along both sides of Soldiers Road, mixed species with Marri over storey to 15m height, more than 50% canopy coverage. Mixed species middle and understorey with patches of grassland. Very heavy surface fuel load, and suspended material.



Photo No 4 Plot No 3

Vegetation Classification

Class A Forest - Low open forest A-04

Description

Vegetation along both sides of Soldiers Road, mixed species with Marri over storey to 15m height, more than 50% canopy coverage. Mixed species middle and understorey with patches of grassland. Very heavy surface fuel load, and suspended material.



Photo No 5 Plot No 4

Vegetation Classification

Class B Woodland - Woodland B-05

Description

Vegetation along Lang Road reserve. Typically, Marri with open canopy less than 30% with grassland understorey. No middle storey and moderate fuel loads. Varies in sections with Christmas trees, Acacia and other scrub like vegetation.



Photo No 5 Plot No 4

Vegetation Classification

Class B Woodland - Woodland B-05

Description

Vegetation along Lang Road reserve. Typically, Marri with open canopy less than 30% with grassland understorey. No middle storey and moderate fuel loads. Varies in sections with Christmas trees, Acacia and other scrub like vegetation.



Photo No 7 Plot No 4

Vegetation Classification

Class B Woodland - Woodland B-05

Description

Vegetation along Lang Road reserve. Typically, Marri with open canopy less than 30% with grassland understorey. No middle storey and moderate fuel loads. Varies in sections with Christmas trees, Acacia and other scrub like vegetation.



Photo No 8 Plot No 4

Vegetation Classification

Class B Woodland - Woodland B-05

Description

Vegetation along Lang Road reserve. Typically, Marri with open canopy less than 30% with grassland understorey. Western sections transgression to more scrub like vegetation with Christmas trees, Acacia, etc.



Photo No 9 Plot No 5

Vegetation Classification

Class B Woodland - Woodland B-05

Description

Small area of Marri trees to 18m with less than 30% canopy coverage. Separated from Plots 2 & 3 by firebreak and pasture. Grassland understorey foliage elevated above the ground.



Photo No 10 Plot No 6

Vegetation Classification

Class G Grassland – Open tussock
G-23

Description

Grazing pasture / tussocks in the adjoining land variable height and coverage.



Photo No 11 Plot No 6

Vegetation Classification

Class G Grassland – Open tussock
G-23

Description

Grazing pasture / tussocks in the adjoining land variable height and coverage.



Photo No 12 Plot No 7

Vegetation Classification

Class B Woodland - Woodland B-05

Description

Windbreak within the subject land, single line of Eucalypts to 18m. Non local species with heavy bark base.



Photo No 13 Plot No 8

Vegetation Classification

Class G Grassland – Sown pasture
G-26

Description

Grassland ungrazed pasture within
the subject land to 750mm.



Photo No 14 Plot No 8

Vegetation Classification

Class G Grassland – Sown pasture
G-26

Description

Grassland ungrazed pasture within
the subject land to 750mm.



Photo No 15 Plot No 8

Vegetation Classification

Class G Grassland – Sown pasture
G-26

Description

Grassland ungrazed pasture within
the subject land to 750mm.



Photo No 16 Plot No 9

Vegetation Classification

Class G Grassland – Tussock grassland G-22

Description

Unmanaged grassland along the railway reserve to 500mm.



Photo No 17 Plot No 10

Vegetation Classification

Excludable - 2.2.3.2(f) Low Threat Vegetation

Description

Existing residential development with managed gardens.



Photo No 18 Plot No 11

Vegetation Classification

Class B Woodland - Woodland B-05

Description

Larger semi residential lots containing mature gums over pasture and gardens.



Photo No 19 Plot No 12

Vegetation Classification

Class A Forest - Open forest A-03

Description

Primarily the vegetation within Bella Cumming Reserve. Mixed species including Marri, Banksia, Sheoak with Grasstree understorey and other shrubs to 1m. Continuous deep litter depth greater than 25mm very heavy surface fuel loads more than 25tph.



Photo No 20 Plot No 12

Vegetation Classification

Class A Forest - Low open forest A-04

Description

Primarily the vegetation within Bella Cumming Reserve. Mixed species including Marri, Banksia, Sheoak with Grasstree understorey and other shrubs to 1m. Continuous deep litter depth greater than 25mm very heavy surface fuel loads more than 25tph.



Photo No 21 Plot No 12

Vegetation Classification

Class A Forest - Open forest A-03

Description

Primarily the vegetation within Bella Cumming Reserve. Mixed species including Marri, Banksia, Sheoak with Grasstree understorey and other shrubs to 1m. Continuous deep litter depth greater than 25mm very heavy surface fuel loads more than 25tph.



3.2 Assessment Outputs

3.2.1 Bushfire Hazard Level Assessment

The vegetation classifications for the final LSP development is shown in Figures 8, and these reflect the modifications described in Section 2.0 and shown in Figure 5.

A Bushfire Hazard Level Assessment plan has been prepared for the LSP as shown in Figure 9.

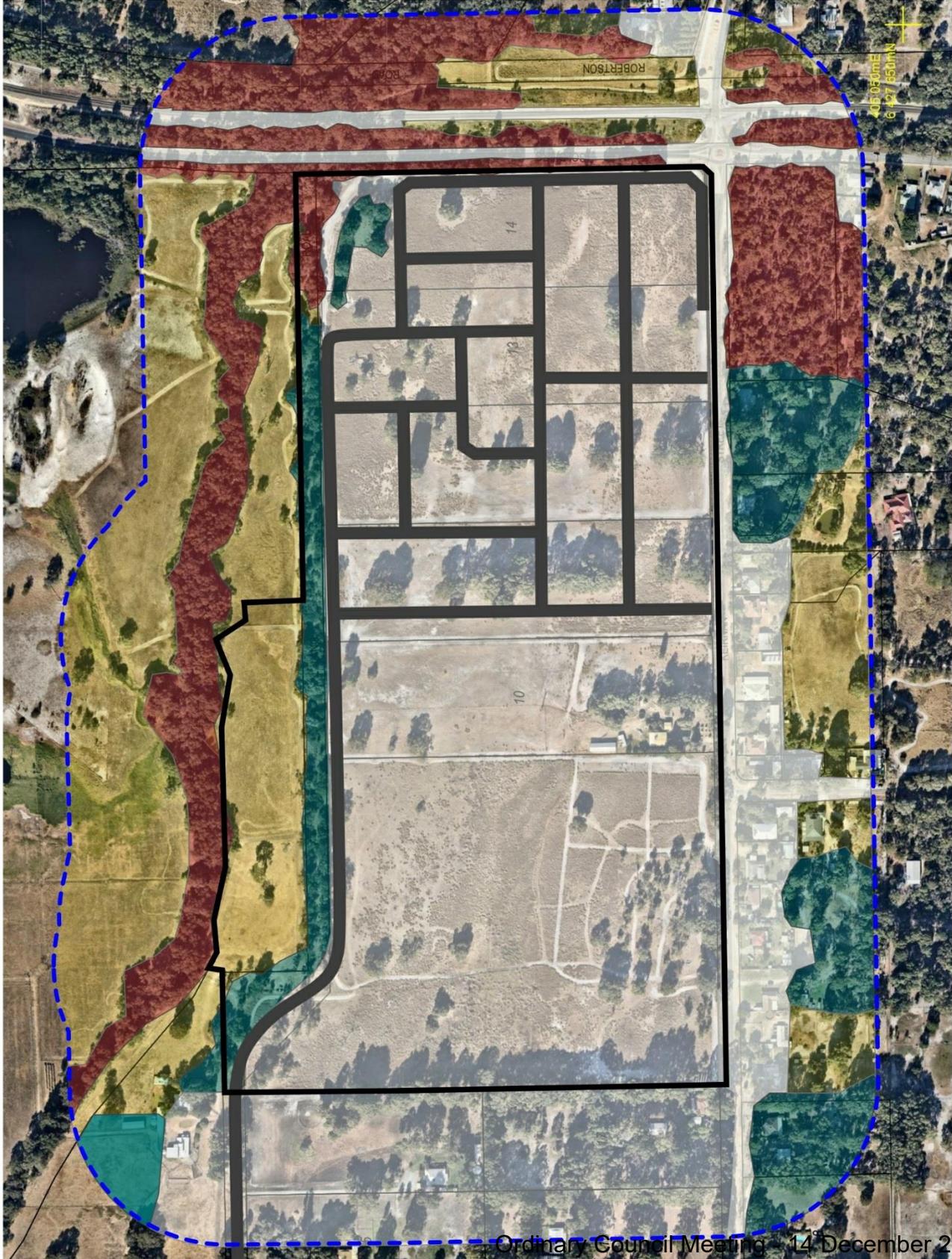
This provides a 'broadbrush' means of determining the potential intensity of a bushfire for a particular area. The bushfire hazard primarily relates to the vegetation on the site, the type and extent (area) of vegetation and its characteristics. The methodology for determining the bushfire hazard level is contained in the Guidelines for Planning in Bushfire Prone Areas (Section 4.1 and Appendix 2).

This confirms that when developed the LSP area will have either a moderate or low bushfire hazard levels. The moderate hazard levels relate to the 100m buffer from the external hazard vegetation.

In accordance with Section 6.2(b) of SPP3.7 Planning in Bushfire Prone Areas any strategic planning proposal, subdivision or development application in an area, that has or will, on completion, have a moderate BHL may be considered for approval.

LEGEND

- LSP BOUNDARY
- - - VEGETATION ASSESSMENT AREA (150m from the external boundary of the subject site)
- ↑ UPSLOPE
- SUBDIVISION ROAD
- ⊕ GEO REFERENCE
- VEGETATION CLASS
- A FOREST
- B WOODLAND
- G GRASSLAND
- EXCLUDED VEGETATION
- Low Threat (2.2.3.2(f))



Keirnan Street
Mundijong
Assessment Date: 21/01/2019
Prepared by: G Lush
Accreditation Level: Level 2
Accreditation No: BPAD 27682
Expiry Date: February 2021
Aerial Photo Date: December 2008

10.1.9 - attachment 1

FIGURE 8

LSP MODIFIED VEGETATION CLASSIFICATIONS



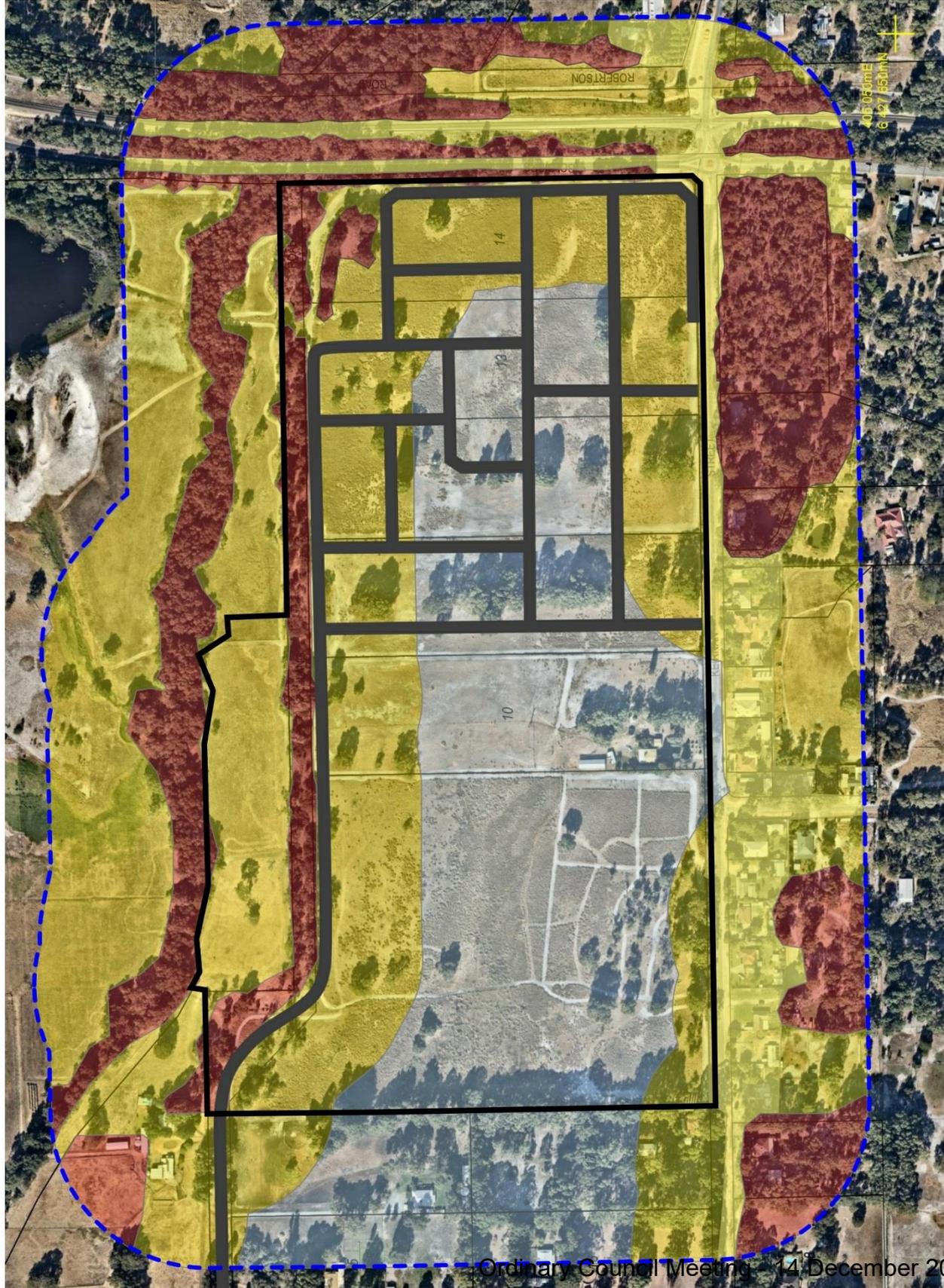
Job No 18-040
Rev Description
A Preliminary
B SP Revisions

Date
10/04/2019
16/04/2020



LEGEND

- LSP BOUNDARY
- - - VEGETATION ASSESSMENT AREA (150m from the external boundary of the subject site)
- SUBDIVISION ROAD
- ⊕ GEO REFERENCE
- BUSHFIRE HAZARD LEVEL
- EXTREME
- MODERATE
- LOW



Location: Keirnan Street, Mundijong
 Assessment Date: 21/01/2019
 Prepared by: G Lush
 Accreditation Level: Level 2
 Accreditation No: BPAD 276820
 Expiry Date: February 2023
 Aerial Photo Date: December 2018

10.1.9 - attachment 1

Date: 10/04/2019
 16/04/2020

Job No 18-040
 Rev Description
 A Preliminary
 B SP Revisions



FIGURE 9
 LSP BUSHFIRE HAZARD LEVELS



3.2.2 BAL Contour Map

The vegetation classifications for the final development of the DJMM land holdings are shown in Figure 10, and these reflect the modifications described in Section 2.0 and shown in Figure 5.

A BAL Contour Map has been prepared for the land owned by DJMM. This is a plan of the subject lot/s illustrating the potential radiant heat impacts and associated indicative BAL ratings after the development is completed.

The BAL Contour Map is shown in Figure 11 and this is based upon the following assumptions:

1. The subject land being modified to a low fuel state by the construction of the subdivision;
2. Allowing for possible revegetation along the Lang Road reserve with Plot 4 potentially becoming Class A Forest;
3. The retention of Plot 5 as Woodland vegetation; and
4. Pruning of branches in Plot 3 that are over hanging, encroaching into the subject land.

As there is no detailed lot design, no table of lot classifications has been provided. The BAL Contour Map indicates that the majority of the site will have either a BAL-12.5 or Bal-Low rating. In some instance that there is a minor encroachment of BAL-40/FZ into the front setback of some lots on the periphery of the subdivision as shown in the attached cross section plan (Figure 12)

The BAL - 29 setback in these instances is 21m for Class A Forest on flat land or upslope.

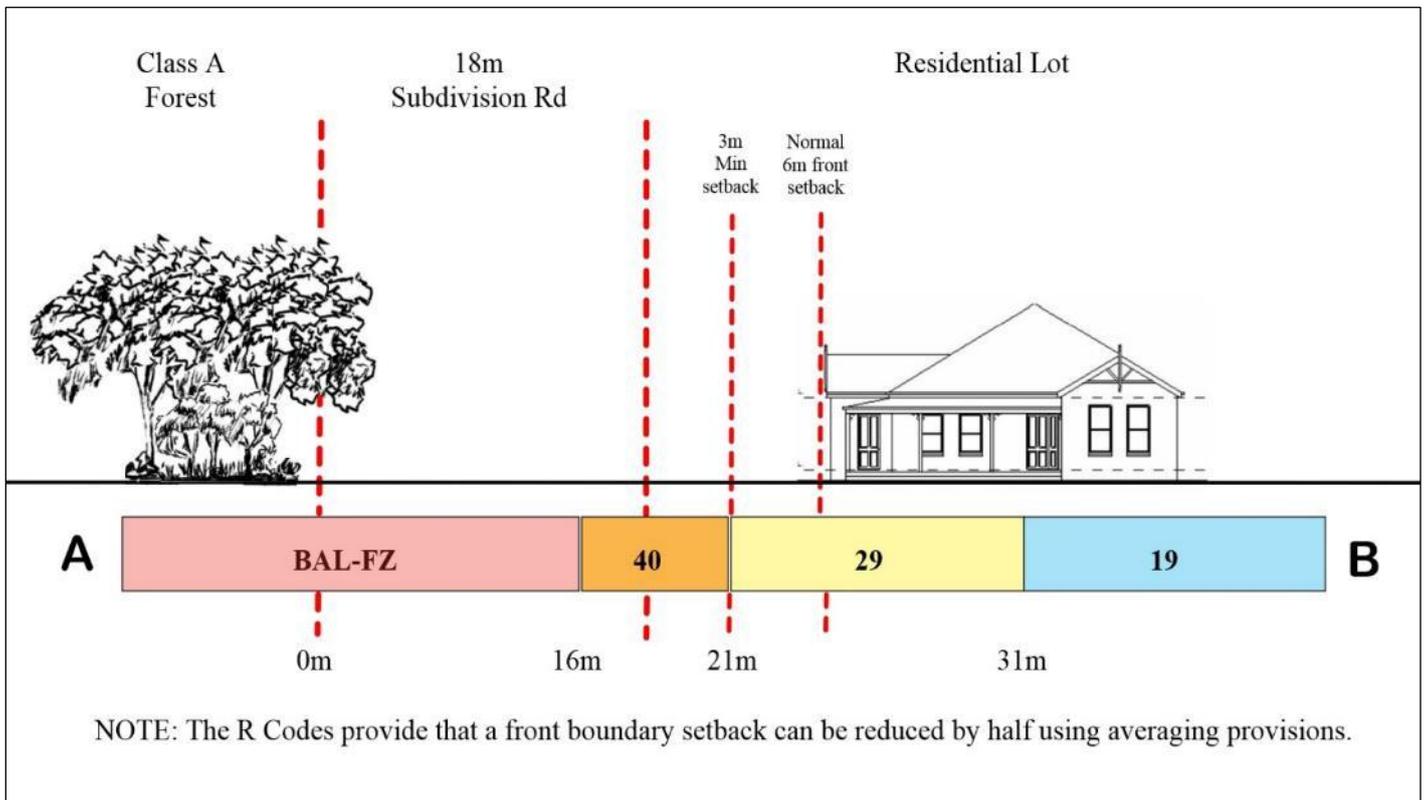


Figure 12 - BAL Cross Section



LEGEND

- SUBJECT LAND —
- VEGETATION ASSESSMENT AREA (150m from the external boundary of the subject site) - - -
- UPSLOPE →
- VEGETATION CLASS
 - A FOREST ■
 - B WOODLAND ■
 - G GRASSLAND ■
 - AREAS TO BE MODIFIED TO LOW THREAT VEGETATION ■
 - EXCLUDED VEGETATION ■
- Low Threat (2.2.3.2(f))

Location: Lot 11, 12, 13, & 14
 Keirnan Street Mundijong

Assessment Date: 21/01/2019

Prepared by: G Lush

Accreditation Level: Level 2

Accreditation No: BPAD 27682

Expiry Date: February 2020

Aerial Photo Date: December 2018



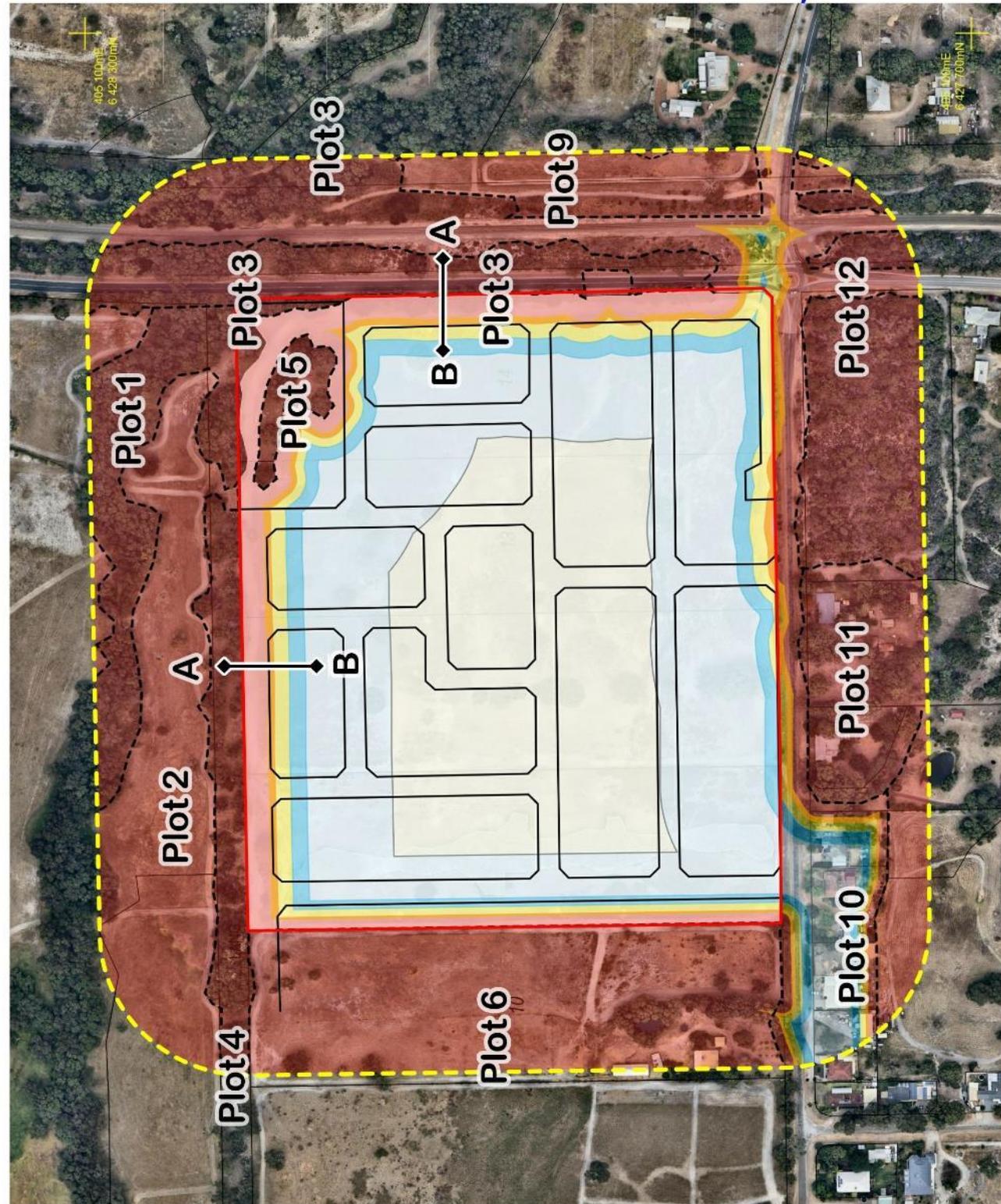
Job No 18-040

Rev Description
 A Preliminary

Date 08/03/2019



FIGURE 10
 DJMM MODIFIED VEGETATION CLASSIFICATION MAP
 (BAL Contour Map)



LEGEND

- SUBJECT LAND —
- BAL CONTOUR ASSESSMENT AREA (100m from the external boundary of the subject site) - - -
- PROPOSED CADASTRE —
- VEGETATION PLOT - - -

INDICATIVE BAL/ RATING

- BAL-FZ ■
- BAL-40 ■
- BAL-29 ■
- BAL-19 ■
- BAL-12.5 ■
- BAL-Low ■

CROSS SECTIONS (See Figure 12)



Location Details:
 Lot 11, 12, 13, & 14
 Keirnan Street Mundijong

Assessment Date: 21/01/2019
 Prepared by: G Lush
 Accreditation Level: Level 2
 Accreditation No: BPAD 27682
 Expiry Date: February 2020
 Aerial Photo Date: December 2018

1.1.9 - attachment



Job No 18-040
 Rev A
 Description Preliminary
 Date 08/03/2019

FIGURE 11
 DJMM - BAL CONTOUR MAP

4.0 IDENTIFICATION OF BUSHFIRE HAZARD ISSUES

The context of the site to the surrounding district is shown in Figure 1. The local context of the site in relation to the overall structure plan areas is shown in Figure 13.

Ultimately the subject land will form part of the expanded Mundijong urban area which will extend over Manjedal Brook, north to Bishop Road and west to the extension of Tonkin Highway.

The subject land is an independent urban cell separated from the balance of the structure plan area by the proposed high school. Important environmental features include the Manjedal Brook corridor, the vegetation in the unmade Lang Road reservation and along Soldiers Road.

The surrounding location has excellent district access in multiple directions.

The land east of Soldiers Road begins to have a more noticeable slope extending to the Darling Escarpment. This area generally has more remnant vegetation compared to the flat farming land to the west. The whole locality is subject to strong stronger "katabatic" easterly winds coming off the escarpment.

Fires occur annually in the district with the annual fire season extending from mid October to mid May. This is the normal period where weather conditions are conducive to the ignition and spread of bushfires. A bushfire can have a number of ignition sources which can originate from either natural or human causes such as:

- Lighting strikes;
- Unattended camp fires;
- Discarded match or cigarette;
- Dry grass in contact with vehicle exhausts;
- Sparks from grinders, slashing or other mechanical operations;
- Backyard rubbish burning;
- Hazard reduction burns;
- Powerlines sparking in strong winds or falling;
- Pole top fires; or
- Deliberate arson.

The principal bushfire hazard is the bushland on the Lang Road reserve, Soldiers Road, the railway line and also the Bella Cumming nature reserve. These are external to the site but require specific management of the hazard interface. This will primarily be achieved by increasing the width of the perimeter subdivision roads adjacent to the classified vegetation which will also ensure an acceptable BAL rating for the lots.

As shown in Figure 9 the majority of the LSP area will have either a Moderate or Low bushfire hazard level assessment.

As shown in Figure 11 the majority of the DJMM land holdings will have either a BAL-12.5 or a BAL-Low rating.

LEGEND

- MANJEDAL BROOK ENVIRONMENTAL CORRIDOR
- ESA - DECLARED FLORA ROAD
- CONSERVATION VEGETATION
- POTENTIAL REVEGETATION
- MAIN LOCAL ACCESS
- FUTURE ACCESS CONNECTION
- ACCESS RESTRICTION
- HAZARD VEGETATION INTERFACE
- POTENTIAL HAZARD INTERFACE

ISSUES

- 1) Retention of existing vegetation along the Lang Road reserve. Hazard interface requires specific design measures and development setbacks.
- 2) Soldiers Road is a declared flora road and environmentally sensitive area. The road side vegetation is a barrier to access including in an emergency.
- 3) Bella Cumming reserve has recognised conservation values.
- 4) Potential revegetation along the Manjedal Brook corridor and adjacent POS areas. The extent of any revegetation may require specific design measures.
- 5) Lot to the south of Keirnan Road may be potentially classified as Woodland.
- 6) Local access road connection to Taylor Road required for development of Lots 11 & 14.
- 7) Retention of habitat trees in local POS.
- 8) High school oval areas may also function as local safer place.

10.1.9 - attachment 1

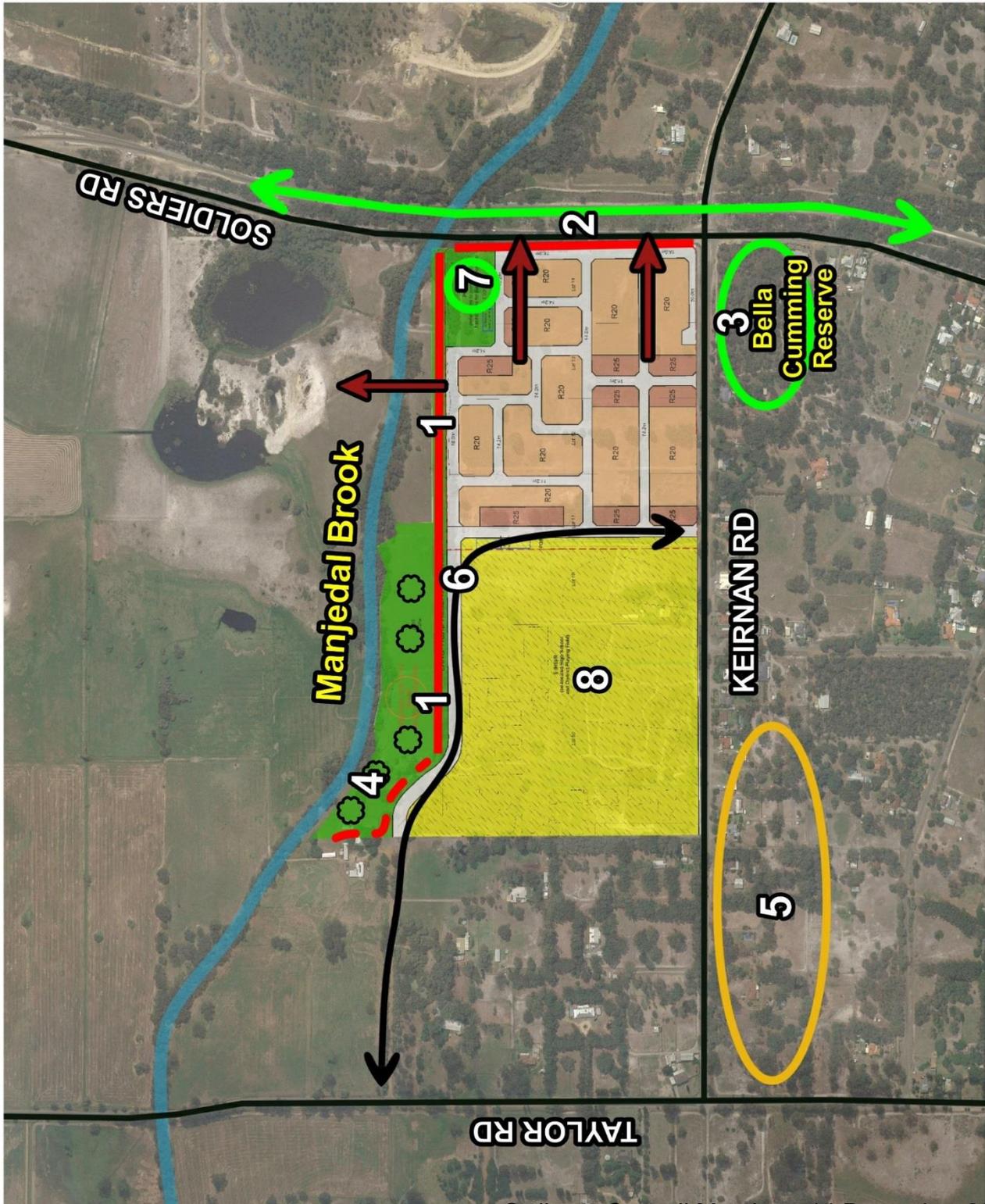


FIGURE 13
STRUCTURE PLAN SPATIAL ISSUES

5.0 ASSESSMENT AGAINST THE BUSHFIRE PROTECTION CRITERIA

5.1 Compliance Table

A summary of the compliance with the Bushfire Protection Criteria for the various planning stages is documented in Table 3.

5.2 Additional Management Strategies

5.2.1 Purchaser Advice

All prospective purchasers must be made aware of the fire management issues, measures and responsibilities associated with the development and subdivision. This can be a notification placed upon the Certificate of Title of all lots pursuant to Section 70A of the Transfer of Land Act advising landowners of this Bushfire Management Plan and BAL requirements.

5.2.2 Staging

The development of the estate may have staged construction. In the event that the subdivision is staged then it is necessary to ensure that appropriate interim measures are provided. These may include:

- Interim access or emergency access ways;
- Creation of additional low fuel zones to ensure that the intended BAL ratings can be applied; or
- The provision of boundary firebreaks especially on any balance lot.

For any proposed stage of the subdivision a statement and plan of the proposed interim fire management measures will be submitted and approved by the Shire.

Table 3 Bushfire Protection Criteria

Design Requirement \ Development Stage	Local Structure Plan	Subdivision Application	Development Application
Element 1 Location			
A1.1 Development Location	Has demonstrated that the developed land will generally have a BAL-29 or lower rating.	Updated BMP to reflect the final subdivision design. Proposed BAL ratings to be confirmed when lot layout is known.	Confirmation of the assumptions made within the BMP.
Element 2 Siting and Design			
A2.1 Asset Protection zone	The proposed lots are not large enough to contain the APZ within their own boundaries. Generally, for the "first row" of dwellings adjacent to the hazard areas the APZ will be provided within the development setback from the front boundary combined with the 18m wide road reserve and in some instance portions of the Local Open Space. This complies with the Guidelines which state on page 63 of the BPC that the APZ may include public roads, waterways, footpaths, buildings, rocky outcrops, golf courses, maintained parkland as well as cultivated gardens in an urban context.	The updated BMP will confirm the BAL-29 setback for the asset protection zone.	Development approval will implement the BMP.
Element 3 Vehicular Access			
A3.1 Two Access Routes	The BMP has shown that externally there is access to the site from multiple directions. Internally there is only access to Keirnan Road with future access proposed to Taylor Street.	The updated BMP must provide for a second access to Taylor Street through the adjoining lots to the east.	Is not applicable as it will be constructed for the subdivision.
A3.2 Public Road	Is not applicable.	The subdivision roads will be constructed in accordance with the Local Government Guidelines for Subdivisional Development	Is not applicable as it will be constructed for the subdivision.

Design Requirement \ Development Stage	Local Structure Plan	Subdivision Application	Development Application
		which meet required specifications in Table 6 of the Bushfire Protection Criteria.	
A3.3 Cul-de-sac / dead end road	There is a single cul-de-sac approximately 190m in length adjacent to Keirnan Road.	The updated BMP will reflect the final subdivision design and confirm compliance with the Bushfire Protection Criteria.	Is not applicable as it will be constructed for the subdivision.
A3.4 Battle-axe	Is not applicable.	Is not applicable.	Is not applicable.
A3.5 Driveway more than 50m	No driveways will be more than 50m in length.	Is not applicable.	Is not applicable.
A3.6 Emergency Access Way	Is not applicable.	Is not applicable.	Is not applicable.
A3.7 Fire Service Access Route	Is not applicable.	Is not applicable.	Is not applicable.
A3.8 Firebreaks	Is not applicable.	Is not applicable.	Is not applicable.
Element 4 Water			
A4.1 Reticulated Areas	The land is serviced by reticulated water.	The subdivision will be serviced with fire hydrants in accordance with the required specification. A plan of the hydrants will be submitted to Council and DFES as part of the subdivision clearance.	Is not applicable as it will be constructed for the subdivision.
A4.2 Non-reticulated Areas	Is not applicable.	Is not applicable.	Is not applicable.
A4.3 Single Lot Non-reticulated	Is not applicable.	Is not applicable.	Is not applicable.

6.0 RESPONSIBILITIES FOR IMPLEMENTATION AND MANAGEMENT OF THE BUSHFIRE MEASURES

The management of the risk posed by bushfires is a shared responsibility between landowners, government and industry. These responsibilities are summarised in Table 4.

The management measures listed below should not be construed to assure total bushfire protection and do not guarantee that a building will not be damaged in a bushfire. The level of protection will be dependent the level of fire preparedness and maintenance under taken by the landowner as well as the design and construction of the dwelling. The severity of a bushfire will depend upon the vegetation fuel loadings; the prevailing weather conditions and the implementation of appropriate fire management measures.

Table 4 DJMM Implementation

No	MANAGEMENT ACTION	TIMING
1.0 Developer Prior to Issue of Titles		
1.1	Construction of subdivision roads to standards outlined in the BMP to ensure safe access and egress.	Subdivision
1.2	Providing a second public road access connection to Taylor Street.	Subdivision
1.3	Preparation of a landscape plan for the POS areas to confirm the proposed BAL ratings.	Subdivision
1.4	A plan demonstrating the location and capacity of fire the fire hydrants shall be submitted to the Shire and DFES	Subdivision
1.5	Preparing a notification be included on the certificate of titles for the lots as having a BAL-12.5 rating or higher advising that the land is subject to a Bushfire Management Plan.	Subdivision
1.6	Provision of a plan for any proposed stages showing the proposed interim fire management measures.	Subdivision
2.0 Developer Prior to Sale		
2.1	Providing prospective residents with a summary of this BMP	Purchase
2.2	Maintaining vacant lots as low threat vegetation with grass less than 100mm in height for all of the year.	Ongoing
3.0 Landowner Prior to Occupancy		
3.1	Ensuring that any application for a building permit for a dwelling is to include an individual BAL assessment to confirm that sufficient land has been cleared to provide for BAL-29 setbacks.	Development
4.0 Landowners Ongoing		
4.1	Maintaining vacant lots as low threat vegetation with grass less than 100mm in height for all of the year.	Ongoing
4.2	Undertaking regular maintenance of their property in preparation for the annual fire season.	Ongoing
4.3	Ensuring that all fire mitigation measures shall be completed by the date prescribed in Shire's Firebreak Notice and Fuel Hazard Reduction Notice.	Ongoing
5.0 Local Government Ongoing Management		
5.1	Ensuring Building Permit Applications and Development Applications are compliant with the building and land use planning provisions.	Ongoing
5.2	Enforce compliance with its annual Firebreak Notice and Fuel Hazard Reduction Notice.	Ongoing

LANDSCAPING DESIGN PRINCIPLES

- This Landscaping Master Plan provides the overarching design principles for the development of the public open space areas and streetscapes within the Local Structure Plan (LSP) area. These design principles are to be further developed in the detailed Landscaping Management Plans to be prepared and approved by the Shire, at subdivision stage for each respective stage of development.
- The LSP design provides a balance between conservation, active and passive recreational spaces for the use and enjoyment of the future community of this residential area.
- The main objective for the landscaping design of each open space area is to enhance and protect the distinctive rural (visual) historical landscape character and amenity of Mundijong.
- In order to achieve this vision, the detailed landscaping plans prepared at subdivision stage are to ensure existing vegetation is retained (where possible) particularly within street verges and along Manjedal Brook; and that the existing natural 'green' linkages within and extending along the road reserves of Soldiers Road and Laing Road are protected.
- Perimeter roads bounding all areas of the proposed recreational reservations are necessary to ensure sufficient separation distance to vegetation, for the purposes of bushfire management.
- Landscaping within the areas of POS are to be selected with reference to the plant species identified in the Shire's Low Flammability Local Native Species.
- Street trees are to be planted at a rate of one (1) tree per residential lot, where possible. The trees are to be placed central to the lot frontage and set back to allow for crossovers, utility services including street lighting, and footpaths. The tree species are to be chosen from the Shire's preferred tree species list and will be identified in the site specific, detailed Landscaping Management Plans, which are required to be prepared at the subdivision application stage and approved by the Shire.
- Tree planting specifications (including species and density) must take into consideration the assigned BAL rating for the nearby residential lots and ensure that the proposed landscaping will not result in any increase to the prescribed BAL rating.
- The drainage basins contained within POS #2 and POS #3 will contain planting suitable for seasonal inundation, e.g. reed and edge species. While it is not expected that the basins will retain standing water during the summer months, it is likely that the soil profile will remain moist. As a result, the vegetation will not completely dry out and therefore, is classified as low threat vegetation.
- Footpath connections are to be provided internally within the recreational areas and will connect with the shared paths and footpaths along the internal road network.

LEGEND

- drainage basin
- existing vegetation
- play elements
- picnic facilities and shelter
- indicative 30m buffer to Manjedal Brook



3 DISTRICT PLAYING FIELDS

- The District Playing Fields are proposed to form part of a co-located reserve for the future High School.
- The High School and the Mundijong community are to share the facilities, ensuring maximum efficiency of the land and amenities provided.
- The development layout and design of the co-located facilities is to be determined by the Shire and the Department of Education, at the appropriate time for its development in the future.
- It is recognised that an Aboriginal Heritage site has been identified on Lot 30 as part of the Aboriginal Heritage Assessment undertaken in support of the LSP. The site is described as "Sam Woods' Camp (M120-01). An elevated sand dune (PAD-01) has also been identified on Lot 30 as having moderate potential to contain subsurface archaeological material.
- As part of the future design process to be undertaken by the Department of Education and the Shire, further detailed recording and assessment will be required of Lot 30. This assessment should include recording of oral histories, detailed surface recording, assessment of artefacts, and subsurface test excavations.

2 LOCAL PARK

- The design for the local park is to ensure retention of the remnant vegetation and to provide for passive recreational opportunities for local residents.
- The habitat trees within this POS area are to be protected for roosting opportunities for the black cockatoo and to provide for identity and a sense of place for the residential community.
- Landscaping is to comprise of native, waterwise shrubs, for low cost ongoing maintenance by the Shire.
- The park will comprise of informal grassed areas for passive and active recreational uses.
- The park will include play elements for children.
- There is opportunity for picnic facilities and shelter to be provided within this space.
- A drainage storage area is to be incorporated into the park and will be landscaped for recreational use.

MANJEDAL BROOK RESERVE

- A proposed open space reserve is to run along the length of the southern edge of the respective section of the Manjedal Brook and will include portion of the 30.0m buffer to the southern edge of the waterway channel, consistent with the LSP for Sub-Precinct G1 to the north of the Brook.
- The recorded Aboriginal Site (M1-08) is a scarred tree, which is to be protected within the reserve. A 30.0 metre buffer around the tree to ensure its tree root system is protected.
- The Reserve is to retain remnant vegetation and will include revegetation with waterwise, native shrub species, to be determined as part of the detailed Landscaping Management Plan for each respective stage of development, at subdivision application stage.
- Informal, irrigated grassed areas will be provided along the reserve, together with the integration of a footpath network to connect with the surrounding residential areas.
- Play elements will be provided within the POS area.
- There is also opportunity to provide for picnic facilities, including BBQ, seating and shelters.

LANDSCAPE MASTER PLAN

Keirnan Street, Mundijong (Sub-Precinct G2)
DWM/AN/ND/JONG PTY LTD

PETER WEBB AND ASSOCIATES
CONSULTANTS IN TOWN PLANNING & URBAN DESIGN



1:5000 @ A3/P2284-23L/MP29.04.2020

ANNEXURE 4
Transportation Noise Assessment
Lloyd George Acoustics



Lloyd George Acoustics

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Transportation Noise Assessment

**Proposed Subdivision
Lots 11 to 14 Keirnan Street, Mundijong**

Reference: 18044394-02

Prepared for:
DJM MUNDIJONG Pty Ltd



Report: 18044394-02**Lloyd George Acoustics Pty Ltd**

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Date:	Rev	Description	Prepared By	Verified
8/04/19	-	Final	Daniel Lloyd	Terry George

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Appendices

- A Acceptable Treatment Packages
- B Terminology

1 INTRODUCTION

It is proposed to develop Lots 11 to 14 Keirnan Street, Mundijong, for residential use. The proposed subdivision is shown on *Figure 1-1*.

As this land is located adjacent to a freight railway, Lloyd George Acoustics have been commissioned to undertake an assessment of future transportation noise levels from passing trains, compare the results of the assessment against relevant transport noise criteria and provide recommendations on mitigation measures where appropriate.

A description of some of the terminology used throughout this report is contained within *Appendix B*.



Figure 1-1 Proposed Subdivision Layout

2 CRITERIA

2.1 Noise

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 apply 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.

In areas where the *target* is exceeded, 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.

For residential buildings, "acceptable indoor noise levels" are taken to be 40 dB $L_{Aeq(Day)}$ in living areas and 35 dB $L_{Aeq(Night)}$ in bedrooms.

2.2 Vibration

There is no legislation or policy in Western Australia that addresses vibration impacts from trains. However, common criteria used in Western Australia are the vibration curves 1.4 and 2 (Annex A) of Australian Standard 2670.2-1990 *Evaluation of human exposure to whole-body vibration Part 2: Continuous and shock induced vibration in buildings (1 to 80 Hz)*. These curves have been found to align well with annoyance from ground-borne vibration from trains and were used as the criteria in the Southern Suburbs Railway.

3 METHODOLOGY

3.1 Site Measurements

Noise and vibration monitoring was undertaken in order to:

- Quantify the existing noise and vibration levels;
- Determine the differences between different acoustic parameters ($L_{Aeq (Day)}$ and $L_{Aeq (Night)}$); and
- Calibrate the noise model for existing or future scenarios.

3.1.1 Noise Measurement

Noise levels were measured on the property boundary using an ARL Ngarra noise data logger programmed to record L_{A1} , L_{A10} , L_{A90} , and L_{Aeq} levels. This instrument complies with the instrumentation requirements of Australian Standard 2702-1984 Acoustics – Methods for the Measurement of Road Traffic Noise. These hold current laboratory calibration certificates and was also field calibrated before and after the measurement session and found to be within +/- 1 dB.

The noise data collected was verified by inspection and professional judgement.

3.1.2 Vibration Measurement

Vibration levels were measured on the property boundary using a Texcel vibration data logger connected to a geophone. The analyser was set to sample the vibration levels every 125 milliseconds and to log the results at one minute intervals. This is considered to be in line with acceptable measurement procedure for train vibration.

3.2 Noise Modelling

The computer programme *SoundPLAN 8.1* was utilised incorporating a modified version of the Nordic Rail Prediction Method (Kilde Rep. 130) algorithm.

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 locomotives and wagons used in the Perth region. In addition, to accurately predict the effect of barriers (hills or buildings), the noise source height of the locomotive was raised from the standard 0.5 metres to 4.0 metres above the railhead.

Noise predictions are made at 1.0 metre from an assumed building facade (resulting in a + 2.5 dB correction due to reflected noise) and at a height of 1.4 metres above ground level for single storey dwellings and 4.4 metres above ground level) for two-storey dwellings.

It should be noted that the Nordic Rail Prediction Method does not allow changes to meteorological conditions, but assumes a standard worst-case scenario. For this project, the wind conditions would not result in significant variations in predictions due to the short distance from the railway to the development.

3.3 Ground Topography & Cadastral Data

Topographical and cadastral data was based on a feature survey provided by Vision Surveys.

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 all two-store buildings 7.0 m.

3.3.1 Train Movements

To represent future train movements on freight railways, the Policy guidelines state that for the assessment of freight rail, "*one train movement per hour is to be used*". Therefore, it would be the $L_{Aeq(night)}$ levels that would dictate compliance or otherwise with the Policy and these have been used in the assessment.

4 RESULTS

4.1 Noise Monitoring

The results of the noise monitoring are shown graphically in *Figure 4-1*. Detailed analysis shows that these levels are highly influenced by road traffic on Soldiers Road, which is not considered in the assessment due to the low traffic volumes. Therefore a typical train passby, as shown in *Figure 4-2*, was used to calibrate the noise model. It should be noted that the large spike in noise as the train approaches the measurement location is as a result of the warning horn, which under the Policy is not to be considered in the assessment.

Based on the analysis and assuming eight train movements, the $L_{Aeq(Night)}$ and L_{Amax} noise levels at the property boundary are presented in *Table 4-1*.

Table 4-1 Measured Noise Level at Monitoring Location

Location	$L_{Aeq(Night)}$	L_{Amax}
Development Boundary	55 dB	75 dB

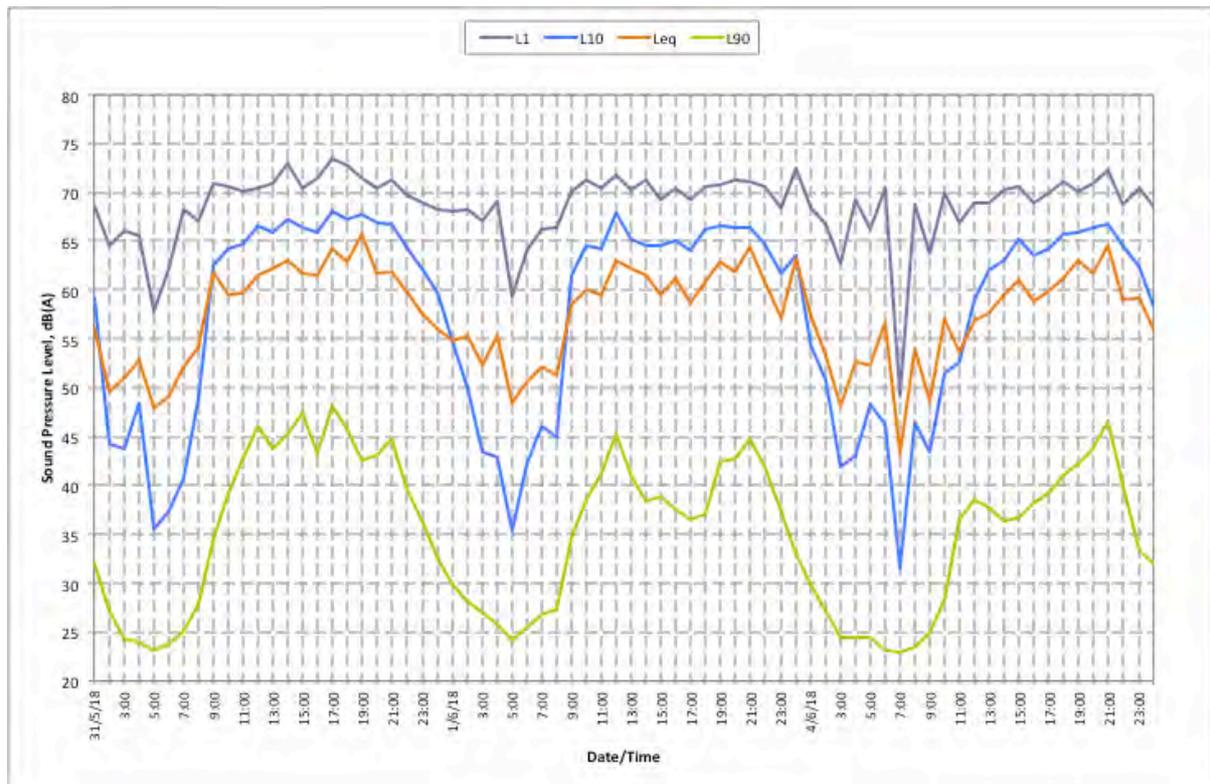


Figure 4-1 Overall Noise Measurement Results

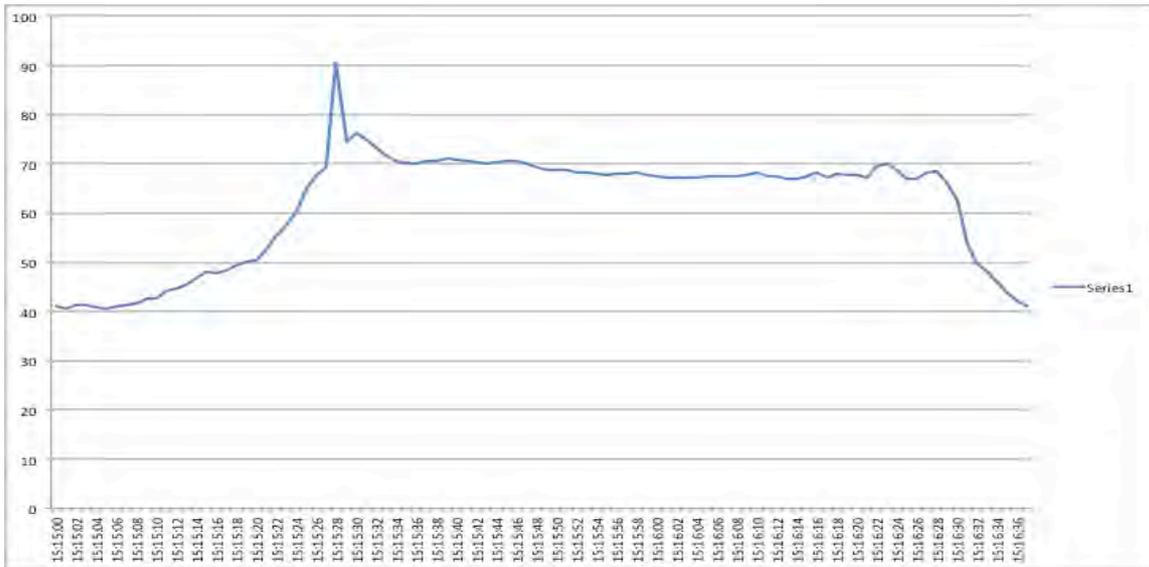


Figure 4-2 Single Train Passby Noise Measurement Results

4.2 Vibration Monitoring

The results of the ground vibration measurements are presented in Figure 4-3. When compared against the Australian Standard 2670.2-1990 criteria, as detailed in Section 2 of this report, it can be seen that the vibration levels are significantly below the criteria at the property boundary. This suggests that further consideration of vibration levels is not required.

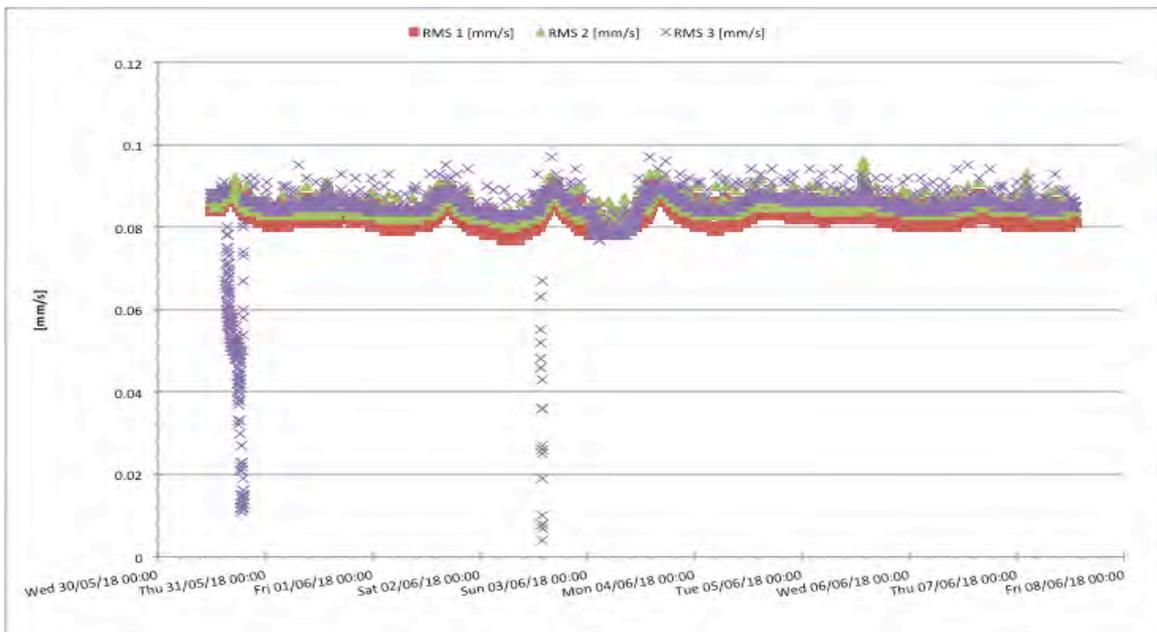
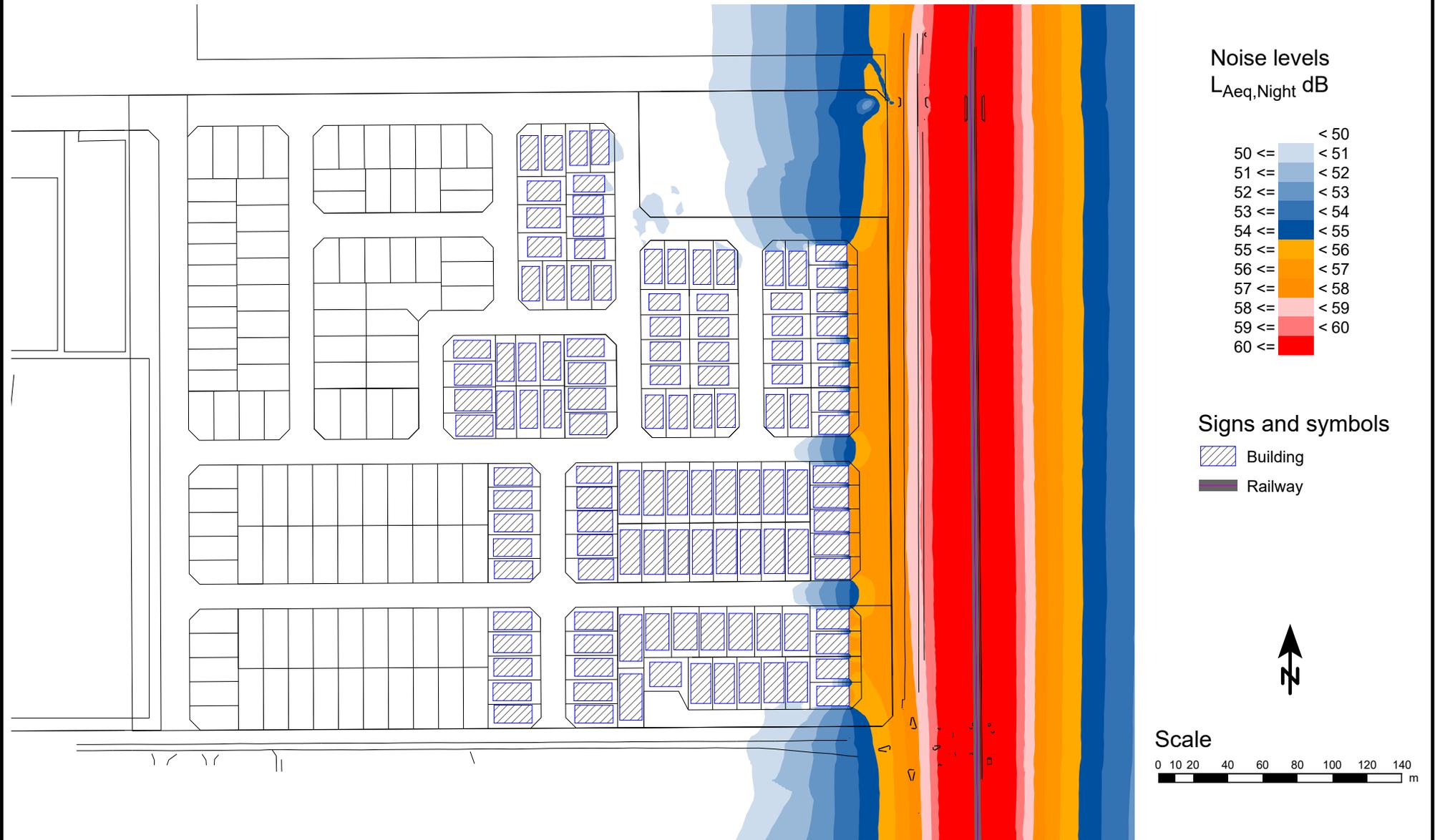


Figure 4-3 Vibration Measurement Results

4.3 Noise Modelling

The result of the noise modelling, calibrated against the measured data is provided in Figures 4-4 and 4-5, being for ground and upper floors respectively.

Figure 4-4



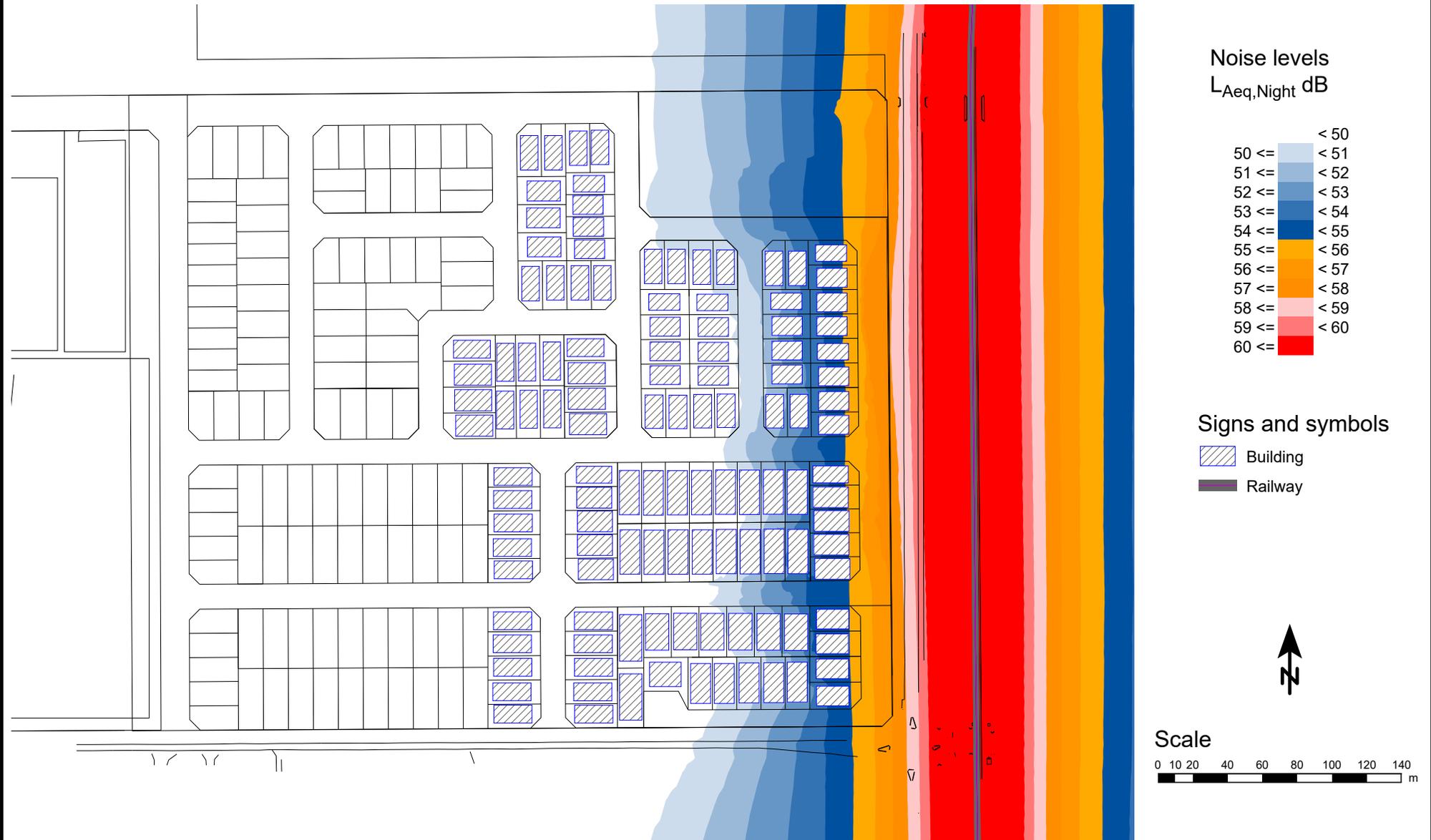
Proposed Residential Subdivision - Lots 11 to 14 Keirnan Street Mundijong

L_{Aeq,Night} Noise Level Contours - Ground Floor - No Mitigation



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Figure 4-5



Proposed Residential Subdivision - Lots 11 to 14 Keirnan Street Mundijong

L_{Aeq,Night} Noise Level Contours - Upper Floor - No Mitigation



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5 ASSESSMENT

From *Figures 4-4 and 4-5*, it can be seen that assuming no noise mitigation measures, there are a number of lots predicted to receive a future transportation noise level that will be above the *target* criteria. Therefore noise mitigation measures must be considered in the development design.

We have been advised that noise barriers would not be an appropriate noise mitigation measure for this development. Therefore, noise mitigation in the form of building facade treatments would be required.

The Policy provides “deemed to comply” facade packages (Package A, B and C) where transportation noise is above the *target* but not more than 5 dB above the *limit*. These facade packages are provided at *Appendix A*. Noise levels that are more than 5 dB above the *limit* would require specialist acoustic advice. It should be noted that specialist advice could also be sought for any house design above the *target*, if desired, and can provide a customised facade design

The facade protection packages for ground and upper floors are shown in *Figures 5-1 and 5-2* respectively.

In addition, the Policy also states that “Customised noise mitigation measures should be implemented with a view to achieving the noise *target* in at least one outdoor living or recreation area on each noise-sensitive lot or, if this is not practicable, within the margin.

Additional requirements include all affected lots to have notifications on lot titles as per the Policy requirements – refer *Appendix A*.

Figure 5-1



Key

-  No Treatment Required
-  "Package A" Treatment
-  "Package B" Treatment
-  "Package C" Treatment
-  Railway

Proposed Residential Subdivision - Lots 11 to 14 Keirnan Street Mundijong
 Required Facade Treatment Ground Floor



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Figure 5-2



Key

-  No Treatment Required
-  "Package A" Treatment
-  "Package B" Treatment
-  "Package C" Treatment
-  Railway

Proposed Residential Subdivision - Lots 11 to 14 Keirnan Street Mundijong
 Required Facade Treatment Upper Floor



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6 CONCLUSION

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 5-1 and 5-2*.
- For dwellings requiring facade Packages, alternative treatment to the deemed to satisfy may be accepted if supported by a report by a suitable qualified acoustical engineer (member firm of the Association of Australasian Acoustical Consultants) and does not contravene any development conditions;
- All affected lots are to have notifications on lot titles as per the Policy requirements – refer *Appendix A*.
- All affected lots are to provide one outdoor entertaining area where noise levels are below the *limit*.

Appendix A

ACCEPTABLE TREATMENT 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.

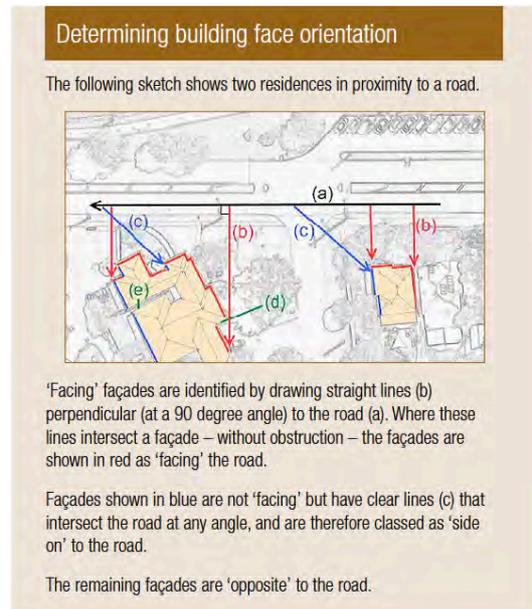
The acceptable treatment packages are intended to simplify compliance with the noise criteria, and the relevant package should be required as a condition of development in lieu of a detailed assessment.

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.



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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Windows systems: As above.
	Opposite	No requirements
Other Habitable Rooms Including Kitchens	Facing	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Windows and external door systems: As above.
	Opposite	No requirements
General	Any	<ul style="list-style-type: none"> 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		<ul style="list-style-type: none"> Locate on the side of the building that is opposite to the corridor if practicable; or Locate within alcove area so that the house shields it from corridor if practicable.

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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Windows systems: As above.
	Opposite	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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. Glass doors to be same performance ($R_w + C_{tr}$ 28) including brush seals.
	Opposite	No requirements
General	Any	<ul style="list-style-type: none"> Walls (minimum $R_w + C_{tr}$ 50) – Two leaves of 90mm thick brick with minimum 50mm cavity. Cavity to include 25mm thick, 24kg/m³ 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		<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Windows systems: Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 34) – 10.5mm thick VLam Hush glass in fixed sash, awning or casement opening with seals to openings.
	Side	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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 40mm 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. Alternatively, change to fully glazed hinged door with perimeter acoustic seals and 10mm thick glass.
	Side	<ul style="list-style-type: none"> 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 certified to R_w 30. Glazed inserts to match the above. Sliding glass doors to have laboratory certificate confirming $R_w + C_{tr}$ 31 performance. Alternatively, change to hinged door with perimeter acoustic seals and 10mm thick glass.
	Opposite	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Walls (minimum $R_w + C_{tr}$ 50) – Two leaves of 90mm thick brick with minimum 50mm cavity. Cavity to include 25mm thick, 24kg/m³ 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		<ul style="list-style-type: none"> 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 $L_{A10,18hour}$ 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 $L_{Aeq,24hour}$ 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 $L_{A10,18hour}$.

R_w

This is the weighted sound reduction index and is similar to the previously used STC (Sound Transmission Class) value. It is a single number rating determined by moving a grading curve in integral steps against the laboratory measured transmission loss until the sum of the deficiencies at each one-third-octave band, between 100 Hz and 3.15 kHz, does not exceed 32 dB. The higher the R_w value, the better the acoustic performance.

C_{tr}

This is a spectrum adaptation term for airborne noise and provides a correction to the R_w value to suit source sounds with significant low frequency content such as road traffic or home theatre systems. A wall that provides a relatively high level of low frequency attenuation (i.e. masonry) may have a value in the order of -4 dB, whilst a wall with relatively poor attenuation at low frequencies (i.e. stud wall) may have a value in the order of -14 dB.

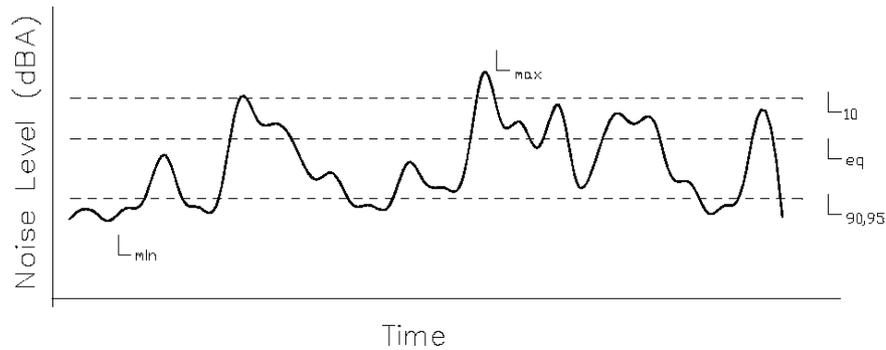
Satisfactory Design Sound Level

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

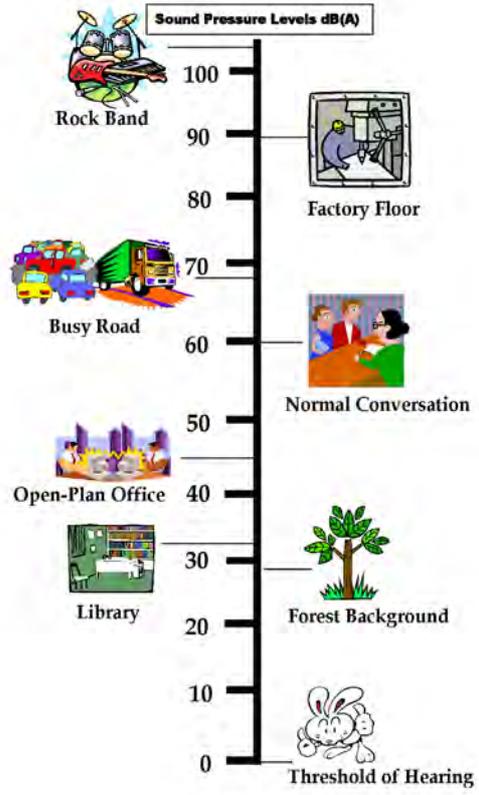


Austroads Vehicle Class

AUSTRROADS Vehicle Classification System						
Level 1 Length Description Type	Level 2 Axles and Axle Groups	Level 3 Vehicle Type Typical Description	Class	Parameters	AUSTRROADS Classification Typical Configuration	
Short up to 5.5m	1 or 2	Short Light Van, Bicycle, Motorcycle etc	1	d(1) < 3.2m and axles = 2		
	3, 4 or 5	Short - Towing Trailer, Caravan, Boat, etc	2	groups = 3 d(1) < 2.5m, d(2) < 3.2m, d(3) < 2.5m and axles = 3, 4 or 5		
Medium 5.5m to 14.5m	2	Two Axle Truck or Bus	3	d(1) > 3.2m and axles = 2		
	3	Three Axle Truck or Bus	4	axles = 3 and groups = 2		
	> 3	Four Axle Truck	5	axles = 3 and groups = 2		
Long 14.5m to 30.5m	3	Three Axle Articulated Three axle articulated vehicle, or Rigid vehicle and trailer	6	d(1) > 3.2m, axles = 3 and groups = 3		
	4	Four Axle Articulated Four axle articulated vehicle, or Rigid vehicle and trailer	7	d(2) > 2.5m or d(1) > 2.5m or d(1) > 3.2m axles = 4 and groups = 2		
	5	Five Axle Articulated Five axle articulated vehicle, or Rigid vehicle and trailer	8	d(2) > 2.5m or d(1) > 2.5m or d(1) > 3.2m axles = 5 and groups = 2		
	> 5	Six Axle Articulated Six axle articulated vehicle, or Rigid vehicle and trailer	9	axles = 6 and groups = 2 or axles = 5 and groups = 3		
Medium Combination 17.5m to 36.5m	> 5	8 Double 8 Double, or Heavy truck and trailer	10	groups = 4 and axles = 6		
	> 5	Double Road Train Double road train, or Medium articulated vehicle and one slip trailer (M.A.C.T.)	11	groups = 2 or 6 and axles = 6		
Large Combination Over 33.5m	> 5	Triple Road Train Triple road train, or Heavy truck and three trailers	12	groups = 6 and axles = 6		

Definitions:
 Group: Axle group, where adjacent axles are less than 2.5m apart
 Groups: Number of axle groups
 Axles: Number of axles (maximum axle spacing of 10.0m)
 d(1): Distance between first and second axle
 d(2): Distance between second and third axle

Typical Noise Levels



ANNEXURE 5
Landscape and Vegetation Strategy
GHD



DJ MacCormick Property Group

Keirnan St Mundijong Landscape and Vegetation Strategy

June 2020

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Appendix A – Figures

Appendix B – Relevant legislation, conservation codes and background information

Appendix C – Desktop searches

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Appendix E – Fauna data

1. Introduction

1.1 Background

DJ MacCormick Property Group (DJM) are developing a property located at Kiernan Street in Mundijong. As part of this development, GHD Pty Ltd (GHD) previously undertook an environmental constraints assessment of a 14 hectare (ha) site at Lots 11, 12, 13 and 14 Kiernan Street, Mundijong. This assessment, along with other technical documents, was included in a Local Structure Plan (LSP), which was submitted to the Shire of Serpentine Jarrahdale (Shire of SJ). The LSP boundary has since been modified and the Shire of SJ is seeking additional environmental information which covers the entire amended LSP area.

1.2 Purpose of this report

DJM engaged GHD Pty Ltd (GHD) to prepare a Landscape and Vegetation Strategy based on the previously delivered Environment Constraints Analysis. The Landscape and Vegetation Strategy will assist in mapping the key attributes of the landscape and natural environment within the LSP area and form the basis of future reports to regulatory authorities for approval.

1.3 Location

1.3.1 Project area

The LSP area (the project area) is located on Lots 10, 11, 12, 13, 14 and 50 Kiernan Street and Lot 101 Lang Road, Mundijong in the Shire of Jarrahdale Serpentine (Figure 1). The land is currently a greenfield site that is flat and environmentally degraded after 70+ years of continuous, low intensity livestock. The total project area covers 36.23 ha and is shown on Figure 1, Appendix A.

1.3.2 Study area

A study area was defined for the desktop based searches of the assessment and includes a 5 km buffer of the project area.

1.4 Scope of work

The scope of works was to:

- Conduct a desktop assessment covering the entire amended LSP area, to determine in detail the environmental value and any potential issues, including:
 - Physical attributes
 - Flora, vegetation and fauna values
 - Wetlands and water courses (mapping of geomorphic wetlands)
 - Heritage
- Complete a site visit to broadly describe the flora, vegetation and fauna areas within the LSP not previously assessed
- Prepare a Landscape and Vegetation Strategy (this report) which documents the results of the desktop and site visit as well as the key attributes and constraints of the environment and landscape, and cultural assets of the LSP area.

1.5 Relevant legislation, conservation codes and background information

In Western Australia significant communities, and flora and fauna are protected under both Federal and State Government legislation. In addition, regulatory bodies also provide a range of guidance and information on expected standards and protocols for environmental surveys.

An overview of key legislation and guidelines, conservation codes and background information relevant to this assessment are provided in Appendix B.

1.6 Limitations

This report has been prepared by GHD for DJM and may only be used and relied on by DJM for the purpose agreed between GHD and DJM as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than DJM arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by DJM and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, access, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

This report has assessed the environmental aspects within the project area (Figure 1, Appendix A). Should the project area change or be refined, further assessment may be required.

2. Methodology

2.1 Desktop assessment

A desktop assessment was undertaken to identify relevant environmental information pertaining to the project area. The assessment included viewing GIS spatial files available from Government of Western Australia (GoWA 2020) and reviewing relevant reports and publically available, government managed databases. The information sources utilised in this assessment are presented in Table 1.

Table 1 Information sources

Aspect	Information sources
Landform, topography and soils	Soil Landscape Mapping (DPIRD-027) (DAFWA 2007)
Contaminated sites	Department of Water and Environmental Regulation (DWER) Contaminated Sites Database (DWER 2020)
Acid Sulfate Soils	Australian Soil Resources Information System (ASRIS 2020)
Conservation areas	Bush Forever Areas 2000 (DOP-071) Department of Biodiversity, Conservation and Attractions (DBCA) – Legislated Lands and Waters (DBCA-011) DBCA – Lands of Interest (DBCA-012) Regional Parks (DBCA-026) Regional Ecological Linkages for the Perth Metropolitan Region
Environmentally Sensitive Areas	DWER Clearing Permit System (DWER 2020)
Hydrology	Ramsar Sites (DBCA-010) Directory of Important Wetlands in Australia - Western Australia (DBCA-045) Geomorphic Wetlands, Swan Coastal Plain (DBCA-019)
Vegetation	Pre-European Vegetation (DPIRD-006) Vegetation Complexes – Swan Coastal Plain (DBCA-046) Native Vegetation Extent (DPIRD-005)
Threatened and Priority Ecological Communities	Threatened Ecological Community (TEC) and Priority Ecological Community (PEC) spatial dataset <i>Environment Protection and Biodiversity Conservation Act 1999</i> (EPBC Act) Protected Matters Search Tool (Department of Agriculture, Water and Environment (DAWE) 2020)
Flora diversity and conservation significant flora	DBCA <i>NatureMap</i> database (DBCA 2007–)
Fauna diversity and conservation significant fauna	DBCA <i>NatureMap</i> database (DBCA 2007–)
Aboriginal heritage	Aboriginal Heritage Places (DAA-001)
European heritage	Heritage Council WA – State Register (SHO-003)
Matters of National Environmental Significance (MNES)	EPBC Act PMST (DAWE 2020)

2.2 Field survey

2.2.1 Flora and vegetation

GHD Ecologists completed a reconnaissance vegetation and flora survey of Lots 11-14 on 3 July 2018 and of Lots 10, 50 and 101 on 12 February 2020. The purpose of the surveys was to verify the desktop assessment, characterise the dominant vegetation units and their condition, and identify and record vascular flora taxa present at the time of survey.

The survey methodology employed by GHD was undertaken with reference to the Environmental Protection Authority (EPA) *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016a).

Data collection

Field survey methods involved traversing the project area by foot to characterise the dominant vegetation and record flora species (native and exotic) present in the project area at the time of survey.

Vegetation units

Vegetation units were identified and boundaries delineated using a combination of aerial photography, topographical features and field data/observations. Vegetation units were described based on structure, dominant taxa and cover characteristics as defined by field observations.

Vegetation condition

The vegetation condition of the project area was assessed and mapped in accordance with the vegetation condition rating scale for the South West and Interzone Botanical Provinces (EPA 2016a). This scale recognises the intactness of vegetation, which is defined by the following:

- Completeness of structural levels.
- Extent of weed invasion.
- Historical disturbance from tracks and other clearing or dumping of rubbish.
- The potential for natural or assisted regeneration.

The scale consists of six rating levels as outlined in Appendix B.

Flora identification and nomenclature

Species well known to the ecologists were identified in the field; all other species were collected and assigned a unique collection number to facilitate tracking. Specimens collected during the field assessment were identified by the use of taxonomic literature, electronic keys and online electronic databases.

The conservation status of all recorded flora was compared against the current lists available on *FloraBase* (WA Herbarium 1998–) and the EPBC Act Threatened species database provided by DAWE.

Nomenclature used in this report follows that used by the Western Australian Herbarium as reported on *FloraBase* (WA Herbarium 1998–).

2.2.2 Fauna (including targeted Black Cockatoo assessment)

The fauna survey was undertaken in conjunction with the flora and vegetation surveys and was undertaken by experienced GHD Ecologists. The purpose of the survey was to identify and describe the dominant fauna habitat types and identify and record fauna species present at the

time of survey. An assessment of the likelihood of conservation significant fauna and their habitats occurring within the project area was also undertaken.

The fauna survey was undertaken with reference to the EPA *Technical Guidance – Sampling methods for terrestrial vertebrate fauna* (EPA 2016b) and *Technical Guidance – Terrestrial Fauna Surveys* (EPA 2016c).

Habitat assessment

The project area assessed for habitat type, structural complexity, type and extent of resource availability and value for fauna. Specifically, the assessment included:

- Habitat structure (e.g. vegetation type, presence/absence of overstorey, midstorey, understorey, ground cover)
- Presence/absence of refuge including: fallen timber (coarse woody debris), hollow-bearing trees and stags and rocks/breakaways, and the type and extent of each refuge
- Location of the habitat within the survey areas in comparison to the habitat within the surrounding landscape
- Identification and evaluation of key habitat features and types identified during the desktop assessment relevant to fauna of conservation significance, including Carnaby's Black Cockatoo
- Evaluation of the likelihood of occurrence of conservation significant fauna within the habitat (based on presence of suitable habitat)
- A representative photograph of each habitat type.

Opportunistic observations

Whilst conducting activities in the project area, opportunistic observations were made of any other vertebrates (or signs of their presence). Fauna taxa observed or heard were noted, and indirect evidence (such as scats, tracks, diggings, nests, feathers, bones, pellets) indicating the current or recent presence of a species also noted. Active searches across all habitat types within the project area were conducted, with searches involving turning over logs or rocks, and examining hollow logs.

Targeted Black Cockatoos habitat assessment

A targeted survey for black cockatoos was conducted in accordance with the EPBC Act referral guidelines for three threatened black cockatoo species: Carnaby's Cockatoo (endangered) *Calyptorhynchus latirostris*, Baudin's Cockatoo (vulnerable) *Calyptorhynchus baudinii* and Forest Red-tailed Black Cockatoo (vulnerable) *Calyptorhynchus banksii naso* (Department of Sustainability, Environment, Water, Populations, and Communities (DSEWPaC) 2012). The assessment involved visual and aural assessment of the project area identifying breeding habitat (presence/absence of actual and potential breeding trees), foraging habitat, roosting areas, current activity and any other signs of use by Carnaby's Black Cockatoos. For the purpose of this assessment, the DSEWPaC (2012) Black Cockatoo referral guidelines were used to define breeding, foraging and night roosting habitat.

The targeted habitat assessment for black cockatoos included:

- The identification and recording (via GPS) of the locations of potential and actual breeding habitat within the project area (relevant tree species with a diameter at breast height (DBH) of >500 millimetres (mm) for Jarrah (*Eucalyptus marginata*), Marri (*Corymbia calophylla*) and Flooded Gum (*Eucalyptus rudis*) or DBH of >300 mm for Wandoo (*Eucalyptus wandoo*) or Salmon Gum (*Eucalyptus salmonophloia*)

- Identifying, describing and recording the size of existing tree hollows and any evidence of use by Black Cockatoos within the project area
- Records of any potential breeding trees which have potential or actual breeding hollows, including size of hollow (small <5 cm, medium 5-10 cm or larger >10 cm).
- Identifying potential night roosting habitat
- Identifying, recording and describing the locations of potential foraging habitat
- Records and photographs of any evidence of black cockatoo feeding, night roosting or breeding use of trees, such as chew marks on nuts or edges of hollows, debris, scats and feathers in quantity below roost sites
- Co-ordinates for all relevant tree and evidence data in tabular and database (Excel and ArcGIS) form.

Fauna nomenclature

Fauna species were identified in the field using available field and electronic guides (e.g. Morcombe 2014). Where identification was not possible, photographs of specimens were collected to be identified later.

Nomenclature used in this report follows the WA Museum as reported on *NatureMap* (DBCA 2007–). This nomenclature is deemed the most up-to-date species information for WA groups: reptiles, amphibians, invertebrates and mammals (including bats). All Aves nomenclature follows Christidis and Boles (2008).

2.3 Limitations

2.3.1 Desktop limitations

Desktop investigations use a variety of online resources such as the WA Museum and DBCA *NatureMap* database, and the EPBC Act PMST. The EPBC Act PMST is based on bioclimatic modelling for the potential presence of species. As such, this does not represent actual records of the species within the area. The records from the DBCA searches of threatened fauna provide more accurate information for the general area. However, some records of collections, sightings or trappings cannot be dated and often misrepresent the current range of threatened species.

2.3.2 Survey limitations

The EPA (2016a and 2016c) Technical Guidelines state that flora and fauna survey reports for environmental impact assessment in WA should contain a section describing the limitations of the survey methods used. The limitations and constraints associated with this field survey are discussed in Table 2. Based on this assessment, the present survey effort has not been subject to any constraints, which affect the thoroughness of the assessment and the conclusions which have been formed.

Table 2 Field survey limitations

Aspect	Constraint	Comment
Sources of information and availability of contextual information	Nil	Adequate information is available for the project area: <ul style="list-style-type: none"> Broad scale (1:250,000) mapping by Beard (1979) and digitised by Shepherd et al. (2002)
Scope (what life forms were sampled etc.)	Nil	Vascular flora and terrestrial vertebrate fauna were sampled during the survey. Non-vascular flora, invertebrate and aquatic fauna were not surveyed.
Proportion of flora collected and identified (based on sampling, timing and intensity) Proportion of fauna identified, recorded and/or collected	Minor	The vegetation and flora surveys were undertaken in winter 2018 and summer 2020. The flora recorded from the field survey is detailed in Section 3.1.4 and a full flora species list is provided in Appendix D. The portion of flora collected and identified was considered high, however it is likely the survey under-recorded annual species due to survey timing. The fauna surveys were undertaken in conjunction with the flora and vegetation surveys and targeted the species which are easily seen, heard or have distinctive signs, such as tracks, scats, diggings, etc. Some cryptic species may not have been identified during the survey and seasonal variation within species can require targeted surveys at particular times of year. However, as a majority of the project area is cleared and not considered habitable by a considerable number of native fauna. The fauna assessment was aimed at identifying habitat types and terrestrial vertebrate fauna utilising the project area. No sampling for invertebrates or aquatic species occurred.
Flora determination	Nil	Flora determination was undertaken by the GHD ecologists in the field. Species were identified to species level where possible. Some species, particularly grasses, sedges and herbs, may have been overlooked due to lack of material. The taxonomy and conservation status of the WA flora is dynamic. This report was prepared with reliance on taxonomy and conservation status current at the time report development, but it should be noted this may change in response to ongoing research and review of International Union for Conservation Nature criteria.
Completeness and further work which might be needed (e.g. was the relevant area fully surveyed)	Nil	All of the project area was accessible on foot.
Mapping reliability	Minor	The vegetation was mapped using high-resolution ESRI aerial imagery obtained from Landgate, topographical features, previous broad scale mapping (Beard 1979) and field data. Data was recorded in the field using hand-held GPS tools (e.g. Samsung Galaxy Tablet S2). Certain atmospheric factors and other sources of error can affect the accuracy of GPS receivers. The GPS units used for this survey are accurate to within ± 5 metres on average. Therefore the data points consisting of coordinates recorded from the GPS may contain inaccuracies.

Aspect	Constraint	Comment
Timing/weather/season/cycle	Minor	The field surveys were conducted in winter 2018 and summer 2020. The timing of the flora and vegetation surveys are not considered the most optimal time to complete surveys on the Swan Coastal Plain (optimal time is during spring) however they should be considered acceptable given the highly degraded nature of the site with little to no native understorey remaining.
Disturbances (e.g. fire, flood, accidental human intervention)	Nil	Much of the project area has been subjected to historical disturbance events (e.g. clearing, burning off); however, these disturbances did not impact the survey.
Intensity (in retrospect, was the intensity adequate)	Nil	The vascular flora of the project area was sampled in accordance with EPA (2016a) and terrestrial fauna sampled in accordance to EPA (2016b). The project area was sufficiently covered by GHD ecologists during the survey.
Resources	Nil	Adequate resources were employed during the field survey. Three-person days were spent undertaking the surveys.
Access restrictions	Nil	The entirety of the project area was accessible at the time of the survey.
Experience levels	Nil	The ecologists who executed the survey are practitioners suitably qualified and experienced in their respective fields. Erin Lynch (senior ecologist) has over 12 years' experience undertaking flora and fauna surveys within WA. Madison Roberts (environmental scientist/ecologist) has 4 years' experience undertaking environmental assessment (including contaminated lands) and 2 year undertaking flora and fauna surveys within WA.

3. Biodiversity and natural environment

3.1 Flora and vegetation

3.1.1 Broad vegetation mapping and extent

Broad scale (1:250,000) pre-European vegetation mapping of the area has been completed by Beard (1979) at an association level. The mapping indicates that one vegetation association intersects the project area:

- Medium woodland; jarrah, marri & wandoo (association 968)

Regional vegetation has been mapped by Heddle et al. (1980) based on major geomorphic units on the Swan Coastal Plain. The Heddle et al. (1980) mapping indicates that two vegetation complexes are present within the project area:

- Guildford complex: A mixture of open forest to tall open forest of *C. calophylla* - *E. wandoo* - *E. marginata* and woodland of *E. wandoo* (with rare occurrences of *E. lane-polei*). Minor components include *E. rudis* - *M. raphiophylla*.
- Forrestfield complex: Vegetation ranges from open forest of *C. calophylla* - *E. wandoo* - *E. marginata* to open forest of *E. marginata* - *C. calophylla* - *C. fraseriana* - *Banksia* spp. Fringing woodland of *E. rudis* in the gullies that dissect this landform.

The pre-European mapping has been adapted and digitised by Shepherd et al. (2002). The extent of the vegetation associations have been determined by the state-wide vegetation remaining extent calculations maintained by the DBCA (Latest update March 2019–GoWA 2019a). As shown in Table 3, the current extents of vegetation association 968 are less than 22% at the IBRA bioregion, IBRA subregion and Local Government Area (LGA) levels.

GoWA (2019b) has assessed the vegetation complexes described and mapped by Heddle et al. (1980) against presumed pre-European extents within the Swan Coastal Plain (SCP) IBRA bioregion (Table 4) and the Shire of Serpentine-Jarrahdale (Table 5) respectively. The Guildford complex has less than 10% of their pre-European extent remaining within the SCP IBRA bioregion whilst both complexes have less than 10% remaining within the Shire of Serpentine-Jarrahdale.

Table 3 Extents of vegetation association mapped within the survey area (GoWA 2019a)

Vegetation association	Scale	Pre-European extent (ha)	Current extent (ha)	Remaining (%)	% Current extent in all DBCA managed lands
968	State WA	296,877.84	95,048.82	32.0	57.64
	IBRA bioregion: SCP (SWA)	136,188.20	9,017.32	6.62	21.61
	IBRA sub-region: Perth (SWA02)	136,188.20	9,017.32	6.62	21.61
	LGA: Shire of Serpentine-Jarrahdale	24,351.49	1,121.13	4.6	12.49

Table 4 Extents of vegetation complexes on the Swan Coastal Plain mapped within the survey area (GoWA 2019b)

Vegetation complex	Pre-European extent (ha)	Current extent (ha)	% of pre-European extent remaining	% of pre-European extent with formal protection
Guilford Complex	90,513.13	4,607.91	5.09	0.33
Forrestfield Complex	22,812.92	2,803.36	12.29	1.58

Table 5 Extents of vegetation complexes within the Shire of Serpentine Jarrahdale mapped within the survey area (GoWA 2019b)

Vegetation complex	Pre-European extent (ha)	Current extent (ha)	% of pre-European extent remaining	Proportion of the vegetation complex within the LGA %
Guilford Complex	12,986.67	552.25	4.25	14.35
Forrestfield Complex	4,514.76	411.02	9.10	19.79

3.1.2 Vegetation types and condition

The project area has predominantly been cleared and historically used for livestock farming and can be described as 'Parkland Cleared'. The vegetation primarily consists of scattered *Eucalyptus* trees (both native and planted/introduced) over introduced grasses (predominantly **Eragrostis curvula*) and herbs. Two rows of introduced Eucalypt species (including *Eucalyptus camaldulensis* and *E. cladocalyx*) have been planted on Lots 11 and 12. Native trees scattered across the properties include *Corymbia calophylla* (Marri), *Eucalyptus marginata* (Jarrah), *Eucalyptus rudis* (Flooded gum), *Xylomelum occidentale* (Woody Pear) and *Allocasuarina fraseriana* (Sheoak).

Three vegetation types are present within the Lang Road Reserve, located between Lot 101 and Lots 50, 10, 11, 12, 13 and 14. They consist of a Jarrah/Marri/Sheoak woodland, *Melaleuca* closed shrubland and marri woodland. The majority of the vegetation consists of *Eucalyptus marginata*, *Corymbia calophylla* and *Allocasuarina fraseriana* over *Banksia* spp., *Xylomelum occidentale* and *Kunzea glabrescens* over introduced grasses. There is no native understorey remaining throughout the project area.

A small pool of water was identified in the far north-eastern corner of Lot 14 during the 2018 spring flora survey (the area was dry during the 2020 summer survey). This area is likely to be seasonally inundated and is situated adjacent to a creekline that flows in a north-west direction outside the boundary of the project area. The vegetation associated with the waterbody was dominated by a small patch of *Typha* sp., *Lepidosperma* sp., **Solanum nigrum* (Black Berry Nightshade) and **Cenchrus clandestinus* (Kikuyu Grass).

The vegetation condition within the entire project area is considered Degraded to Completely Degraded. The project area had been highly modified with only scattered remnant tree/shrub species remaining. The vegetation structure is no longer intact and is completely dominated by an understorey/ground cover of common herbaceous and grassy weeds.

Vegetation types and condition are described in further detail with representative photographs in Table 6 and are mapped on Figure 4, Appendix A.

Riparian vegetation

During the field survey, no riparian vegetation was recorded across the project area. There were the occasional scattered *Eucalyptus rudis* (Flooded gum) which are usually associated with lakes, swamps and floodplains. At the time of the field visits there was no evidence of waterlogging or swamp vegetation species growing on the project area. Anecdotal evidence from the landowner adjacent to the project area suggested there is an underground spring which runs from east to west through the property. This could be seen as a slight depression in the landscape.

During the field surveys, Manjedal Brook (Conservation Category wetland UFI 15446) was identified adjacent to the northern boundary. At the time of the 2018 spring survey, this Brook was flowing to the west, running underneath Soldier Rd and past the northern boundary of the project area. This wetland was associated with Flooded Gum (*Eucalyptus rudis*), Jarrah and Marri over primarily invasive grasses and other weed species.

Table 6 Vegetation types identified within the project area

Vegetation type	Vegetation description and condition	Site Photo
Jarrah/Marri/Sheoak Woodland	<p><i>Eucalyptus marginata</i>, <i>Corymbia calophylla</i> and <i>Allocasuarina fraseriana</i> woodland over <i>Banksia</i> spp., <i>Xylomelum occidentale</i> and <i>Kunzea glabrescens</i> tall open shrubland over <i>*Ehrharta calycina</i>, <i>*Bromus diandrus</i> and <i>*Cenchrus clandestinus</i> grassland.</p> <p><u>Vegetation condition</u> Degraded: 1.72 ha Completely Degraded: 1.09 ha</p> <p>Total extent: 2.81 ha</p>	
Melaleuca Closed Shrubland	<p>Scattered <i>Corymbia calophylla</i> over <i>Melaleuca preissiana</i> and <i>Melaleuca raphiophylla</i> closed tall shrubland over <i>Kunzea glabrescens</i> scattered shrubs over <i>*Ehrharta calycina</i>, <i>*Bromus diandrus</i> and <i>*Cenchrus clandestinus</i> grassland</p> <p><u>Vegetation condition</u> Degraded: 0.39 ha</p> <p>Total extent: 0.39 ha</p>	

Vegetation type	Vegetation description and condition	Site Photo
Marri Woodland	<p><i>Corymbia calophylla</i> with scattered <i>Eucalyptus rudis</i> woodland over <i>Acacia pulchella</i> var. <i>glaberrima</i>, <i>Grevillea vestita</i> and <i>Xanthorrhoea preissii</i> scattered shrubs over <i>Ehrharta calycina</i>, <i>Avena barbata</i> and <i>Cenchrus clandestinus</i> grassland. A small patch of <i>Typha</i> sp. was growing in association with a low-lying area (small ditch). I</p> <p><u>Vegetation condition</u> Degraded: 0.08 ha</p> <p>Total extent: 0.08 ha</p>	
Parkland Cleared	<p>The vegetation consists of scattered trees (predominantly Eucalypt species both native and planted/introduced) over cleared understorey dominated by <i>Eragrostis curvula</i>.</p> <p>Scattered native tree species remaining include <i>Eucalyptus marginata</i>, <i>Corymbia calophylla</i>, <i>Eucalyptus rudis</i>, <i>Xylomelum occidentale</i> and <i>Allocasuarina fraseriana</i>.</p> <p><u>Vegetation condition</u> Completely degraded: 32.95</p> <p>Total extent: 32.95 ha</p>	

3.1.3 Threatened and Priority ecological communities

A search of the EPBC Act PMST identified five EPBC Act-listed TECs potentially occurring within the study area. These TECs were also identified in a search of the DBCA TEC/PEC database, however, one is listed as a Priority 3 PEC by DBCA. An additional three TECs and two PECs were identified in a search of the DBCA TEC/PEC database. Details of these communities are provided in Table 7 with the boundaries of the TECs and PECs from the DBCA search shown on Figure 3, Appendix A.

No TECs or PECs were identified within the project area during the surveys.

Table 7 Threatened and Priority Ecological Communities identified in the desktop searches

Community type	EPBC Act	Description
Tuart (<i>Eucalyptus gomphocephala</i>) Woodlands and Forests of the Swan Coastal Plain ecological community	EPBC Act: Critically Endangered DBCA: Priority 3	Mostly confined to Quindalup Dunes and Spearwood Dunes from Jurien Bay to the Sabina River, with outliers along some rivers. Tuart is the key dominant canopy species however Tuart communities comprise a variety of flora and fauna assemblages. Flora commonly occurring with Tuart include Peppermint (<i>Agonis flexuosa</i>), <i>Banksia attenuata</i> , <i>Banksia grandis</i> , <i>Allocasuarina fraseriana</i> , <i>Xylomelum occidentale</i> , <i>Macrozamia riedlei</i> , <i>Xanthorrhoea preissii</i> , <i>Spyridium globulosum</i> , <i>Templetonia retusa</i> and <i>Diplolaena dampieri</i> .
Banksia Woodlands of the Swan Coastal plain (TEC) Banksia dominated woodlands of the Swan Coastal Plain IBRA region (PEC)	EPBC Act: Endangered DBCA: Priority 3	The ecological community is a woodland associated with the SCP of southwest WA. A key diagnostic feature is a prominent tree layer of Banksia, with scattered Eucalyptus and other tree species often present among or emerging above the Banksia canopy. The understorey is a species rich mix of sclerophyllous shrubs, graminoids and forbs. The ecological community is characterised by a high endemism and considerable localised variation in species composition across its range.
Clay Pans of the Swan Coastal Plain (TEC) Herb rich shrublands in clay pans (SCP08) (TEC)	EPBC Act: Critically Endangered BC Act: Vulnerable	This vegetation community type occurs in low lying flats with a clay impeding layer allowing seasonal inundation. While aquatic annuals are common, the pools are probably not inundated to the same depth or for the same length of time as in the Herb rich saline shrublands in clay pans TEC (SCP07).
<i>Corymbia calophylla</i> – <i>Kingia australis</i> woodlands on heavy soils of the Swan Coastal Plain (SCP3a) (TEC)	EPBC Act: Endangered BC Act: Critically Endangered	The ecological community is a woodland community located on the heavy soils of the eastern side of the SCP. Typical and common native plant taxa in the community are: <i>Corymbia calophylla</i> (marri), the shrubs <i>Banksia dallanneyi</i> , <i>Philotheca spicata</i> , <i>Kingia australis</i> and <i>Xanthorrhoea preissii</i> ; herbs, rushes and sedges, <i>Cyathochaeta avenacea</i> , <i>Dampiera linearis</i> , <i>Haemodorum laxum</i> , <i>Desmocladius fasciculatus</i> , <i>Mesomelaena tetragona</i> and <i>Tetraria octandra</i> (Gibson et al 1994; WA DEC 2011). The introduced grass <i>Briza maxima</i> is also common in the community, although weed cover in most occurrences is currently quite low.

Community type	EPBC Act	Description
<i>Corymbia calophylla</i> – <i>Xanthorrhoea preissii</i> woodlands and shrublands of the Swan Coastal Plain (SCP3c) (TEC)	EPBC Act: Endangered BC Act: Critically Endangered	The ecological community is located on heavy soils of the eastern side of the SCP between Bullsbrook, and Capel. Dominant species in the community are the trees <i>Corymbia calophylla</i> (marri), and occasionally <i>Eucalyptus wandoo</i> (wandoo); the shrubs <i>Xanthorrhoea preissii</i> , <i>Acacia pulchella</i> , <i>Banksia dallanneyi</i> , <i>Gompholobium marginatum</i> , and <i>Hypocalymma angustifolium</i> and the herbs <i>Burchardia congesta</i> , <i>Cyathochaeta avenacea</i> and <i>Neurachne alopecuroidea</i> . The introduced species <i>Briza maxima</i> and <i>Hypochaeris glabra</i> are also common, but weed levels in most occurrences are generally quite low (Gibson et al 1994).
<i>Eucalyptus haematoxylon</i> - <i>Eucalyptus marginata</i> woodlands on Whicher foothills (SCP1a) (PEC)	DBCA: Priority 3	Community occurs along the northern edge of State Forest along the base of the Whicher Range and is composed of <i>Eucalyptus haematoxylon</i> – <i>Corymbia calophylla</i> - <i>Eucalyptus marginata</i> forests and woodlands. Taxa virtually restricted to the type include <i>Acacia varia</i> subsp. <i>varia</i> , <i>Agonis grandiflora</i> and <i>Xanthosia pusilla</i> .
<i>Banksia attenuata</i> and/or <i>Eucalyptus marginata</i> woodlands of the eastern side of the Swan Coastal Plain (SCP20b) (TEC)	BC Act: Endangered	The community occurs on sands at the base of the Scarp between Byford and Yarloop predominantly on the Pinjarra Plain and Ridge Hill Shelf. Most of the occurrences of this community type are <i>Eucalyptus marginata</i> – <i>Banksia attenuata</i> woodlands but the community also occurs as <i>Banksia</i> woodlands and heaths. A diverse shrub layer comprising <i>Hakea stenocarpa</i> , <i>Conostylis setosa</i> and <i>Johnsonia</i> aff. <i>pubescens</i> differentiates this community type from the other two subgroups.
Southern wet shrublands, Swan Coastal Plain (SCP2) (TEC)	BC Act: Endangered	No description available
<i>Corymbia calophylla</i> - <i>Eucalyptus marginata</i> woodlands on sandy clay soils of the southern Swan Coastal Plain (SCP3b) (TEC)	BC Act: Vulnerable	No description available
<i>Casuarina obesa</i> association (PEC)	DBCA: Priority 1	Thomas Rd to Serpentine River, Swan Coastal Plain. No detailed information to assess if distinct community.

3.1.4 Flora diversity

The *NatureMap* database search identified 584 plant taxa, representing 74 families and 249 genera that have previously been recorded within the study area. This total comprises 488 native flora taxa and 96 naturalised flora taxa. Dominant families recorded within the project area include Fabaceae (56 species), Myrtaceae (50 species) and Cyperaceae (49 species). The *NatureMap* database search results is provided in Appendix C.

The field surveys recorded a total of 45 flora species within the project area, including 24 native and 21 introduced/weed species. The project area is not considered representative of the floristic diversity in the area due to the highly degraded nature of the site. The list of flora identified during the survey is provided in Appendix D.

Of the 21 introduced/weed species identified within the project area, three are listed as a Declared Pest under the *Biosecurity and Agriculture Management Act 2007* and/or Weed of National Significance (WONS):

- **Zantedeschia aethiopica* (Arum Lily) – Declared Pest
- **Gomphocarpus fruticosus* (Narrowleaf Cottonbush) – Declared Pest
- **Asparagus asparagoides* (Bridal Creeper) – Declared Pest and WONS.

The location of Declared Pests and WONS recorded during the surveys are provided on Figure 4, Appendix A.

3.1.5 Threatened and Priority flora

Searches of the EPBC Act PMST, *NatureMap* and DBCA databases identified the presence/potential presence of 29 conservation significant flora taxa within the study area. This total included:

- 18 taxa listed under the EPBC Act and/or as Threatened BC Act
- Two Priority 2 taxa
- Eight Priority 3 taxa
- One Priority 4 taxon.

The locations of the records from DBCA database are presented on Figure 3, Appendix A.

No Threatened or Priority flora were identified within the project area during the field surveys.

A likelihood of occurrence assessment was conducted post-field survey for all conservation significant flora taxa identified in the desktop assessment. This assessment took into account previous records, habitat requirements, efficacy of the survey, intensity of the survey, flowering times and the cryptic nature of species.

The likelihood of occurrence assessment post-field survey concluded that all significant species identified in the desktop searches are unlikely or highly unlikely to occur within the project area.

3.2 Fauna

3.2.1 Fauna habitats

The survey identified three broad fauna habitat types within the project area, Parkland Cleared, Mixed Woodland/Shrubland and Sedgeland associated with the minor waterbody. All habitat types are highly degraded with little to no native understorey remaining. A description of each habitat type is provided in Table 8.

Table 8 Fauna habitat types within the project area

Habitat type	Description	Indicative photo
Parkland cleared	<p>Cleared paddocks where the understorey has been completely cleared of native vegetation. Consists of scattered individual or clumps of native and planted tree species (mostly Eucalypts) over introduced grasses and herbs. The natural structure of the vegetation is no longer intact.</p> <p>This habitat type is considered to be completely degraded and of low habitat value. However the native Eucalypt species (Jarrah and Marri) and some introduced Eucalypt species provide suitable foraging habitat for threatened black cockatoos as well as providing potential breeding and roosting habitat.</p>	
Mixed Woodland/ Shrubland	<p>Mixed woodland / shrubland dominated by jarrah, marri, woody pear, sheoak and <i>Banksia</i> species. The ground cover is completely dominated by introduced grasses and herbs.</p> <p>This habitat type is in a degraded condition and contains low to moderate habitat value. The scattered shrubs and trees may provide habitat and linkage for birds and mobile mammals traversing the environment. Limited fallen branches, logs or hollows were present in this habitat type. The Eucalypt, Banksia and sheoak trees provide suitable foraging habitat for Black Cockatoo's with some evidence of feeding observed on marri nuts. The marri and jarrah trees provide potential breeding and roosting habitat. Quenda diggings were also observed throughout this habitat.</p>	

Habitat type	Description	Indicative photo
Sedgeland (waterbody)	<p>A very small waterbody was identified in the north-east corner of the project area which was dominated by <i>Typha</i>, invasive grasses (kikuyu) and other introduced species. The surface water provides a water source for local fauna as well as habitat for fauna such as frogs. One frog species was identified from calls during the 2018 survey. The upper canopy consisted of Marri and scattered Flooded Gum (located outside the project boundary).</p>	

3.2.2 Fauna diversity

The *NatureMap* database search identified 182 fauna taxa, including 106 birds, 30 invertebrates, 20 mammals, 20 reptiles and 6 amphibians. This total comprises 174 native fauna taxa and 8 naturalised fauna taxa. The *NatureMap* database search is provided in Appendix C.

During the field surveys a total of 19 fauna species were recorded within the project area, including 13 birds, five mammals and one amphibian. Of these, six species are introduced.

A full list of fauna recorded during the survey is provided in Appendix E.

3.2.3 Threatened and Priority Fauna

Searches of the EPBC Act PMST and *NatureMap* identified the present/potential presence of 20 conservation significant fauna taxa within the study area. This total does not include those species that are exclusively marine as no marine habitat is present within the project area. Similarly, spurious records have also been removed from the search results.

No Threatened or Priority fauna species were observed during the 2018 field survey. One Threatened species, the Forest Red-tailed Black Cockatoo, was observed flying over the project area during the 2020 survey. During both surveys evidence of an additional two conservation significant species was observed (diggings and chew marks on marri nuts). They included:

- Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*) – Listed as Endangered under the EPBC Act and BC Act.
- Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) – listed as Vulnerable under the EPBC Act and BC Act.
- Quenda / Southern Brown Bandicoot (*Isodon fusciventer*) – Listed as Priority 4 by the DBCA.

Black Cockatoo habitat assessment

During the survey, a small group of Forest Red-tailed Black Cockatoos were observed flying over the project area. A small group could also be heard in the distance. No black cockatoo species were directly seen feeding within the project area, however evidence of foraging was observed in the form of chewed Marri nuts, with bite marks typical of the Forest Red-tailed Black Cockatoo and Carnaby's Black Cockatoo.

Foraging habitat

There are numerous records of black cockatoos occurring within and around the project area. Evidence of cockatoo feeding was observed over the surveyed area (Plate 1). Suitable foraging species within the project area primarily include Jarrah, Marri, Banksia and Sheoak as well as some of the planted Eucalypt species. There is approximately 2.91 ha of suitable foraging habitat within the project area (Table 9).



Plate 1 Chew marks on marri nuts attributed to the Forest Red-tailed Black Cockatoo and Carnaby's Black Cockatoo

Potential Breeding habitat

No breeding activity was recorded during the field survey. The field survey identified 88 potential breeding trees with DBH of greater than 500 mm within the project area (Figure 5, Appendix A). Of these 38 are Jarrah, 46 are Marri and four are Flooded gum. Three of the 88 trees recorded contained hollows, this included one Jarrah tree with 1 large hollow and one Marri tree with 2 large hollows. No evidence of breeding was observed. Results of the black cockatoo habitat survey are provided in Table 9 and mapping of potential habitat trees provided in Figure 5, Appendix A.

Breeding success is dependent on both the nesting and foraging areas being relatively close together and sufficient to support the population (DSEWPaC 2012). The trees identified during the survey were generally scattered across the project area and have the potential to be utilised by black cockatoos in the future. The closest known breeding tree has been recorded approximately 10 km east of the project area, in the Jarrahdale area (Department of Planning 2011).

Roosting habitat

A roost is an area or site with a roost tree or a number of roost trees where black cockatoos congregate at dusk to rest overnight. A night roost can include tall trees (>8 m height) within 1 km of the central roosting area of larger roost sites (>150 cockatoos) and within 500 m for smaller roost sites (<150 cockatoos) (Glossop et al. 2011). Typically, night roost sites have a standing water source nearby for drinking which may be a natural waterway or lake but constructed lakes, farm dams and stock water troughs are also used (Glossop et al. 2011). No evidence of roosting by black cockatoos was identified within the project area during the field assessment.

The project area provides suitable roosting habitat based on the presence of suitable roosting trees and presence of suitable foraging habitat. Although there is no permanent standing water within the survey area, there are a number of lake and river systems in the local area.

Table 9 Black Cockatoo habitat within the project area

Habitat type	Description
Foraging habitat	There is approximately 2.91 ha of foraging habitat for Black Cockatoos within the project area consisting of remnant and introduced Eucalypts within the parkland cleared habitat type.
Actual breeding habitat	No breeding events were recorded within the project area of any species of Black Cockatoo during the survey.
Potential breeding habitat	88 potential breeding trees with DBH > 500 mm, including 38 Jarrah, 48 Marri and four Flooded gum. Of the 88 trees, three contained hollows, this included: <ul style="list-style-type: none"> • One Jarrah with 3 hollows (small, medium and large) • One Marri with 2 large hollows • One Marri with 1 small hollow.
Roosting habitat	No roosting sites were recorded as being used by Black Cockatoos within the project area. The remnant and introduced Eucalypt species provide suitable roosting habitat.

Quenda / Southern Brown Bandicoot (Isoodon fusciventer)

The Quenda prefers dense scrubby, often swampy, vegetation with dense cover up to one metre high. However, it also occurs in woodlands, and may use less ideal habitat where this habitat occurs adjacent to the thicker, more desirable vegetation. The species often feeds in adjacent forest and woodland that is burnt on a regular basis and in areas of pasture and cropland lying close to dense cover (Van Dyke and Strahan 2008).

Diggings attributable to the Quenda were recorded amongst the dense grasslands of the farmland during the 2018 survey and within the woodland and shrubland habitat within the Lang Road reserve during the 2020 survey.

Fauna likelihood of occurrence

A Likelihood of Occurrence assessment was conducted post-field survey for all conservation significant fauna taxa identified in the desktop assessment. This assessment is based on species biology, habitat requirements, the quality and availability of suitable habitat as determined during the field survey and records of the species in the survey area and locality.

Twenty (20) conservation significant fauna species were identified during the desktop assessment as potentially occurring in the survey area and/or surrounding region. Of these, 15 were deemed unlikely or highly unlikely to be present or do not have significant habitat in the project area. Two species are considered likely to occur and three have been recorded within the project area. The likely and recorded (present) species are summarised in Table 10.

Table 10 Summary of fauna species considered likely to occur within the project area

Name	Conservation status	Likelihood of occurrence justification
Carnaby's Black Cockatoo (<i>Calyptorhynchus latirostris</i>)	Endangered (EPBC Act and WC Act)	Present – evidence of foraging on marri nuts. Suitable foraging and roosting habitat present as well as potential breeding habitat.
Forest Red-tailed Black Cockatoo (<i>Calyptorhynchus banksii naso</i>)	Vulnerable (EPBC Act and WC Act)	Present – evidence of foraging on marri nuts. Suitable foraging and roosting habitat present as well as potential breeding habitat.

Name	Conservation status	Likelihood of occurrence justification
Quenda, southwestern brown bandicoot (<i>Isoodon fusciventer</i>)	Priority 4 (DBCA listed)	Present – diggings attributable to the quenda were observed amongst the dense grasses in the project area. Suitable habitat in adjacent reserves and nearby creeklines.
Peregrine Falcon (<i>Falco peregrinus</i>)	Specially Protected (WC Act)	Likely – The project area provides suitable habitat. The species is known from the area with the closest known record approximately 1 km east of the project area, along the creek system that abuts the project area
Baudin's Black Cockatoo (<i>Calyptorhynchus baudinii</i>)	Endangered (EPBC Act and WC Act)	Likely – the project area provides suitable foraging and roosting habitat and potential breeding habitat. The project area is located within the known foraging range for this species however it is outside of the currently documented breeding range for this species.

3.3 Conservation areas and reserves

No DBCA-managed estates are located within the project area. Five DBCA-managed sites lie within the study area. These are summarised in Table 11.

Table 11 DBCA managed lands within the study area

ID	Name	Category	Distance from project area
R 46818	Bella Cumming Reserve	Nature reserve	1.18 km south
R 23012	Watkins Road Nature Reserve	Nature Reserve	1.83 km south-south east
R 50826	Un-named	Section 5(1)(h) reserve	3.13 km south-east
R 2457	Cardup Nature Reserve	Nature Reserve	3.1 km north
F22	Jarrahdale State Forest	State Forest	4.2 km east

3.3.1 Bush Forever

The project area is situated immediately adjacent to one Bush Forever site, no. 350 (Byford to Serpentine Rail/Road Reserves and Adjacent Bushland) (Figure 2, Appendix A). This site includes remnant roadside vegetation along Soldiers Road and adjacent railway reserve extending from Nettleton Road in the north to Mundijong Road in the south. The site also includes Bella Cumming Reserve south of Kiernan Road.

3.3.2 Ecological Linkages

The project area intersects one regional ecological linkage mapped in the Regional Ecological Linkages for the Perth Metropolitan Region (PMR) dataset, Link No. 65 (Figure 2, Appendix A). This link connects Bush Forever Sites 321, 350, 362 and 365. Vegetation associated with this ecological linkage includes remnant vegetation along Soldiers Road and adjacent railway reserve, outside of the project area.

3.3.3 Environmentally sensitive areas

A number of ESAs occur on or intersect the project area (Figure 2, Appendix A). These ESAs are associated with TEC buffers, bush forever sites and geomorphic wetlands.

4. Landforms, soils and topography

4.1 Landform and soils

The project area is located on the Swan Coastal Plain on the east part of the Darling Plateau. The majority of the project area is located on the Bassendean Dune System, which is a series of shoreline deposits and coastal dunes. The system is characterised by low hills of sand with sandy swamps in depressions (swales) between the dunes.

Soil landscape mapping indicates that three soil landscape types occur within the project area:

- Bassendean B2 Phase (212Bs_B2) – Flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.
- Bassendean B2a Phase (212Bs_B2a) – Flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with an intensely coloured yellow B horizon usually well within 1 m of the surface.
- Forrestfield F3 Phase (213Fo_F3) – Foot slopes (1-3%) with deep, imperfectly drained yellow and, less commonly, acidic gley duplex soils.

4.2 Topography

The topography of the project area is predominantly flat and slightly sloping towards the west.

4.3 Acid Sulfate Soil Risk Mapping

Acid Sulphate Soil (ASS) risk mapping indicates that the project area contains soils with low risk of ASS occurrence.

4.4 Contaminated sites

The DWER holds information on known contaminated sites on the Contaminated Sites Database which have been classified by the DWER as one of the following:

- Contaminated – remediation required.
- Contaminated – restricted use.
- Remediated for restricted use.

A review of the Contaminated Sites Database on 25th June 2018 indicated the project area is not known to be contaminated.

Within a 5 km buffer of the project area, one parcel of land (Parcel ID: 12570) located approximately 2.32 km south is listed as 'Contaminated – restricted use'. This site is a former service station listed due to the presence of hydrocarbons (LNAPL) in the groundwater beneath the site, which extends to the west-northwest. Hydrocarbon impacted soil is also present in the smear zone of the seasonally fluctuating impacted groundwater. Although the project area is hydraulically down-gradient to the contaminated site, due to the distance and reported remediation efforts, the project area is not suspected to be at risk to secondary contamination from this site.

A parcel of land located approximately 2.31 km south of the Site (Parcel ID: 20134) is listed as 'Remediated for restricted use'. This site is a road reserve affected by hydrocarbons from the adjacent service station (Parcel ID: 12570 mentioned above). The site is contaminated and has been remediated such that it is suitable for its current land use, but may not be suitable for a

more sensitive land use. The contamination status of this site is not considered to be of major risk to the environmental health of the project area.

Basic Summary of Records related to the two aforementioned sites are presented in Appendix C. It should be noted that land suspected but not classified as being contaminated is not displayed in the database

5. Natural and cultural assets

5.1 Surface water

5.1.1 Surface water

There are no creeklines within the project area. The closest surface water body appears to be the Manjedal Brook which flows in an east-west direction and is north of the project area (reaching within 5 m of the project area boundary). Approximately 170 m north of the project area on an adjacent property lies two water bodies (potentially dams) with unknown use. There was a small depression filled with water within the far north-eastern corner of the project area, close to Manjedal Brook. The vegetation associated with the waterbody was dominated by *Typha* sp., (naturalised species), Kikuyu grass (*Cenchrus clandestinus*), a *Lepidosperma* species and other introduced grasses and herbs. This depression is likely to be dry over the summer months.

5.1.2 Wetlands

RAMSAR wetlands and Wetlands of National Significance

There are no RAMSAR listed wetlands or Wetlands of National Significance occurring 5 km of the project area.

Geomorphic wetlands

Two Geomorphic Wetland intersect the project area:

- One Multiple Use wetland (UFI 16021) that covers the majority of the project area with the exception of land near the southern boundary.
- One conservation category wetland (UFI 15446) that intersects the northern boundary of the project area. This wetland is association with Manjedal Brook.

There are a further seven geomorphic wetlands within 500 m of the project area (Table 12 and Figure 2, Appendix A).

Table 12 Geomorphic wetlands within 500 m of the project area

UFI	Type	Category	Location
15448	Palusplain	Multiple Use	~60 m north from the project boundary
15447	Palusplain	Multiple Use	~30 m north from the project boundary
14969	Palusplain	Conservation	~15 m from the southern project boundary
7842	Palusplain	Multiple Use	~50 m from the southern project boundary
7835	Sumpland	Conservation	~140 m from the northern project boundary
14945	Palusplain	Conservation	~235 m from the northern project boundary
7834	Sumpland	Multiple Use	~300 m from the northern project boundary

5.2 Heritage

5.2.1 Aboriginal Heritage

One Aboriginal heritage site is located within the project area. The site, Site ID 37115 (MJ-09) is located on the eastern portion of Lot 101 Lang Road. This site is proposed to be protected within the Public Open Space POS and is currently the subject of a site specific Aboriginal Heritage Assessment.

A search of the Department of Planning, Lands and Heritage (DPLH) Aboriginal Heritage Inquiry System identify 13 Registered Aboriginal Sites and 26 Other Heritage Places within the study area. These search results are presented in Appendix C.

5.2.2 European Heritage

A search of the Government of Western Australia, Heritage Council State Heritage Office database 'inHerit' revealed no State Heritage listed sites within the project area.

Fourteen European Heritage listed places lie within the study area (Table 16). The Manjedal Brook (ID 8482) is the closest European Heritage Site to the project area, running between 10-70 m north of the northern boundary. The Manjedal Brook is listed as a Municipal Inventory Category 5: 'Historic Site or Significant Vegetation Historic site without built features; historic site/building much modified or with association to historic personage/s (i.e. monument/memorial); or a cultural or natural landscape valued by the community.'

6. Urban and Rural Forest Strategy

The Shire of Serpentine Jarrahdale Urban and Rural Forest Strategy 2018-2028 was endorsed by Council in September 2018, and promotes cool, shady and liveable suburbs where healthy trees are retained and new ones planted. Specifically, the Strategy seeks to:

- Retain current level of canopy cover, and increase where possible
- Maintain the rural character of the Shire
- Increase community support for trees
- Enhance community wellbeing and health
- Promote environmental sustainability.

The project area provides opportunities for the retention of native vegetation including native trees such as Marri (*Corymbia calophylla*) and Jarrah (*Eucalyptus marginata*) in the Lang Road Reserve and the north east corner of the project area. These trees provide biodiversity and habitat, for native fauna, including black cockatoos. There are also opportunities to retain native trees in local parks throughout the project area.

7. Summary

7.1 Local context

The project area has predominantly been cleared and historically used for livestock farming. The majority of the project area can be described as 'Parkland Cleared' and comprises scattered *Eucalyptus* trees (both native and planted/introduced) over introduced grasses and herbs. The vegetation structure is no longer intact and is completely dominated by an understorey/ground cover of weeds. There are small areas of the project area that support native vegetation in degraded condition, these areas are mostly associated with the Lang Road Reserve. The vegetation within the project area provides low habitat value for fauna, however, it does provide potential breeding, foraging and potential roosting habitat for black cockatoos and other conservation significant fauna such as the Quenda.

There is native vegetation (and fauna habitat) present in the vicinity of the project area, including in Bush Forever site no. 350 along Soldiers Road and Manjedal Brook (north of the project area). The vegetation in these areas is dominated by Marri and Jarrah, with Flooded Gum, *Melaleuca raphiophylla* and *M. preissiana* along Manjedal Brook. Native vegetation associated with ecological linkage, Link no. 65 includes remnant vegetation along Soldiers Road and adjacent railway reserve (i.e. Bush Forever site no. 350), outside of the project area.

7.2 Key attributes and constraints

Key attributes and constraints associated with the project area include:

- The majority of the project area has been cleared, however, there are small areas that support native vegetation in degraded condition that are mostly associated with the Lang Road Reserve. These areas contain Marri and Jarrah trees and provide potential breeding, foraging and potential roosting habitat for black cockatoos.
- Desktop mapping identified one TEC and one PEC as potentially occurring within the project area. No TECs or PECs were identified within the project area during the field surveys.
- The project area lies outside, but immediately adjacent to Bush Forever site, no. 350 (Byford to Serpentine Rail/Road Reserves and Adjacent Bushland). This site is part of a Regional Ecological Linkage that connects Bush Forever Sites 321, 350, 362 and 365.
- The project area is characterised by sandy soils and is predominantly flat and slightly sloping towards the west.
- There are no creeklines within the project area; the closest surface water body is Manjedal Brook which flows in an east-west direction and is north of the project area. There was a small depression filled with water within the far north-eastern corner of the project area, close to Manjedal Brook. The vegetation associated with the waterbody was dominated by *Typha* sp., Kikuyu grass (*Cenchrus clandestinus*) and other introduced grasses and herbs. This depression is likely to be dry over the summer months.
- The majority of the project area is covered by a Multiple Use wetland (UFI 16021). The ecological value of this wetland is limited due to the historical clearing and land use of the project area.
- One Other Heritage Place is located within the project area, Site ID 37115 (MJ-09), this site is located adjacent to Manjedal Brook.

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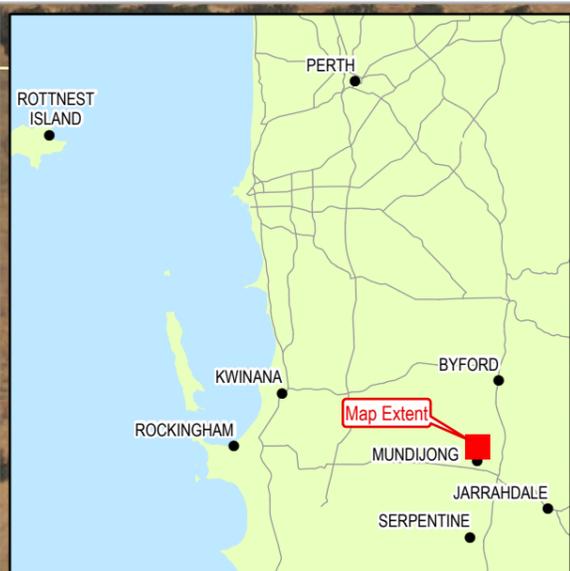
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Appendices

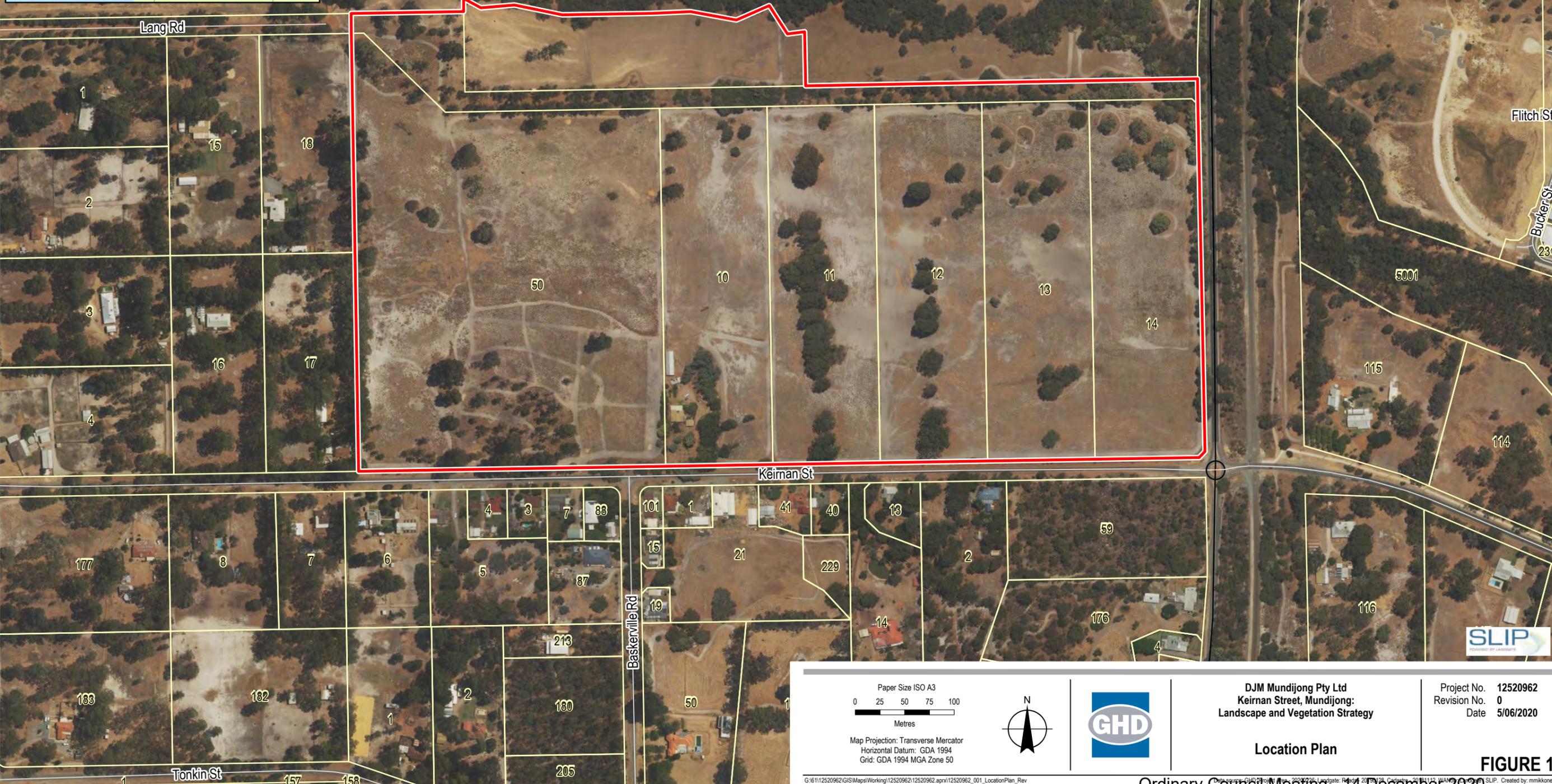
Appendix A – Figures

- Figure 1 Project area**
- Figure 2 Land use constraints**
- Figure 3 Hydrology constraints**
- Figure 4 Vegetation type and condition**
- Figure 5 Black cockatoo habitat**



10.1.9 - attachment 1 Legend

- Major Road
- Minor Road
- ▭ Survey Area
- ▭ Cadastre



Paper Size ISO A3
 0 25 50 75 100
 Metres

Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 50



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Keirnan Street, Mundijong:
Landscape and Vegetation Strategy

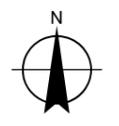
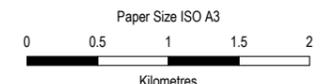
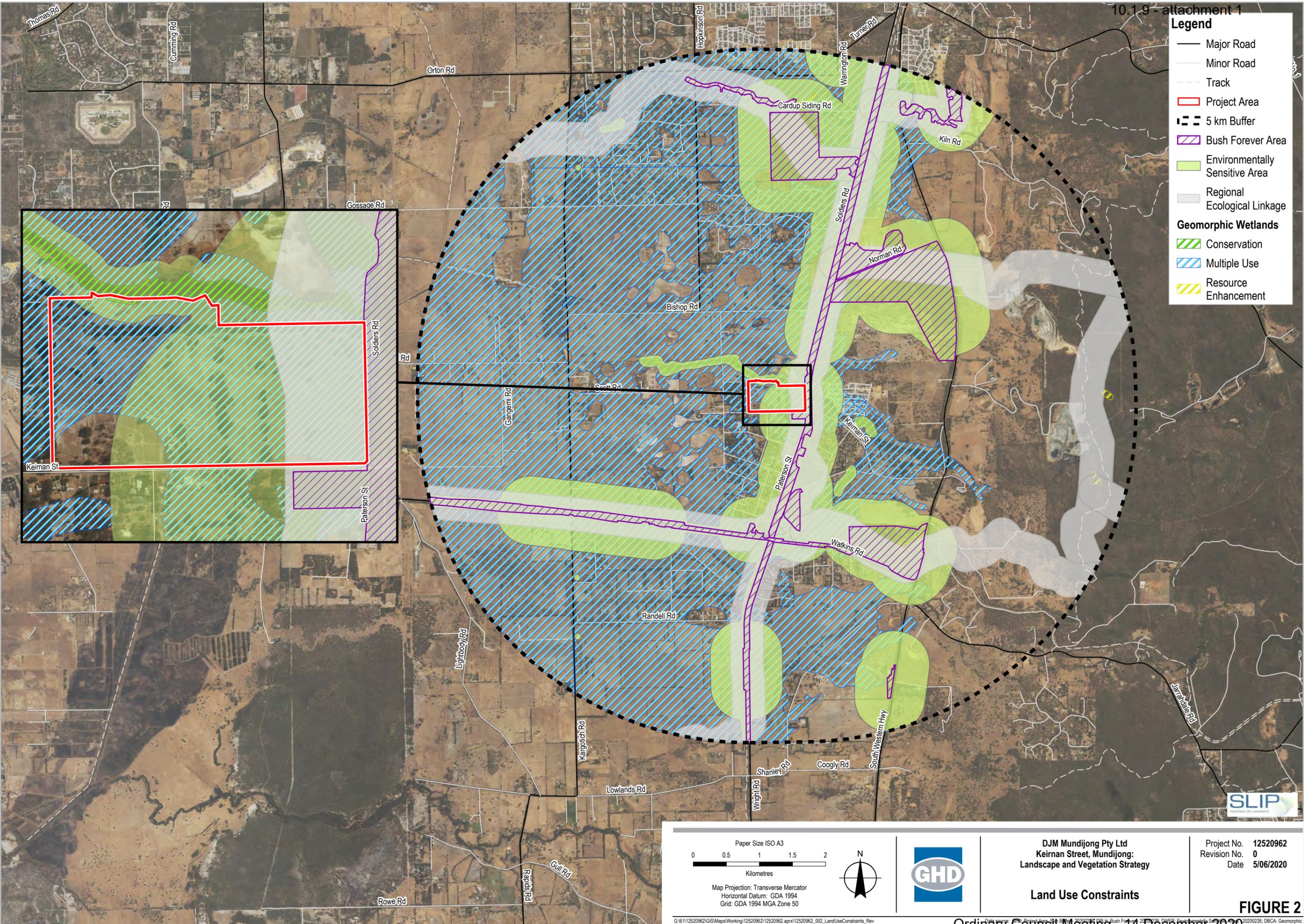
Project No. **12520962**
 Revision No. **0**
 Date **5/06/2020**

Location Plan

FIGURE 1

Legend

- Major Road
- Minor Road
- - - Track
- ▭ Project Area
- ⊞ 5 km Buffer
- ▨ Bush Forever Area
- Environmentally Sensitive Area
- Regional Ecological Linkage
- Geomorphic Wetlands**
- ▨ Conservation
- ▨ Multiple Use
- ▨ Resource Enhancement



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 Keiman Street, Mundijong:
 Landscape and Vegetation Strategy

Project No. 12520962
 Revision No. 0
 Date 5/06/2020

Land Use Constraints

FIGURE 2

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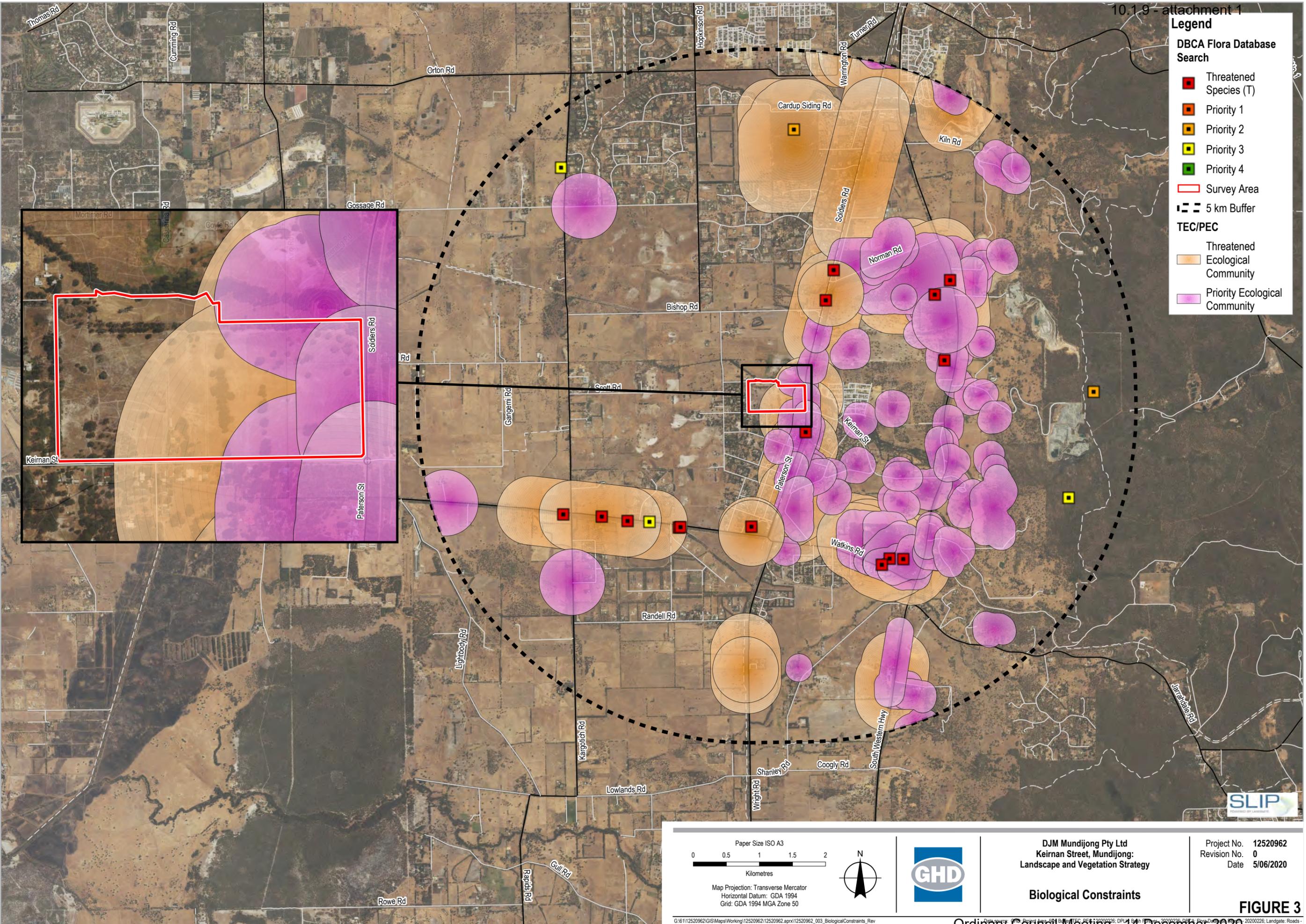
Legend

DBCA Flora Database Search

- Threatened Species (T)
- Priority 1
- Priority 2
- Priority 3
- Priority 4
- Survey Area
- 5 km Buffer

TEC/PEC

- Threatened Ecological Community
- Priority Ecological Community



<p>Paper Size ISO A3</p> <p>Kilometres</p> <p>Map Projection: Transverse Mercator Horizontal Datum: GDA 1994 Grid: GDA 1994 MGA Zone 50</p>			<p>DJM Mundijong Pty Ltd Keirman Street, Mundijong: Landscape and Vegetation Strategy</p>	<p>Project No. 12520962 Revision No. 0 Date 5/06/2020</p>
			<p>Biological Constraints</p>	<p>FIGURE 3</p>

Legend

Declared Pest

-  **Asparagus asparagaceae*
-  **Gomphocarpus fruticosus*

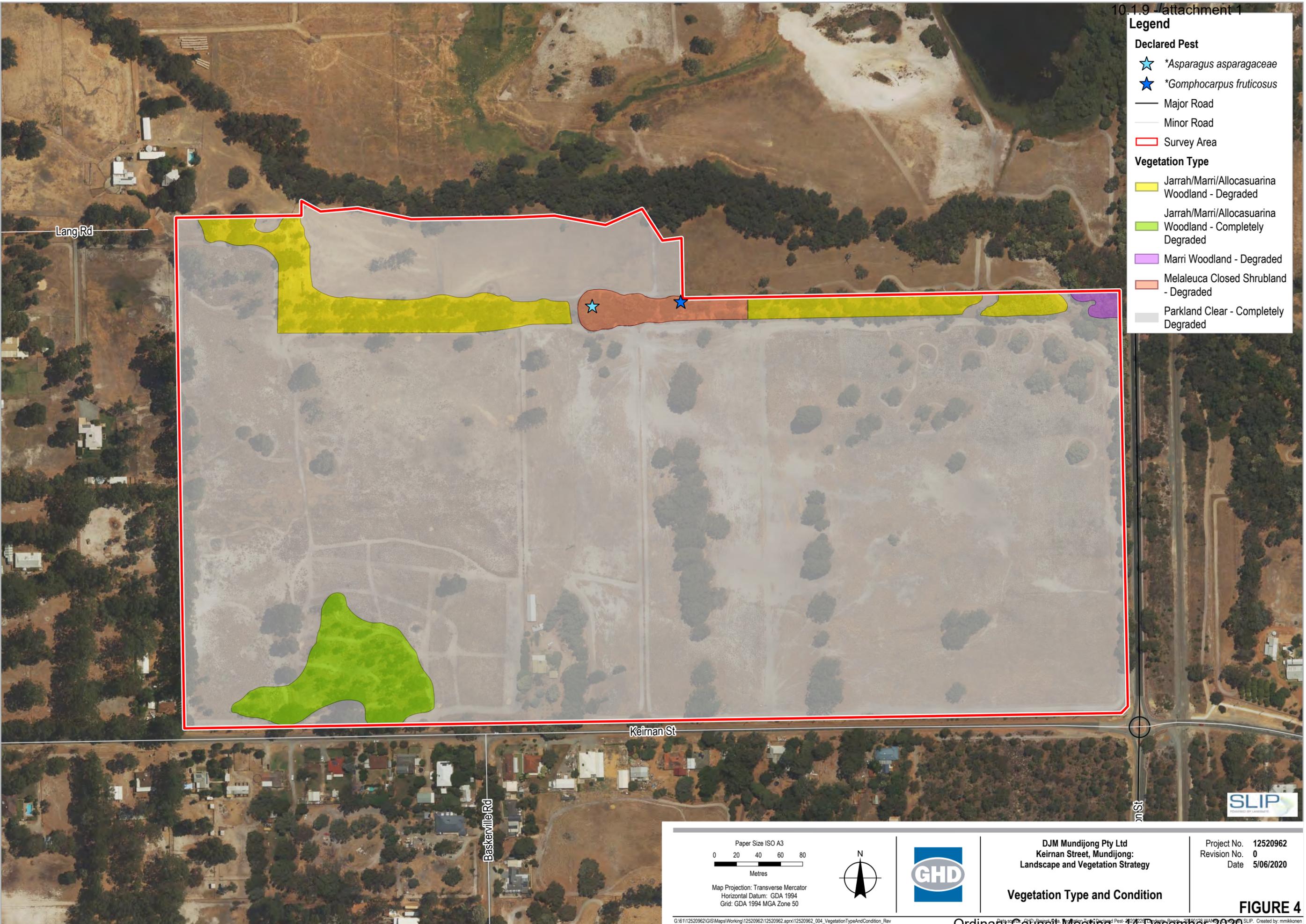
Major Road


Minor Road


Survey Area


Vegetation Type

-  Jarrah/Marri/Allocasuarina Woodland - Degraded
-  Jarrah/Marri/Allocasuarina Woodland - Completely Degraded
-  Marri Woodland - Degraded
-  Melaleuca Closed Shrubland - Degraded
-  Parkland Clear - Completely Degraded



<p>Paper Size ISO A3</p> <p>0 20 40 60 80</p> <p>Metres</p> <p>Map Projection: Transverse Mercator Horizontal Datum: GDA 1994 Grid: GDA 1994 MGA Zone 50</p>	 	<p>DJM Mundijong Pty Ltd Keirnan Street, Mundijong: Landscape and Vegetation Strategy</p> <p>Vegetation Type and Condition</p>	<p>Project No. 12520962 Revision No. 0 Date 5/06/2020</p> <p>FIGURE 4</p>
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Legend

- ▲ Quenda Observations
- ▲ Black Cockatoo Activity

Potential Habitat Tree

- *Corymbia calophylla* (No Hollows)
- *Corymbia calophylla* (1Hollow)
- *Corymbia calophylla* (2Hollows)
- *Eucalyptus marginata* (No Hollows)
- *Eucalyptus marginata* (3Hollows)
- *Eucalyptus rudis* (No Hollows)

- Major Road
- Minor Road
- ▭ Survey Area
- ▭ Black Cockatoo Foraging Habitat



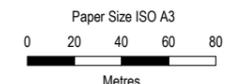
Lang Rd

Soldiers Rd

Keirman St

Baskerville Rd

St



Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 50



DJM Mundijong Pty Ltd
 Keirman Street, Mundijong:
 Landscape and Vegetation Strategy

Black Cockatoo Habitat

Project No. 12520962
 Revision No. 0
 Date 5/06/2020



FIGURE 5

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 Print date: 05 Jun 2020 - 10:17

Appendix B – Relevant legislation, conservation codes and background information

Relevant legislation

Federal *Environment Protection and Biodiversity Conservation Act 1999*

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Federal Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places, which are defined in the EPBC Act as Matters of National Environmental Significance (MNES).

The biological aspects listed as MNES include:

- Nationally threatened flora and fauna species and ecological communities
- Migratory species

A person must not undertake an action that has, will have, or is likely to have a significant impact (direct or indirect) on MNES, without approval from the Federal Minister for the Environment.

The EPBC Act is administered by the Department of Agriculture, Water and the Environment (DAWE).

State *Environmental Protection Act 1986*

The *Environmental Protection Act 1986* (EP Act) is the primary legislative Act dealing with the protection of the environment in Western Australia. The Act allows the Environmental Protection Authority (EPA), to prevent, control and abate pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing. Part IV of the EP Act is administered by the EPA and makes provisions for the EPA to undertake environmental impact assessment of significant proposals, strategic proposals and land use planning schemes.

The Department of Water and Environment Regulation (DWER) is responsible for administering the clearing provisions of the EP Act (Part V). Clearing of native vegetation in Western Australia requires a permit from the DWER, unless exemptions apply. Applications for clearing permits are assessed by the Department and decisions are made to grant or refuse the application in accordance with the Act. When making a decision the assessment considers clearing against the ten clearing principles as specified in Schedule 5 of the EP Act:

- a) Native vegetation should not be cleared if it comprises a high level of biodiversity.
- b) Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of a significance habitat for fauna indigenous to Western Australia.
- c) Native vegetation should not be cleared if it includes, or is necessary, for the continued existence of rare flora.
- d) Native vegetation should not be cleared if it comprises the whole or part of native vegetation in an area that has been extensively cleared.
- e) Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.
- f) Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland.
- g) Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.
- h) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.

- i) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.
- j) Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding.

Exemptions for clearing include clearing that is a requirement of a written law or authorised under certain statutory processes (listed in Schedule 6 of the EP Act) and exemptions for prescribed low impact day-to-day activities (prescribed in the Environmental Protection (Clearing of Native Vegetation) Regulations 2004); these exemptions do not apply in environmentally sensitive areas (ESAs).

State Biodiversity and Conservation Act 2016

The *Biodiversity Conservation Act 2016* (BC Act) provides for the conservation and protection of biodiversity and biodiversity components, as well as the promotion of the ecologically sustainable use of biodiversity components in Western Australia. The BC Act replaces both the repealed *Wildlife Conservation Act 1950* (WC Act) and the *Sandalwood Act 1929* (Sandalwood Act), as well as their associated regulations. To attain the objectives of the BC Act, principles of ecological sustainable development have been established:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations
- If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
- The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- The conservation of biodiversity and ecological integrity should be a fundamental consideration in decision-making
- Improved valuation, pricing and incentive mechanisms should be promoted.

The BC Act is administered by the Department of Biodiversity Conservation and Attractions (DBCA).

State Biosecurity and Agriculture Management Act 2007

The *Biosecurity and Agriculture Management Act 2007* (BAM Act) and associated regulations are administered by the Department of Primary Industries and Regional Development (DPIRD) and replace the repealed *Agriculture and Related Resources Protection Act 1976*. The main purposes of the BAM Act and its regulations are to:

- Prevent new animal and plant pests (vermin and weeds) and diseases from entering WA
- Manage the impact and spread of those pests already present in the state
- Safely manage the use of agricultural and veterinary chemicals
- Increased control over the sale of agricultural products that contain violative chemical residues.

The Western Australian Organism List (WAOL) provides the status of organisms which have been categorised under the BAM Act. A Declared Pest is a prohibited organism or an organism for which a declaration under Section 22(2) of the Act is in force. Declared Pests may be assigned a control category including: C1 (exclusion), C2 (eradication) and C3 (management). The category may apply to the whole of the State, LGAs, districts, individual properties or even paddocks, and all landholders are obliged to comply with the specific category of control. Categories of control are defined below.

DPIRD Categories for Declared Pests under the BAM Act

Control class code	Description
C1 (Exclusion)	Pests will be assigned to this category if they are not established in Western Australia and control measures are to be taken, including border checks, in order to prevent them entering and establishing in the State.
C2 (Eradication)	Pests will be assigned to this category if they are present in Western Australia in low enough numbers or in sufficiently limited areas that their eradication is still a possibility.
C3 (Management)	Pests will be assigned to this category if they are established in Western Australia but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area which currently is free of that pest.

Background information

Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESAs) are declared by the Minister for Environment under Section 51B of the EP Act. The Table below outlines the aspects of areas declared as ESA in the Environmental Protection (Environmentally Sensitive Areas) Notice 2005.

Aspects of ESAs

Aspects of Environmentally Sensitive Areas
A declared World Heritage property as defined in Section 13 of the EPBC Act.
An area that is included on the Register of the National Estate (RNE), because of its natural values, under the <i>Australian Heritage Commission Act 1975</i> of the Commonwealth (the RNE was closed in 2007 and is no longer a statutory list – all references to the RNE were removed from the EPBC Act on 19 February 2012).
A defined wetland and the area within 50 m of the wetland. Defined wetlands include Ramsar wetlands, conservation category wetlands and nationally important wetlands.
The area covered by vegetation within 50 m of rare flora, to the extent to which the vegetation is continuous with the vegetation in which the rare flora is located.
The area covered by a Threatened Ecological Community.
A Bush Forever Site listed in “Bush Forever” Volumes 1 and 2 (2000), published by the Western Australia Planning Commission, except to the extent to which the site is approved to be developed by the Western Australia Planning Commission.
The areas covered by the <i>Environmental Protection (Gnangara Mound Crown Land) Policy 1992</i> .
The areas covered by the <i>Environmental Protection (Western Swamp Tortoise Habitat) Policy 2002</i> .
The areas covered by the lakes to which the <i>Environmental Protection (Swan Coastal Plain Lakes) Policy 1992</i> (EPP Lakes) applies.
Protected wetlands as defined in the <i>Environmental Protection (South West Agricultural Zone Wetlands) Policy 1998</i> .

Reserves and conservation areas

Bush Forever

Bush Forever, which was released in December 2000 and proclaimed in 2010, is a Government initiative aimed to retain and protect regionally significant bushland on the Swan Coastal Plain within the Perth Metropolitan Region. Bush Forever aims to protect more than 51,000 hectares of regionally significant bushland within 287 sites across the metropolitan portion of the Swan Coastal Plain (Government of Western Australia (GoWA) 2000). Bush Forever sites constitute ESAs as declared by a notice under Section 51B of the EP Act.

Department of Biodiversity, Conservation and Attractions managed lands and waters

DBCA manages lands and waters throughout Western Australia to conserve ecosystems and species, and to provide for recreation and appreciation of the natural environment. DBCA managed lands and waters include national parks, conservation parks and reserves, marine parks and reserves, regional parks, nature reserves, State forest and timber reserves. DBCA managed conservation estate, is

vested with the Conservation Commission of Western Australia. Access to, or through, some areas of DBCA managed lands may require a permit or could be restricted due to management activities. Proposed land use changes and development proposals that abut DBCA managed lands will generally be referred to DBCA throughout the assessment process.

Wetlands

Wetlands include not only lakes with open water, but areas of seasonally, intermittently or permanently waterlogged soil.

Ramsar Listed Wetlands

The Convention of Wetlands of International Importance was signed in 1971 at the Iranian town of Ramsar. The Convention has since been referred to as the Ramsar Convention. Ramsar Listed wetlands are “sites containing representative, rare or unique wetlands, or wetlands that are important for conserving biological diversity ... because of their ecological, botanical, zoological, limnological or hydrological importance” (DEE 2019b). Once a Ramsar Listed Wetland is designated, the country agrees to manage its conservation and ensure its wise use. Under the Convention, wise use is broadly defined as “maintaining the ecological character of a wetland” (DEE 2019b).

Nationally important wetlands

Wetlands of national significance are listed under the Directory of Important Wetlands in Australia. Nationally important wetlands are wetlands which meet at least one of the following criteria (DEE 2019a):

- It is a good example of a wetland type occurring within a biogeographic region in Australia
- It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex
- It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail
- The wetland supports one percent or more of the national populations of any native plant or animal taxa
- The wetland supports native plant or animal taxa or communities which are considered endangered or vulnerable at the national level
- The wetland is of outstanding historical or cultural significance

Geomorphic wetlands

Categorisation of wetlands has been conducted by Hill et al. (1996), delineating Swan Coastal Plain wetlands into levels of protection and management categories. Conservation Category Wetlands are wetlands that support high levels of attributes and functions. Resource Enhancement Wetlands are those that have been partly modified but still support substantial functions and attributes. Multiple Use Wetlands are classified as those wetlands with few attributes that still provide important wetland functions. Multiple Use wetlands have few important ecological attributes and functions remaining.

The Geomorphic Wetlands Swan Coastal Plain dataset displays the location, boundary, geomorphic classification (wetland type) and management category of wetlands on the Swan Coastal Plain.

Vegetation extent and status

The National Objectives and Targets for Biodiversity Conservation 2001–2005 (Commonwealth of Australia 2001) recognise that the retention of 30 percent or more of the pre-clearing extent of each ecological community is necessary if Australia’s biological diversity is to be protected. This is the threshold level below which species loss appears to accelerate exponentially and loss below this level

should not be permitted. This level of recognition is in keeping with the targets recommended in the review of the National Strategy for the Conservation of Australia's Biological Diversity (ANZECC 2000).

The extent of remnant native vegetation in WA has been assessed by Shepherd et al. (2002) and the GoWA (2018), based on broadscale vegetation association mapping by Beard (various publications). The GoWA produces Statewide Vegetation Statistics Reports that are used for a number of purposes including conservation planning, land use planning and when assessing development applications. The reports are updated at least every two years.

Vegetation condition

The vegetation condition can be assessed in accordance with the vegetation condition rating scale for the South West and Interzone Botanical Provinces (EPA 2016a). The scale recognises the intactness of vegetation and consists of six rating levels as outlined below.

Vegetation condition rating scale for the South West and Interzone Botanical Provinces

Condition	South West and Interzone Botanical Provinces description
Pristine	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species. Damage to trees caused by fire, the presence of non-aggressive weeds and occasional vehicle tracks.
Very Good	Vegetation structure altered, obvious signs of disturbance. Disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds at high density, partial clearing, dieback and grazing.
Completely Degraded	The structure of vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Conservation codes

Species of significant flora, fauna and communities are protected under both Federal and State Acts. The Federal EPBC Act provides a legal framework to protect and manage nationally important flora and communities. The State BC Act is the primary wildlife conservation legislation in Western Australia. Information on the conservation codes is summarised in the following sections.

Ecological communities

Conservation significant communities

Ecological communities are defined as naturally occurring biological assemblages that occur in a particular type of habitat (English and Blyth 1997). Federally listed Threatened Ecological Communities (TECs) are protected under the EPBC Act. The BC Act provides for the Minister to list an ecological community as a TEC (section 27), or as a collapsed ecological community (section 31) statutory listing of State TECs by the Minister. The legislation also describes statutory processes for preparing recovery plans for TECs, the registration of their critical habitat, and penalties for unauthorised modification of TECs.

Possible TECs that do not meet survey criteria are added to the DBCA Priority Ecological Community (PEC) List under Priorities 1, 2 and 3. These are ecological communities that are adequately known; are rare but not threatened, or meet criteria for Near Threatened. PECs that have been recently removed from the threatened list are placed in Priority 4. These ecological communities require regular monitoring. Conservation dependent ecological communities are placed in Priority 5. PECs are not listed under any formal Federal or State legislation, however, may be listed as TECs under the EPBC Act.

Conservation codes and definitions for TECs listed under the EPBC Act and/ or BC Act

Categories	Definition
Federal Government Conservation Categories (EPBC Act)	
Critically Endangered (CR)	An ecological community if, at that time, is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria (as outlined in Environment Protection and Biodiversity Conservation Regulations 2000)
Endangered (EN)	An ecological community if, at that time: A) is not critically endangered; and B) is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria (as outlined in Environment Protection and Biodiversity Conservation Regulations 2000)
Vulnerable (VU)	An ecological community if, at that time: A) is not critically endangered or endangered; and B) is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria (as outlined in Environment Protection and Biodiversity Conservation Regulations 2000)
Western Australia Conservation Categories (BC Act)	
<u>Threatened Ecological Communities</u>	

Categories	Definition
Critically Endangered (CR)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated.
Endangered (EN)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future.
Vulnerable (VU)	An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.

Collapsed ecological communities

An ecological community is eligible for listing as a collapsed ecological community at a particular time if, at that time –

- (a) there is no reasonable doubt that the last occurrence of the ecological community has collapsed); or
- (b) the ecological community has been so extensively modified throughout its range that no occurrence of it is likely to recover –
 - (i) its species composition or structure; or
 - (ii) its species composition and structure.

Section 33 of the BC Act provides for a collapsed ecological community to be regarded as a threatened ecological community if it is discovered in a state that no longer makes it eligible for listing as a collapsed ecological community.

Conservation categories and definitions for PECS as listed by the DBCA

Category	Description
Priority 1	Poorly known ecological communities. Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤5 occurrences or a total area of ≤100 ha). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority 2	Poorly known ecological communities. Communities that are known from few occurrences with a restricted distribution (generally ≤10 occurrences or a total area of ≤200 ha). At least some occurrences are not believed to be under immediate threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.

Category	Description
Priority 3	<p>Poorly known ecological communities.</p> <p>(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or:</p> <p>(ii) communities known from a few widespread occurrences, which are either large or with significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;</p> <p>(iii) communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.</p> <p>Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.</p>
Priority 4	<p>Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.</p> <p>(i) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands.</p> <p>(ii) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.</p> <p>(iii) Ecological communities that have been removed from the list of threatened communities during the past five years.</p>
Priority 5	<p>Conservation Dependent ecological communities.</p> <p>Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.</p>

Other significant vegetation

Vegetation may be significant for a range of reasons other than a statutory listing. The EPA (2016b) states that significant vegetation may include vegetation that includes the following:

- Restricted distribution
- Degree of historical impact from threatening processes
- Local endemism in restricted habitats
- Novel combinations of taxa
- A role as a refuge
- A role as a key habitat for Threatened species or large population representing a significant proportion of the local to regional total population of a species
- Being representative of a vegetation unit in 'pristine' condition in a highly cleared landscape, recently discovered range extensions, or isolated outliers of the main range)
- Being poorly reserved.

This may apply at a number of levels, so the unit may be significant when considered at the fine-scale (intra-locality), intermediate-scale (locality or inter-locality) or broad-scale (local to region).

Flora and fauna

Conservation significant flora and fauna

Species of significant flora are protected under both Federal and State legislation. Any activities that are deemed to have a significant impact on species that are recognised by the EPBC Act, and/or the BC Act can warrant referral to the DEE and/or the EPA.

The Federal conservation level of flora and fauna species and their significance status is assessed under the EPBC Act. The significance levels for flora and fauna used in the EPBC Act align with the International Union for Conservation of Nature (IUCN) Red List criteria, which are internationally recognised as providing best practice for assigning the conservation status of species. The EPBC Act also protects land and migratory species that are listed under International Agreements. The list of migratory species established under section 209 of the EPBC Act comprises:

- Migratory species which are native to Australia and are included in the appendices to the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals Appendices I and II)
- Migratory species included in annexes established under the Japan-Australia Migratory Bird Agreement (JAMBA) and the China–Australia Migratory Bird Agreement (CAMBA)
- Native, migratory species identified in a list established under, or an instrument made under, an international agreement approved by the Minister, such as the Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA)

The State conservation level of flora and fauna species and their significance status also follows the IUCN Red List criteria. Under the BC Act flora and fauna can be listed as Threatened, Extinct and as Specially Protected species.

Threatened species are those species which have been adequately searched for and are deemed to be, in the wild, either rare, under identifiable threat of extinction, or otherwise in need of special protection, and have been gazetted as such. The assessment of the conservation status of Threatened species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria. Specially protected species meet one or more of the following categories: species of special conservation interest; migratory species; cetaceans; species subject to international agreement; or species otherwise in need of special protection. Species that are listed as Threatened or Extinct species under the BC Act cannot also be listed as Specially Protected species.

Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna.

Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

For the purposes of this assessment, all species listed under the EPBC Act, BC Act and DBCA Priority species are considered conservation significant.

Conservation categories and definitions for EPBC Act and BC Act listed flora and fauna species

Conservation category	Definition
Threatened species	
Critically Endangered (CR)	<p>Threatened species considered to be “facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines”.</p> <p>Listed as critically endangered under section 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines.</p>
Endangered (EN)	<p>Threatened species considered to be “facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines”.</p> <p>Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines</p>
Vulnerable (VU)	<p>Threatened species considered to be “facing a high risk of extinction in the wild in the medium term future, as determined in accordance with criteria set out in the ministerial guidelines”.</p> <p>Listed as vulnerable under section 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines.</p>
Extinct species	
Extinct (EX)	Species where “there is no reasonable doubt that the last member of the species has died”, and listing is otherwise in accordance with the ministerial guidelines (section 24 of the BC Act).
Extinct in the Wild (EW)	Species that “is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form”, and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act).
Specially protected species	
Migratory (MI)	<p>Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act).</p> <p>Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), an environmental treaty under the United Nations Environment Program. Migratory species listed under the BC Act are a subset of the migratory animals, that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species</p>

Conservation category	Definition
Species of special conservation interest (conservation dependent fauna) (CD)	Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened.
Other specially protected fauna (OS)	Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act).

Conservation codes for DBCA listed Priority flora and fauna

Priority category	Definition
Priority 1	<p>Poorly-known taxa</p> <p>Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.</p>
Priority 2	<p>Poorly-known taxa</p> <p>Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.</p>
Priority 3	<p>Poorly-known taxa</p> <p>Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.</p>
Priority 4	<p>Rare, Near Threatened and other taxa in need of monitoring</p> <p>A. Rare: Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.</p> <p>B. Near Threatened. Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.</p> <p>C. Taxa that have been removed from the list of threatened taxa during the past five years for reasons other than taxonomy.</p>

Other significant flora

Flora species, subspecies, varieties, hybrids and ecotypes may be significant for a range of reasons, other than a statutory listing. The EPA (2016b) states that significant flora may include taxa that have:

- A keystone role in a particular habitat for threatened or Priority flora or fauna species, or large populations representing a considerable proportion of the local or regional total population of a species
- Relictual status, being representation of taxonomic or physiognomic groups that no longer occur widely in the broader landscape
- Anomalous features that indicate a potential new discovery
- Being representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range)
- The presence of restricted subspecies, varieties, or naturally occurring hybrids
- Local endemism (a restricted distribution) or association with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems)
- Being poorly reserved

Other significant fauna

Fauna species may be significant for a range of reasons other than those protected by international agreement or treaty, Specially Protected or Priority Fauna. Significant fauna may include short-range endemic species, species that have declining populations or declining distributions, species at the extremes of their range, or isolated outlying populations, or species which may be undescribed (EPA 2010).

Introduced plants (weeds)

Declared Pests

Information on species considered to be Declared Pests is provided under *State Biosecurity and Agriculture Management Act 2007*.

Weeds of National Significance

The spread of weeds across a range of land uses or ecosystems is important in the context of socio-economic and environmental values. The assessment of Weeds of National Significance (WoNS) is based on four major criteria:

- Invasiveness
- Impacts
- Potential for spread
- Socio-economic and environmental values

Australian state and territory governments have identified thirty-two Weeds of National Significance (WoNS); a list of 20 WoNS was endorsed in 1999 and a further 12 were added in 2012.

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Appendix C – Desktop searches

EPBC Act PMST report

NatureMap Flora report

NatureMap Fauna report

Heritage reports

Basic summary of records



EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about [Environment Assessments](#) and the EPBC Act including significance guidelines, forms and application process details.

Report created: 10/02/20 12:32:02

[Summary](#)

[Details](#)

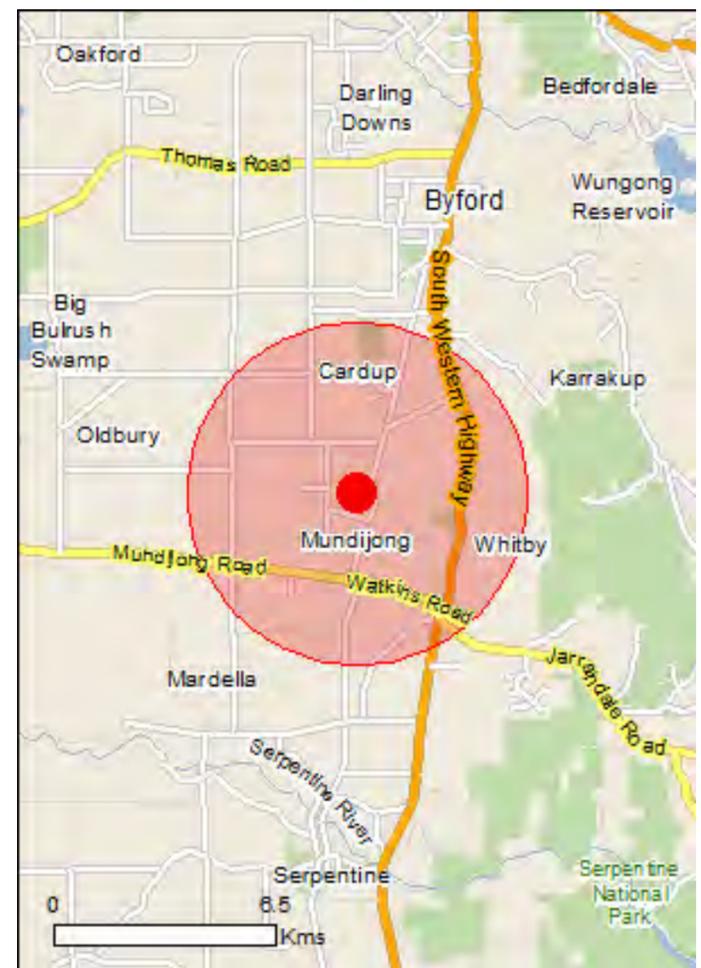
[Matters of NES](#)

[Other Matters Protected by the EPBC Act](#)

[Extra Information](#)

[Caveat](#)

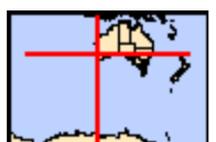
[Acknowledgements](#)



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

[Coordinates](#)

Buffer: 5.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the [Administrative Guidelines on Significance](#).

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	2
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	5
Listed Threatened Species:	27
Listed Migratory Species:	8

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at <http://www.environment.gov.au/heritage>

A [permit](#) may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	13
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	3
Regional Forest Agreements:	1
Invasive Species:	38
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar)	[Resource Information]
Name	Proximity
Forrestdale and thomsons lakes Peel-yalgorup system	Within 10km of Ramsar 30 - 40km upstream

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Community likely to occur within area
Clay Pans of the Swan Coastal Plain	Critically Endangered	Community likely to occur within area
Corymbia calophylla - Kingia australis woodlands on heavy soils of the Swan Coastal Plain	Endangered	Community known to occur within area
Corymbia calophylla - Xanthorrhoea preissii woodlands and shrublands of the Swan Coastal Plain	Endangered	Community known to occur within area
Tuart (Eucalyptus gomphocephala) Woodlands and Forests of the Swan Coastal Plain ecological community	Critically Endangered	Community may occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat known to occur within area
Calyptorhynchus baudinii Baudin's Cockatoo, Long-billed Black-Cockatoo [769]	Endangered	Roosting known to occur within area
Calyptorhynchus latirostris Carnaby's Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Species or species habitat known to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur

Name	Status	Type of Presence within area
Mammals		
Bettongia penicillata ogilbyi Woylie [66844]	Endangered	Species or species habitat known to occur within area
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat known to occur within area
Pseudocheirus occidentalis Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit [25911]	Critically Endangered	Species or species habitat may occur within area
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area
Anthocercis gracilis Slender Tailflower [11103]	Vulnerable	Species or species habitat may occur within area
Caladenia huegelii King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat likely to occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat likely to occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leaved Hammer Orchid, Glossy-leaved Hammer Orchid, Warty Hammer Orchid [16753]	Endangered	Species or species habitat known to occur within area
Drakaea micrantha Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
Eleocharis keigheryi Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat may occur within area
Eucalyptus x balanites Cadda Road Mallee, Cadda Mallee [87816]	Endangered	Species or species habitat likely to occur within area
Grevillea curviloba subsp. incurva Narrow curved-leaf Grevillea [64909]	Endangered	Species or species habitat may occur within area
Lasiopetalum pterocarpum Wing-fruited Lasiopetalum [64922]	Endangered	Species or species habitat likely to occur within area
Synaphea sp. Fairbridge Farm (D. Papenfus 696) Selena's Synaphea [82881]	Critically Endangered	Species or species habitat likely to occur within area
Synaphea sp. Serpentine (G.R. Brand 103) [86879]	Critically Endangered	Species or species habitat known to occur within area
Tetraria australiensis Southern Tetraria [10137]	Vulnerable	Species or species

Name	Status	Type of Presence
Thelymitra stellata Star Sun-orchid [7060]	Endangered	Species or species habitat may occur within area

Listed Migratory Species [[Resource Information](#)]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area

Migratory Terrestrial Species

Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
---------------------------------------------------------	--	--------------------------------------------------

Migratory Wetlands Species

Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [[Resource Information](#)]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area

Extra Information

State and Territory Reserves [\[Resource Information \]](#)

Name	State
Cardup	WA
Unnamed WA46818	WA
Watkins Road	WA

Regional Forest Agreements [\[Resource Information \]](#)

Note that all areas with completed RFAs have been included.

Name	State
South West WA RFA	Western Australia

Invasive Species [\[Resource Information \]](#)

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resources Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Plants		
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Solanum elaeagnifolium Silver Nightshade, Silver-leaved Nightshade, White Horse Nettle, Silver-leaf Nightshade, Tomato Weed, White Nightshade, Bull-nettle, Prairie-berry, Satansbos, Silver-leaf Bitter-apple, Silverleaf-nettle, Trompillo [12323]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-32.28033 115.98483

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- [-Office of Environment and Heritage, New South Wales](#)
- [-Department of Environment and Primary Industries, Victoria](#)
- [-Department of Primary Industries, Parks, Water and Environment, Tasmania](#)
- [-Department of Environment, Water and Natural Resources, South Australia](#)
- [-Department of Land and Resource Management, Northern Territory](#)
- [-Department of Environmental and Heritage Protection, Queensland](#)
- [-Department of Parks and Wildlife, Western Australia](#)
- [-Environment and Planning Directorate, ACT](#)
- [-Birdlife Australia](#)
- [-Australian Bird and Bat Banding Scheme](#)
- [-Australian National Wildlife Collection](#)
- Natural history museums of Australia
- [-Museum Victoria](#)
- [-Australian Museum](#)
- [-South Australian Museum](#)
- [-Queensland Museum](#)
- [-Online Zoological Collections of Australian Museums](#)
- [-Queensland Herbarium](#)
- [-National Herbarium of NSW](#)
- [-Royal Botanic Gardens and National Herbarium of Victoria](#)
- [-Tasmanian Herbarium](#)
- [-State Herbarium of South Australia](#)
- [-Northern Territory Herbarium](#)
- [-Western Australian Herbarium](#)
- [-Australian National Herbarium, Canberra](#)
- [-University of New England](#)
- [-Ocean Biogeographic Information System](#)
- [-Australian Government, Department of Defence Forestry Corporation, NSW](#)
- [-Geoscience Australia](#)
- [-CSIRO](#)
- [-Australian Tropical Herbarium, Cairns](#)
- [-eBird Australia](#)
- [-Australian Government – Australian Antarctic Data Centre](#)
- [-Museum and Art Gallery of the Northern Territory](#)
- [-Australian Government National Environmental Science Program](#)
- [-Australian Institute of Marine Science](#)
- [-Reef Life Survey Australia](#)
- [-American Museum of Natural History](#)
- [-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania](#)
- [-Tasmanian Museum and Art Gallery, Hobart, Tasmania](#)
- Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the [Contact Us](#) page.

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NatureMap Species Report

Created By Guest user on 12/03/2020

Kingdom Plantae
Current Names Only Yes
Core Datasets Only Yes
Method 'By Circle'
Centre 115° 59' 09" E, 32° 16' 50" S
Buffer 5km
Group By Family

Family	Species	Records
Aizoaceae	1	1
Amaranthaceae	1	1
Anarthriaceae	1	5
Apiaceae	5	19
Apocynaceae	2	2
Araliaceae	4	20
Arecaceae	1	1
Asparagaceae	26	98
Asphodelaceae	1	1
Asteraceae	29	110
Boryaceae	2	17
Campanulaceae	7	17
Caryophyllaceae	2	2
Casuarinaceae	6	17
Celastraceae	2	5
Centrolepidaceae	8	51
Colchicaceae	3	20
Convolvulaceae	1	2
Crassulaceae	7	11
Cupressaceae	1	3
Cyperaceae	49	258
Dasygongonaceae	6	31
Dilleniaceae	6	30
Droseraceae	12	80
Elaeocarpaceae	2	5
Ericaceae	8	27
Euphorbiaceae	7	16
Fabaceae	56	213
Gentianaceae	2	22
Geraniaceae	3	4
Goodeniaceae	11	51
Haemodoraceae	21	83
Hemerocallidaceae	10	28
Hydatellaceae	2	8
Hypoxidaceae	1	1
Iridaceae	15	89
Isoetaceae	1	2
Juncaceae	3	12
Juncaginaceae	2	4
Lamiaceae	1	1
Lauraceae	2	17
Lentibulariaceae	3	4
Loganiaceae	2	3
Loranthaceae	1	2
Macarthuriaceae	1	1
Malvaceae	1	2
Myrtaceae	50	209
Onagraceae	3	3
Orchidaceae	29	69
Orobanchaceae	3	4
Oxalidaceae	1	6
Phyllodraceae	3	16
Phyllanthaceae	1	3
Pittosporaceae	1	1
Plantaginaceae	3	3
Poaceae	37	192
Polygalaceae	1	1
Polygonaceae	2	2
Potamogetonaceae	1	1
Primulaceae	2	6
Proteaceae	44	175
Pteridaceae	2	2
Restionaceae	15	51
Rosaceae	1	5
Rubiaceae	2	13
Rutaceae	2	4
Santalaceae	1	1
Scrophulariaceae	2	2
Selaginellaceae	1	1
Solanaceae	1	1
Stylidiaceae	29	107
Thymelaeaceae	4	15
Violaceae	1	1
Xanthorrhoeaceae	4	47
TOTAL	584	2338

Name ID	Species Name	Naturalised	Conservation Code	Endemic To Query Area
Aizoaceae				
1.	48513 <i>Aizoon pubescens</i>	Y		
Amaranthaceae				
2.	2751 <i>Ptilotus polystachyus</i> (Prince of Wales Feather)			
Anarthriaceae				
3.	1097 <i>Lyginia barbata</i>			
Apiaceae				
4.	6205 <i>Actinotus leucocephalus</i> (Flannel Flower)			
5.	6222 <i>Homalosciadium homalocarpum</i>			
6.	6245 <i>Pentapeltis peltigera</i>			
7.	6263 <i>Schoenolaena juncea</i>			
8.	6289 <i>Xanthosia huegelii</i>			
Apocynaceae				
9.	6580 <i>Asclepias curassavica</i> (Redhead Cottonbush)	Y		
10.	6587 <i>Gomphocarpus fruticosus</i> (Narrowleaf Cottonbush)	Y		
Araliaceae				
11.	6223 <i>Hydrocotyle alata</i>			
12.	6226 <i>Hydrocotyle callicarpa</i> (Small Pennywort)			
13.	6229 <i>Hydrocotyle diantha</i>			
14.	6280 <i>Trachymene pilosa</i> (Native Parsnip)			
Arecaceae				
15.	17910 <i>Washingtonia filifera</i>	Y		
Asparagaceae				
16.	8779 <i>Asparagus asparagoides</i> (Bridal Creeper)	Y		
17.	13562 <i>Lachenalia aloides</i>	Y		
18.	1307 <i>Laxmannia ramosa</i> (Branching Lily)			
19.	11911 <i>Laxmannia ramosa</i> subsp. <i>ramosa</i>			
20.	11464 <i>Laxmannia sessiliflora</i> subsp. <i>australis</i>			
21.	1309 <i>Laxmannia squarrosa</i>			
22.	1222 <i>Lomandra brittanii</i>			
23.	1223 <i>Lomandra caespitosa</i> (Tufted Mat Rush)			
24.	1228 <i>Lomandra hermaphrodita</i>			
25.	1232 <i>Lomandra micrantha</i> (Small-flower Mat-rush)			
26.	1234 <i>Lomandra nigricans</i>			
27.	1239 <i>Lomandra preissii</i>			
28.	1240 <i>Lomandra purpurea</i> (Purple Mat Rush)			
29.	1243 <i>Lomandra sericea</i> (Silky Mat Rush)			
30.	<i>Lomandra</i> sp.			
31.	1246 <i>Lomandra suaveolens</i>			
32.	1312 <i>Sowerbaea laxiflora</i> (Purple Tassels)			
33.	1328 <i>Thysanotus dichotomus</i> (Branching Fringe Lily)			
34.	1338 <i>Thysanotus manglesianus</i> (Fringed Lily)			
35.	<i>Thysanotus manglesianus/patersonii</i> complex			
36.	1339 <i>Thysanotus multiflorus</i> (Many-flowered Fringe Lily)			
37.	1343 <i>Thysanotus patersonii</i>			
38.	1351 <i>Thysanotus sparteus</i>			
39.	1354 <i>Thysanotus tenellus</i>			
40.	1357 <i>Thysanotus thyrsoides</i>			
41.	1358 <i>Thysanotus triandrus</i>			
Asphodelaceae				
42.	1366 <i>Bulbine semibarbata</i> (Leek Lily)			
Asteraceae				
43.	7829 <i>Angianthus drummondii</i>		P3	
44.	7838 <i>Arctotheca calendula</i> (Cape Weed, African Marigold)	Y		
45.	7867 <i>Brachyscome bellidioides</i>			
46.	7935 <i>Cichorium intybus</i> (Chicory)	Y		
47.	<i>Coryza</i> sp. <i>Mud07</i>			Y
48.	7946 <i>Cotula cotuloides</i> (Smooth Cotula)			
49.	7961 <i>Dittrichia graveolens</i> (Stinkwort)	Y		
50.	12741 <i>Hyalosperma cotula</i>			
51.	8086 <i>Hypochoeris glabra</i> (Smooth Catsear)	Y		
52.	18585 <i>Lagenophora huegelii</i>			
53.	9356 <i>Logfia gallica</i>	Y		

Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
54.	14337 <i>Millotia tenuifolia</i> var. <i>laevis</i>		P2	
55.	14344 <i>Millotia tenuifolia</i> var. <i>tenuifolia</i> (Soft <i>Millotia</i>)			
56.	8133 <i>Olearia elaeophila</i>			
57.	32716 <i>Olearia lehmanniana</i>			
58.	8163 <i>Pithocarpa corymbulosa</i> (<i>Corymbose Pithocarpa</i>)		P3	
59.	8175 <i>Podolepis gracilis</i> (<i>Slender Podolepis</i>)			
60.	8195 <i>Quinetia urvillei</i>			
61.	13234 <i>Rhodanthe manglesii</i>			
62.	25884 <i>Senecio pinnatifolius</i> var. <i>latilobus</i>			
63.	8224 <i>Siloxerus filifolius</i>			
64.	8225 <i>Siloxerus humifusus</i> (<i>Procumbent Siloxerus</i>)			
65.	8231 <i>Sonchus oleraceus</i> (<i>Common Sowthistle</i>)	Y		
66.	25902 <i>Symphotrichum squamatum</i> (<i>Bushy Starwort</i>)	Y		
67.	20024 <i>Tagetes erecta</i> (<i>Marigold</i>)	Y		
68.	8251 <i>Trichocline spathulata</i> (<i>Native Gerbera</i>)			
69.	8255 <i>Ursinia anthemoides</i> (<i>Ursinia</i>)	Y		
70.	38388 <i>Ursinia anthemoides</i> subsp. <i>anthemoides</i>	Y		
71.	8257 <i>Vellereophyton dealbatum</i> (<i>White Cudweed</i>)	Y		
Boryaceae				
72.	1272 <i>Borya scirpoidea</i>			
73.	1273 <i>Borya sphaerocephala</i> (<i>Pincushions</i>)			
Campanulaceae				
74.	7396 <i>Isotoma hypocrateriformis</i> (<i>Woodbridge Poison</i>)			
75.	7407 <i>Lobelia rhytidisperma</i> (<i>Wrinkled-seeded Lobelia</i>)			
76.	7408 <i>Lobelia tenuior</i> (<i>Slender Lobelia</i>)			
77.	7410 <i>Monopsis debilis</i>	Y		
78.	37440 <i>Monopsis debilis</i> var. <i>depressa</i>	Y		
79.	7384 <i>Wahlenbergia capensis</i> (<i>Cape Bluebell</i>)	Y		
80.	7386 <i>Wahlenbergia gracilentia</i> (<i>Annual Bluebell</i>)			
Caryophyllaceae				
81.	2909 <i>Silene gallica</i> (<i>French Catchfly</i>)	Y		
82.	2918 <i>Stellaria media</i> (<i>Chickweed</i>)	Y		
Casuarinaceae				
83.	1728 <i>Allocasuarina fraseriana</i> (<i>Sheoak, Kondil</i>)			
84.	1732 <i>Allocasuarina humilis</i> (<i>Dwarf Sheoak</i>)			
85.	1734 <i>Allocasuarina microstachya</i>			
86.	1739 <i>Allocasuarina thuyoides</i> (<i>Horned Sheoak</i>)			
87.	18321 <i>Casuarina glauca</i>	Y		
88.	1742 <i>Casuarina obesa</i> (<i>Swamp Sheoak, Kuli</i>)			
Celastraceae				
89.	4733 <i>Stackhousia monogyna</i>			
90.	4737 <i>Tripterococcus brunonis</i> (<i>Winged Stackhousia</i>)			
Centrolepidaceae				
91.	1117 <i>Aphelia cyperoides</i>			
92.	1119 <i>Aphelia nutans</i>			
93.	1121 <i>Centrolepis aristata</i> (<i>Pointed Centrolepis</i>)			
94.	1123 <i>Centrolepis caespitosa</i>			
95.	1125 <i>Centrolepis drummondiana</i>			
96.	1130 <i>Centrolepis humillima</i> (<i>Dwarf Centrolepis</i>)			
97.	1132 <i>Centrolepis mutica</i>			
98.	1134 <i>Centrolepis polygyna</i> (<i>Wiry Centrolepis</i>)			
Colchicaceae				
99.	12770 <i>Burchardia congesta</i>			
100.	1385 <i>Burchardia multiflora</i> (<i>Dwarf Burchardia</i>)			
101.	12072 <i>Wurmbea dioica</i> subsp. <i>alba</i>			
Convolvulaceae				
102.	6663 <i>Cuscuta epithymum</i> (<i>Lesser Dodder, Greater Dodder</i>)	Y		
Crassulaceae				
103.	3136 <i>Crassula alata</i>	Y		
104.	17701 <i>Crassula closiana</i>			
105.	3137 <i>Crassula colorata</i> (<i>Dense Stonecrop</i>)			
106.	3138 <i>Crassula decumbens</i> (<i>Rufous Stonecrop</i>)			
107.	20271 <i>Crassula extrorsa</i>			
108.	15706 <i>Crassula natans</i> var. <i>minus</i>	Y		
109.	3144 <i>Crassula peduncularis</i> (<i>Purple Stonecrop</i>)			

Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
Cupressaceae				
110.	36600 <i>Callitris pyramidalis</i> (Swamp Cypress)			
Cyperaceae				
111.	739 <i>Baumea acuta</i> (Pale Twig-rush)			
112.	763 <i>Chorizandra enodis</i> (Black Bristlerush)			
113.	768 <i>Cyathochaeta avenacea</i>			
114.	815 <i>Cyperus tenellus</i> (Tiny Flatsedge)	Y		
115.	910 <i>Isolepis cernua</i> (Nodding Club-rush)			
116.	20200 <i>Isolepis cernua</i> var. <i>setiformis</i>			
117.	912 <i>Isolepis cyperoides</i>			
118.	14540 <i>Isolepis hystrix</i>	Y		
119.	917 <i>Isolepis marginata</i> (Coarse Club-rush)			
120.	919 <i>Isolepis oldfieldiana</i>			
121.	<i>Lepidosperma</i> aff. <i>coastale</i> (#134)			Y
122.	<i>Lepidosperma</i> aff. <i>pubisquamum</i> (#166)			
123.	<i>Lepidosperma</i> aff. <i>resinosum</i>			
124.	925 <i>Lepidosperma angustatum</i>			
125.	41620 <i>Lepidosperma asperatum</i>			
126.	929 <i>Lepidosperma carphoides</i> (Black Rapier Sedge)			
127.	930 <i>Lepidosperma costale</i>			
128.	<i>Lepidosperma eastern terete scps</i> (BJK&NG 232)			
129.	936 <i>Lepidosperma leptostachyum</i>			
130.	937 <i>Lepidosperma longitudinale</i> (Pithy Sword-sedge)			
131.	940 <i>Lepidosperma pubisquamum</i>			
132.	941 <i>Lepidosperma resinosum</i>			
133.	942 <i>Lepidosperma rostratum</i>		T	
134.	944 <i>Lepidosperma scabrum</i>			
135.	<i>Lepidosperma</i> sp.			
136.	<i>Lepidosperma</i> sp. <i>Mud3</i>			Y
137.	945 <i>Lepidosperma squamatum</i>			
138.	955 <i>Mesomelaena pseudostygia</i>			
139.	957 <i>Mesomelaena tetragona</i> (Semaphore Sedge)			
140.	<i>Schoenus</i> aff. <i>brevisetis</i> (Mud2, #135)			
141.	975 <i>Schoenus bifidus</i>			
142.	978 <i>Schoenus brevisetis</i>			
143.	979 <i>Schoenus caespititius</i>			
144.	980 <i>Schoenus capillifolius</i>		P3	
145.	982 <i>Schoenus clandestinus</i>			
146.	1002 <i>Schoenus nanus</i> (Tiny Bog Rush)			
147.	1006 <i>Schoenus odontocarpus</i>			
148.	17614 <i>Schoenus plumosus</i>			
149.	1011 <i>Schoenus rigens</i>			
150.	17731 <i>Schoenus</i> sp. <i>Waroona</i> (G.J. Keighery 12235)		P3	
151.	<i>Schoenus</i> sp. aff. <i>breviculmis sthct</i>			Y
152.	1019 <i>Schoenus subflavus</i> (Yellow Bog-rush)			
153.	1020 <i>Schoenus sublateralis</i>			
154.	1023 <i>Schoenus tenellus</i>			
155.	1026 <i>Schoenus unispiculatus</i>			
156.	1033 <i>Tetraria australiensis</i>		T	
157.	1034 <i>Tetraria capillaris</i> (Hair Sedge)			
158.	1036 <i>Tetraria octandra</i>			
159.	1038 <i>Tricostularia neesii</i>			
Dasypogonaceae				
160.	1213 <i>Calectasia cyanea</i> (Blue Tinsel Lily)		T	
161.	1214 <i>Calectasia grandiflora</i> (Blue Tinsel Lily)			
162.	19309 <i>Calectasia narragara</i>			
163.	1218 <i>Dasypogon bromeliifolius</i> (Pineapple Bush)			
164.	1220 <i>Dasypogon obliquifolius</i>			
165.	1221 <i>Kingia australis</i> (Kingia, Pulonok)			
Dilleniaceae				
166.	5108 <i>Hibbertia acerosa</i> (Needle Leaved Guinea Flower)			
167.	5134 <i>Hibbertia huegelii</i>			
168.	5135 <i>Hibbertia hypericoides</i> (Yellow Buttercups)			
169.	45534 <i>Hibbertia hypericoides</i> subsp. <i>hypericoides</i>			
170.	48381 <i>Hibbertia striata</i>			
171.	5176 <i>Hibbertia vaginata</i>			
Droseraceae				
172.	3092 <i>Drosera bulbosa</i> (Red-leaved Sundew)			

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173.	3095 <i>Drosera erythrorhiza</i> (Red Ink Sundew)			
174.	3097 <i>Drosera gigantea</i> (Giant Sundew)			
175.	3098 <i>Drosera glanduligera</i> (Pimpernel Sundew)			
176.	3101 <i>Drosera heterophylla</i> (Swamp Rainbow)			
177.	48769 <i>Drosera indumenta</i>			
178.	3106 <i>Drosera macrantha</i> (Bridal Rainbow)			
179.	3109 <i>Drosera menziesii</i> (Pink Rainbow)			
180.	29178 <i>Drosera porrecta</i>			
181.	8911 <i>Drosera rosulata</i>			
182.	49090 <i>Drosera</i> sp. Branched styles (S.C. Coffey 193)			
183.	3131 <i>Drosera stolonifera</i> (Leafy Sundew)			
Elaeocarpaceae				
184.	4535 <i>Tetradlea hirsuta</i> (Black Eyed Susan)			
185.	48341 <i>Tetradlea hirsuta</i> subsp. <i>viminea</i>			
Ericaceae				
186.	6314 <i>Andersonia lehmanniana</i>			
187.	6334 <i>Astroloma pallidum</i> (Kick Bush)			
188.	6337 <i>Astroloma stomarrhena</i> (Red Swamp Cranberry)			
189.	6348 <i>Conostephium pendulum</i> (Pearl Flower)			
190.	6349 <i>Conostephium preissii</i>			
191.	6445 <i>Leucopogon squarrosus</i>			
192.	6456 <i>Lysinema ciliatum</i> (Curry Flower)			
193.	6476 <i>Styphelia tenuiflora</i> (Common Pinheath)			
Euphorbiaceae				
194.	13753 <i>Euphorbia dallachyana</i>			
195.	29940 <i>Euphorbia maculata</i>	Y		
196.	34757 <i>Euphorbia prostrata</i>	Y		
197.	4662 <i>Monotaxis grandiflora</i> (Diamond of the Desert)			
198.	19585 <i>Monotaxis grandiflora</i> var. <i>grandiflora</i>			
199.	4666 <i>Monotaxis occidentalis</i>			
200.	4716 <i>Stachystemon vermicularis</i>			
Fabaceae				
201.	15429 <i>Acacia alata</i> var. <i>alata</i>			
202.	15466 <i>Acacia applanata</i>			
203.	15469 <i>Acacia barbinervis</i> subsp. <i>barbinervis</i>			
204.	11926 <i>Acacia drewiana</i> subsp. <i>drewiana</i>			
205.	3374 <i>Acacia huegelii</i>			
206.	11519 <i>Acacia lasiocarpa</i> var. <i>bracteolata</i>			
207.	3410 <i>Acacia lateriticola</i>			
208.	3442 <i>Acacia microbotrya</i> (Manna Wattle, Kalyang)			
209.	15481 <i>Acacia pulchella</i> var. <i>glaberrima</i>			
210.	15483 <i>Acacia pulchella</i> var. <i>pulchella</i>			
211.	3541 <i>Acacia sessilis</i>			
212.	<i>Acacia</i> sp.			
213.	3557 <i>Acacia stenoptera</i> (Narrow Winged Wattle)			
214.	3591 <i>Acacia urophylla</i>			
215.	3602 <i>Acacia willdenowiana</i> (Grass Wattle)			
216.	3692 <i>Aotus procumbens</i>			
217.	48782 <i>Bossiaea angustifolia</i>			
218.	3710 <i>Bossiaea eriocarpa</i> (Common Brown Pea)			
219.	3714 <i>Bossiaea ornata</i> (Broad Leaved Brown Pea)			
220.	3761 <i>Chorizema rhombeum</i>			
221.	35838 <i>Cristonia biloba</i> subsp. <i>biloba</i>			
222.	3805 <i>Daviesia decurrens</i> (Prickly Bitter-pea)			
223.	19747 <i>Daviesia decurrens</i> subsp. <i>decurrens</i>			
224.	16585 <i>Daviesia nudiflora</i> subsp. <i>nudiflora</i>			
225.	3832 <i>Daviesia physodes</i>			
226.	3845 <i>Daviesia triflora</i>			
227.	3880 <i>Eutaxia virgata</i>			
228.	10909 <i>Gompholobium confertum</i>			
229.	3950 <i>Gompholobium knightianum</i>			
230.	3951 <i>Gompholobium marginatum</i>			
231.	3954 <i>Gompholobium polymorphum</i>			
232.	3955 <i>Gompholobium preissii</i>			
233.	3957 <i>Gompholobium tomentosum</i> (Hairy Yellow Pea)			
234.	3964 <i>Hovea chorizemifolia</i> (Holly-leaved Hovea)			
235.	3968 <i>Hovea trisperma</i> (Common Hovea)			
236.	12859 <i>Hovea trisperma</i> var. <i>trisperma</i>			

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237.	20462 <i>Jacksonia gracillima</i>		P3	
238.	4018 <i>Jacksonia lehmannii</i>			
239.	4029 <i>Jacksonia sternbergiana</i> (Stinkwood, Kapur)			
240.	4037 <i>Kennedia coccinea</i> (Coral Vine)			
241.	4041 <i>Kennedia microphylla</i>			
242.	4044 <i>Kennedia prostrata</i> (Scarlet Runner)			
243.	3669 <i>Labichea punctata</i> (Lance-leaved Cassia)			
244.	4059 <i>Lotus angustissimus</i> (Narrowleaf Trefoil)	Y		
245.	<i>Lotus sp. Mud3</i>			Y
246.	8564 <i>Lotus subbiflorus</i>	Y		
247.	4100 <i>Mirbelia spinosa</i>			
248.	4113 <i>Ornithopus compressus</i> (Yellow Serradella)	Y		
249.	4114 <i>Ornithopus pinnatus</i> (Slender Serradella)	Y		
250.	4207 <i>Sphaerolobium medium</i>			
251.	4211 <i>Sphaerolobium vimineum</i> (Leafless Globe Pea)			
252.	4291 <i>Trifolium arvense</i> (Hare's Foot Clover)	Y		
253.	4292 <i>Trifolium campestre</i> (Hop Clover)	Y		
254.	4295 <i>Trifolium dubium</i> (Suckling Clover)	Y		
255.	17541 <i>Trifolium incarnatum</i> var. <i>incarnatum</i>	Y		
256.	4325 <i>Viminaria juncea</i> (Swishbush, Koweda)			
Gentianaceae				
257.	6539 <i>Centaureum erythraea</i> (Common Centaury)	Y		
258.	6543 <i>Cicendia filiformis</i> (Slender Cicendia)	Y		
Geraniaceae				
259.	4332 <i>Erodium botrys</i> (Long Storksbill)	Y		
260.	4335 <i>Erodium cygnorum</i> (Blue Heronsbill)			
261.	4340 <i>Geranium retrorsum</i>			
Goodeniaceae				
262.	7411 <i>Anthotium humile</i> (Dwarf Anthotium)			
263.	12724 <i>Anthotium junciforme</i>			
264.	7454 <i>Dampiera linearis</i> (Common Dampiera)			
265.	29362 <i>Goodenia coerulea</i>			
266.	12551 <i>Goodenia micrantha</i>			
267.	7568 <i>Lechenaultia biloba</i> (Blue Leschenaultia)			
268.	7574 <i>Lechenaultia floribunda</i> (Free-flowering Leschenaultia)			
269.	7602 <i>Scaevola calliptera</i>			
270.	7619 <i>Scaevola lanceolata</i> (Long-leaved Scaevola)			
271.	7635 <i>Scaevola pilosa</i> (Hairy Fan-flower)			
272.	13182 <i>Scaevola repens</i> var. <i>repens</i>			
Haemodoraceae				
273.	1409 <i>Anigozanthos humilis</i> (Catspaw)			
274.	1411 <i>Anigozanthos manglesii</i> (Mangles Kangaroo Paw, Kurulbrang)			
275.	1416 <i>Anigozanthos viridis</i> (Green Kangaroo Paw, Kurulbardang)			
276.	11566 <i>Anigozanthos viridis</i> subsp. <i>viridis</i>			
277.	1418 <i>Conostylis aculeata</i> (Prickly Conostylis)			
278.	11826 <i>Conostylis aculeata</i> subsp. <i>aculeata</i>			
279.	12109 <i>Conostylis aculeata</i> subsp. <i>preissii</i>			
280.	1423 <i>Conostylis aurea</i> (Golden Conostylis)			
281.	1436 <i>Conostylis juncea</i>			
282.	1454 <i>Conostylis setigera</i> (Bristly Cottonhead)			
283.	1455 <i>Conostylis setosa</i> (White Cottonhead)			
284.	1464 <i>Haemodorum brevisepalum</i>			
285.	1468 <i>Haemodorum laxum</i>			
286.	1472 <i>Haemodorum simplex</i>			
287.	1474 <i>Haemodorum sparsiflorum</i>			
288.	1475 <i>Haemodorum spicatum</i> (Mardja)			
289.	1478 <i>Phlebocarya ciliata</i>			
290.	1479 <i>Phlebocarya filifolia</i>			
291.	1481 <i>Tribonanthes australis</i> (Southern Tiurndin)			
292.	1482 <i>Tribonanthes brachypetala</i> (Nodding Tiurndin)			
293.	1485 <i>Tribonanthes violacea</i> (Violet Tiurndin)			
Hemerocallidaceae				
294.	23474 <i>Agrostocrinum hirsutum</i>			
295.	1261 <i>Agrostocrinum scabrum</i> (Blue Grass Lily)			
296.	1264 <i>Amocrinum preissii</i>			
297.	1276 <i>Caesia micrantha</i> (Pale Grass Lily)			
298.	1259 <i>Dianella revoluta</i> (Blueberry Lily)			
299.	1298 <i>Johnsonia pubescens</i> (Pipe Lily)			

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300.	19272 <i>Johnsonia pubescens</i> subsp. <i>cygnorum</i>		P2	
301.	19632 <i>Johnsonia pubescens</i> subsp. <i>pubescens</i>			
302.	1361 <i>Tricoryne elatior</i> (Yellow Autumn Lily)			
303.	1362 <i>Tricoryne humilis</i>			
Hydatellaceae				
304.	1139 <i>Trithuria bibracteata</i>			
305.	1141 <i>Trithuria submersa</i>			
Hypoxidaceae				
306.	43760 <i>Pauridia occidentalis</i>			
Iridaceae				
307.	18279 <i>Babiana angustifolia</i>	Y		
308.	18392 <i>Freesia alba</i> x <i>leichtlinii</i>	Y		
309.	1518 <i>Gladiolus angustus</i> (Long Tubed Painted Lady)	Y		
310.	1520 <i>Gladiolus caryophyllaceus</i> (Wild Gladiolus)	Y		
311.	19179 <i>Moraea flaccida</i> (One-leaf Cape Tulip)	Y		
312.	1546 <i>Patersonia juncea</i> (Rush Leaved Patersonia)			
313.	1550 <i>Patersonia occidentalis</i> (Purple Flag, Koma)			
314.	1556 <i>Romulea rosea</i> (Guildford Grass)	Y		
315.	1558 <i>Sparaxis bulbifera</i>	Y		
316.	13103 <i>Watsonia borbonica</i>	Y		
317.	1566 <i>Watsonia marginata</i>	Y		
318.	1567 <i>Watsonia meriana</i> (Bulbil Watsonia)	Y		
319.	18108 <i>Watsonia meriana</i> var. <i>bulbillifera</i>	Y		
320.	18118 <i>Watsonia meriana</i> var. <i>meriana</i>	Y		
321.	<i>Watsonia</i> sp. <i>Mud09</i>			Y
Isoetaceae				
322.	11 <i>Isoetes drummondii</i> (Quillwort)			
Juncaceae				
323.	1178 <i>Juncus bufonius</i> (Toad Rush)	Y		
324.	1180 <i>Juncus capitatus</i> (Capitate Rush)	Y		
325.	1188 <i>Juncus pallidus</i> (Pale Rush)			
Juncaginaceae				
326.	40661 <i>Cynogeton lineare</i>			
327.	18587 <i>Triglochin nana</i>			
Lamiaceae				
328.	6856 <i>Hemigenia incana</i> (Silky Hemigenia)			
Lauraceae				
329.	2951 <i>Cassytha flava</i> (Dodder Laurel)			
330.	2952 <i>Cassytha glabella</i> (Tangled Dodder Laurel)			
Lentibulariaceae				
331.	<i>Polypompholyx tenella</i> ssp.			
332.	7153 <i>Utricularia tenella</i>			
333.	7157 <i>Utricularia violacea</i> (Violet Bladderwort)			
Loganiaceae				
334.	16825 <i>Phyllangium divergens</i>			
335.	16177 <i>Phyllangium paradoxum</i>			
Loranthaceae				
336.	2401 <i>Nuytsia floribunda</i> (Christmas Tree, Mudja)			
Macarthuriaceae				
337.	2839 <i>Macarthuria australis</i>			
Malvaceae				
338.	10915 <i>Brachychiton populneus</i> (Kurrajong)	Y		
Myrtaceae				
339.	<i>Astartea</i> aff. <i>fascicularis</i> ssp.			
340.	20350 <i>Astartea affinis</i> (West-coast Astartea)			
341.	45402 <i>Babingtonia urbana</i> (Coastal Plain Babingtonia)		P3	
342.	5411 <i>Calothamnus hirsutus</i>			
343.	5439 <i>Calytrix angulata</i> (Yellow Starflower)			
344.	5441 <i>Calytrix aurea</i>			
345.	5458 <i>Calytrix flavescens</i> (Summer Starflower)			
346.	5460 <i>Calytrix fraseri</i> (Pink Summer Calytrix)			
347.	5498 <i>Chamelaucium uncinatum</i> (Geraldton Wax)			
348.	17104 <i>Corymbia calophylla</i> (Marri)			

Name ID	Species Name	Naturalised	Conservation Code	Endemic To Query Area
349.	18193 <i>Darwinia thymoides</i> subsp. <i>thymoides</i>			
350.	13950 <i>Eremaea asterocarpa</i> subsp. <i>asterocarpa</i>			
351.	14104 <i>Eremaea pauciflora</i> var. <i>pauciflora</i>			
352.	5690 <i>Eucalyptus lane-poolei</i> (Salmon White Gum)			
353.	5708 <i>Eucalyptus marginata</i> (Jarrah, Djara)			
354.	13547 <i>Eucalyptus marginata</i> subsp. <i>marginata</i> (Jarrah)			
355.	13548 <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> (Blue-leaved Jarrah)			
356.	13511 <i>Eucalyptus rudis</i> subsp. <i>rudis</i>			
357.	12906 <i>Eucalyptus wandoo</i> subsp. <i>wandoo</i>			
358.	5817 <i>Hypocalymma angustifolium</i> (White Myrtle, Kudjid)			
359.	5825 <i>Hypocalymma robustum</i> (Swan River Myrtle)			
360.	5835 <i>Kunzea micrantha</i>			
361.	17461 <i>Kunzea micrantha</i> subsp. <i>micrantha</i>			
362.	5841 <i>Kunzea recurva</i>			
363.	37580 <i>Melaleuca acutifolia</i>			
364.	36296 <i>Melaleuca armillaris</i> subsp. <i>armillaris</i>	Y		
365.	5925 <i>Melaleuca lateriflora</i> (Gorada)			
366.	5926 <i>Melaleuca lateritia</i> (Robin Redbreast Bush)			
367.	20297 <i>Melaleuca osullivanii</i>			
368.	5946 <i>Melaleuca pauciflora</i>			
369.	5952 <i>Melaleuca preissiana</i> (Moonah)			
370.	5978 <i>Melaleuca teretifolia</i> (Banbar)			
371.	5980 <i>Melaleuca thymoides</i>			
372.	5984 <i>Melaleuca uncinata</i> (Broom Bush, Kwidjard)			
373.	5987 <i>Melaleuca viminea</i> (Mohan)			
374.	6006 <i>Pericalymma ellipticum</i> (Swamp Teatree)			
375.	16478 <i>Pericalymma ellipticum</i> var. <i>floridum</i>			
376.	6012 <i>Regelia ciliata</i>			
377.	6033 <i>Scholtzia involucrata</i> (Spiked Scholtzia)			
378.	6070 <i>Verticordia acerosa</i>			
379.	12388 <i>Verticordia acerosa</i> var. <i>preissii</i>			
380.	6076 <i>Verticordia densiflora</i> (Compacted Featherflower)			
381.	15432 <i>Verticordia densiflora</i> var. <i>densiflora</i>			
382.	6088 <i>Verticordia huegelii</i> (Variegated Featherflower)			
383.	15433 <i>Verticordia huegelii</i> var. <i>huegelii</i>			
384.	12430 <i>Verticordia huegelii</i> var. <i>stylosa</i>			
385.	14714 <i>Verticordia lindleyi</i> subsp. <i>lindleyi</i>		P4	
386.	6107 <i>Verticordia pennigera</i>			
387.	6110 <i>Verticordia plumosa</i> (Plumed Featherflower)			
388.	12449 <i>Verticordia plumosa</i> var. <i>brachyphylla</i>			
Onagraceae				
389.	6137 <i>Oenothera affinis</i> (Longflower Evening Primrose)	Y		
390.	6140 <i>Oenothera mollissima</i>	Y		
391.	14292 <i>Oenothera stricta</i> subsp. <i>stricta</i>	Y		
Orchidaceae				
392.	1586 <i>Caladenia discoidea</i> (Dancing Orchid)			
393.	1592 <i>Caladenia flava</i> (Cowslip Orchid)			
394.	15348 <i>Caladenia flava</i> subsp. <i>flava</i>			
395.	1605 <i>Caladenia marginata</i> (White Fairy Orchid)			
396.	1613 <i>Caladenia reptans</i> (Little Pink Fairy Orchid)			
397.	19649 <i>Disa bracteata</i>	Y		
398.	12943 <i>Diuris brumalis</i>			
399.	10791 <i>Diuris carinata</i> (Bee Orchid)			
400.	11049 <i>Diuris corymbosa</i>			
401.	1632 <i>Diuris emarginata</i> (Tall Donkey Orchid)			
402.	1634 <i>Diuris laxiflora</i> (Bee Orchid)			
403.	1635 <i>Diuris longifolia</i> (Common Donkey Orchid)			
404.	12939 <i>Diuris magnifica</i>			
405.	1637 <i>Diuris purdiei</i> (Purdie's Donkey Orchid)		T	
406.	1638 <i>Diuris setacea</i> (Bristly Donkey Orchid)			
407.	1639 <i>Drakaea elastica</i> (Glossy-leaved Hammer Orchid)		T	
408.	1640 <i>Drakaea glyptodon</i> (King-in-his-carriage)			
409.	11156 <i>Drakaea livida</i>			
410.	1646 <i>Eriochilus dilatatus</i> (White Bunny Orchid)			
411.	1653 <i>Leporella fimbriata</i> (Hare Orchid)			
412.	10954 <i>Microtis media</i> (Tall Mignonette Orchid)			
413.	1672 <i>Prasophyllum fimbria</i> (Fringed Leek Orchid)			
414.	1680 <i>Prasophyllum parvifolium</i> (Autumn Leek Orchid)			
415.	48675 <i>Pterostylis atosanguinea</i>			

Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
416.	1693 <i>Pterostylis recurva</i> (Jug Orchid)			
417.	12217 <i>Pterostylis sanguinea</i>			
418.	1698 <i>Pterostylis vittata</i> (Banded Greenhood)			
419.	1701 <i>Thelymitra antennifera</i> (Vanilla Orchid)			
420.	1705 <i>Thelymitra crinita</i> (Blue Lady Orchid)			
Orobanchaceae				
421.	7046 <i>Bellardia trixago</i> (Bellardia)	Y		
422.	48868 <i>Bellardia viscosa</i>	Y		
423.	7089 <i>Parentucellia latifolia</i> (Common Bartsia)	Y		
Oxalidaceae				
424.	4352 <i>Oxalis glabra</i>	Y		
Philydraceae				
425.	1172 <i>Philydrella drummondii</i>			
426.	1173 <i>Philydrella pygmaea</i> (Butterfly Flowers)			
427.	14306 <i>Philydrella pygmaea</i> subsp. <i>pygmaea</i>			
Phyllanthaceae				
428.	4691 <i>Poranthera microphylla</i> (Small Poranthera)			
Pittosporaceae				
429.	25788 <i>Billardiera fraseri</i> (Elegant Pronaya)			
Plantaginaceae				
430.	4717 <i>Callitriche stagnalis</i> (Common Starwort)	Y		
431.	14282 <i>Gratiola pubescens</i>			
432.	7085 <i>Misopates orontium</i> (Lesser Snapdragon)	Y		
Poaceae				
433.	184 <i>Aira caryophyllea</i> (Silvery Hairgrass)	Y		
434.	185 <i>Aira cupaniana</i> (Silvery Hairgrass)	Y		
435.	197 <i>Amphipogon debilis</i>			
436.	200 <i>Amphipogon turbinatus</i>			
437.	207 <i>Aristida contorta</i> (Bunched Kerosene Grass)			
438.	17233 <i>Austrostipa campylachne</i>			
439.	17234 <i>Austrostipa compressa</i>			
440.	<i>Austrostipa semibarbata/campylachne</i>			Y
441.	17257 <i>Austrostipa variabilis</i>			
442.	233 <i>Avena barbata</i> (Bearded Oat)	Y		
443.	8661 <i>Brachypodium distachyon</i> (False Brome)	Y		
444.	244 <i>Briza maxima</i> (Blowfly Grass)	Y		
445.	245 <i>Briza minor</i> (Shivery Grass)	Y		
446.	267 <i>Chloris gayana</i> (Rhodes Grass)	Y		
447.	283 <i>Cynodon dactylon</i> (Couch)	Y		
448.	306 <i>Dichelachne crinita</i> (Longhair Plumegrass)			
449.	347 <i>Ehrharta calycina</i> (Perennial Veldt Grass)	Y		
450.	349 <i>Ehrharta longiflora</i> (Annual Veldt Grass)	Y		
451.	376 <i>Eragrostis curvula</i> (African Lovegrass)	Y		
452.	379 <i>Eragrostis elongata</i> (Clustered Lovegrass)			
453.	434 <i>Gastridium phleoides</i> (Nitgrass)	Y		
454.	450 <i>Hordeum marinum</i>	Y		
455.	19955 <i>Lachnagrostis plebeia</i>			
456.	478 <i>Lolium rigidum</i> (Wimmera Ryegrass)	Y		
457.	<i>Lolium sp.</i>			
458.	14985 <i>Melinis repens</i>	Y		
459.	492 <i>Neurachne alopecuroidea</i> (Foxtail Mulga Grass)			
460.	40424 <i>Pentameris airoides</i> subsp. <i>airoides</i>	Y		
461.	571 <i>Poa annua</i> (Winter Grass)	Y		
462.	582 <i>Polypogon monspeliensis</i> (Annual Beardgrass)	Y		
463.	583 <i>Polypogon tenellus</i>			
464.	40425 <i>Rytidosperma caespitosum</i>			
465.	40426 <i>Rytidosperma occidentale</i>			
466.	40430 <i>Rytidosperma pilosum</i>			
467.	613 <i>Setaria verticillata</i> (Whorled Pigeon Grass)	Y		
468.	722 <i>Vulpia bromoides</i> (Squirrel Tail Fescue)	Y		
469.	724 <i>Vulpia myuros</i> (Rat's Tail Fescue)	Y		
Polygalaceae				
470.	4564 <i>Comesperma virgatum</i> (Milkwort)			
Polygonaceae				
471.	2419 <i>Polygonum aviculare</i> (Wireweed)	Y		
472.	2429 <i>Rumex acetosella</i> (Sorrel)			

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		Y		
Potamogetonaceae				
473.	111 <i>Potamogeton ochreateus</i> (Blunt Pondweed)			
Primulaceae				
474.	36375 <i>Lysimachia arvensis</i> (Pimpernel)	Y		
475.	36373 <i>Lysimachia minima</i>	Y		
Proteaceae				
476.	1790 <i>Adenanthos meisneri</i>			
477.	1791 <i>Adenanthos obovatus</i> (Basket Flower)			
478.	1800 <i>Banksia attenuata</i> (Slender Banksia, Piara)			
479.	32678 <i>Banksia bipinnatifida</i> subsp. <i>bipinnatifida</i>			
480.	32576 <i>Banksia dallanneyi</i> (Couch Honeyypot)			
481.	32580 <i>Banksia dallanneyi</i> subsp. <i>dallanneyi</i> var. <i>dallanneyi</i>			
482.	1819 <i>Banksia grandis</i> (Bull Banksia, Pulgarla)			
483.	32214 <i>Banksia kippistiana</i>			
484.	1834 <i>Banksia menziesii</i> (Firewood Banksia)			
485.	32202 <i>Banksia nivea</i> (Honeyypot Dryandra, Pudjarn)			
486.	32053 <i>Banksia undata</i> (Urchin Dryandra)			
487.	1882 <i>Conospermum stoechadis</i> (Common Smokebush)			
488.	15611 <i>Conospermum stoechadis</i> subsp. <i>stoechadis</i> (Common Smokebush)			
489.	1964 <i>Grevillea bipinnatifida</i> (Fuchsia Grevillea)			
490.	19628 <i>Grevillea bipinnatifida</i> subsp. <i>bipinnatifida</i>			
491.	2066 <i>Grevillea pilulifera</i> (Woolly-flowered Grevillea)			
492.	2080 <i>Grevillea quercifolia</i> (Oak-leaf Grevillea)			
493.	2122 <i>Grevillea wilsonii</i> (Native Fuchsia)			
494.	2137 <i>Hakea ceratophylla</i> (Horned Leaf Hakea)			
495.	2152 <i>Hakea cyclocarpa</i> (Ramshorn)			
496.	2166 <i>Hakea incrassata</i> (Marble Hakea)			
497.	2175 <i>Hakea lissocarpha</i> (Honey Bush)			
498.	2179 <i>Hakea marginata</i>			
499.	2197 <i>Hakea prostrata</i> (Harsh Hakea)			
500.	2203 <i>Hakea ruscifolia</i> (Candle Hakea)			
501.	2206 <i>Hakea stenocarpa</i> (Narrow-fruited Hakea)			
502.	2214 <i>Hakea trifurcata</i> (Two-leaf Hakea)			
503.	2216 <i>Hakea varia</i> (Variable-leaved Hakea)			
504.	2221 <i>Isopogon asper</i>			
505.	14083 <i>Lambertia multiflora</i> var. <i>darlingensis</i>			
506.	2273 <i>Persoonia saccata</i> (Snottygobble)			
507.	20391 <i>Petrophile juncifolia</i>			
508.	2299 <i>Petrophile linearis</i> (Pixie Mops)			
509.	2301 <i>Petrophile macrostachya</i>			
510.	2308 <i>Petrophile seminuda</i>			
511.	2311 <i>Petrophile squamata</i>			
512.	2312 <i>Petrophile striata</i>			
513.	2316 <i>Stirlingia latifolia</i> (Blueboy)			
514.	2321 <i>Synaphea acutiloba</i> (Granite Synaphea)			
515.	2323 <i>Synaphea gracillima</i>			
516.	2324 <i>Synaphea petiolaris</i> (Synaphea)			
517.	30751 <i>Synaphea</i> sp. <i>Pinjarra Plain</i> (A.S. George 17182)		T	
518.	28354 <i>Synaphea</i> sp. <i>Serpentine</i> (G.R. Brand 103)		T	
519.	2331 <i>Xylomelum occidentale</i> (Woody Pear, Djandin)			
Pteridaceae				
520.	31 <i>Cheilanthes austrotenuifolia</i>			
521.	12818 <i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>			
Restionaceae				
522.	17845 <i>Apodasmia ceramophila</i>			
523.	17685 <i>Chaetanthus aristatus</i>			
524.	17706 <i>Chordiflex sinuosus</i>			
525.	17691 <i>Desmocladius fasciculatus</i>			
526.	16595 <i>Desmocladius flexuosus</i>			
527.	46362 <i>Desmocladius lateriflorus</i>			
528.	1070 <i>Hypolaena exsulca</i>			
529.	1071 <i>Hypolaena fastigiata</i>			
530.	1075 <i>Lepidobolus preissianus</i>			
531.	18074 <i>Lepidobolus preissianus</i> subsp. <i>preissianus</i>			
532.	1077 <i>Leptocarpus canus</i> (Hoary Twine-rush)			
533.	1078 <i>Leptocarpus coangustatus</i>			
534.	46380 <i>Leptocarpus kraussii</i>			

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535.	1088 <i>Lepyrodia macra</i> (Large Scale Rush)			
536.	1090 <i>Lepyrodia muirii</i>			
Rosaceae				
537.	3191 <i>Rubus ulmifolius</i> (Blackberry)	Y		
Rubiaceae				
538.	18254 <i>Opercularia apiciflora</i>			
539.	18255 <i>Opercularia vaginata</i> (Dog Weed)			
Rutaceae				
540.	11503 <i>Boronia crenulata</i> subsp. <i>crenulata</i> var. <i>crenulata</i>			
541.	18529 <i>Philothea spicata</i> (Pepper and Salt)			
Santalaceae				
542.	2355 <i>Leptomeria squarrolosa</i>			
Scrophulariaceae				
543.	7055 <i>Dischisma capitatum</i> (Woolly-headed Dischisma)	Y		
544.	13405 <i>Phyllopodium cordatum</i>	Y		
Selaginellaceae				
545.	6 <i>Selaginella gracillima</i> (Tiny Clubmoss)			
Solanaceae				
546.	7022 <i>Solanum nigrum</i> (Black Berry Nightshade)	Y		
Stylidiaceae				
547.	7675 <i>Levenhookia pulcherrima</i> (Beautiful Stylewort)		P2	
548.	7676 <i>Levenhookia pusilla</i> (Midget Stylewort)			
549.	18564 <i>Stylidium aceratum</i>		P3	
550.	<i>Stylidium</i> aff. <i>androsaceum</i>			
551.	30278 <i>Stylidium androsaceum</i>			
552.	7693 <i>Stylidium brunonianum</i> (Pink Fountain Triggerplant)			
553.	7696 <i>Stylidium calcaratum</i> (Book Triggerplant)			
554.	7699 <i>Stylidium carnosum</i> (Fleshy-leaved Triggerplant)			
555.	7702 <i>Stylidium ciliatum</i> (Golden Triggerplant)			
556.	7712 <i>Stylidium despectum</i> (Dwarf Triggerplant)			
557.	7713 <i>Stylidium dichotomum</i> (Pins-and-needles)			
558.	7717 <i>Stylidium divaricatum</i> (Daddy-long-legs)			
559.	7718 <i>Stylidium diversifolium</i> (Touch-me-not)			
560.	7742 <i>Stylidium inundatum</i> (Hundreds and Thousands)			
561.	7749 <i>Stylidium leptophyllum</i> (Needle-leaved Triggerplant)			
562.	25829 <i>Stylidium neurophyllum</i> (Coastal Plain Triggerplant)			
563.	7768 <i>Stylidium obtusatum</i> (Pinafore Triggerplant)			
564.	7773 <i>Stylidium petiolare</i> (Horn Triggerplant)			
565.	7774 <i>Stylidium piliferum</i> (Common Butterfly Triggerplant)			
566.	7782 <i>Stylidium pulchellum</i> (Thumbelina Triggerplant)			
567.	33106 <i>Stylidium recurvum</i>			
568.	7785 <i>Stylidium repens</i> (Matted Triggerplant)			
569.	<i>Stylidium roseo-alatum</i>			
570.	7790 <i>Stylidium roseoalatum</i> (Pink-wing Triggerplant)			
571.	7798 <i>Stylidium schoenoides</i> (Cow Kicks)			
572.	<i>Stylidium</i> sp.			
573.	45594 <i>Stylidium tenue</i> subsp. <i>majusculum</i> (Showy Fountain Triggerplant)			
574.	23511 <i>Stylidium thesioides</i> (Delicate Triggerplant)			
575.	7806 <i>Stylidium utricularioides</i> (Pink Fan Triggerplant)			
Thymelaeaceae				
576.	11404 <i>Pimelea imbricata</i> var. <i>major</i>			
577.	11402 <i>Pimelea imbricata</i> var. <i>piligera</i>			
578.	5266 <i>Pimelea suaveolens</i> (Scented Banjine)			
579.	12041 <i>Pimelea suaveolens</i> subsp. <i>suaveolens</i>			
Violaceae				
580.	5216 <i>Hybanthus calycinus</i> (Wild Violet)			
Xanthorrhoeaceae				
581.	1280 <i>Chamaescilla corymbosa</i> (Blue Squill)			
582.	11299 <i>Chamaescilla corymbosa</i> var. <i>corymbosa</i>			
583.	1253 <i>Xanthorrhoea gracilis</i> (Graceful Grass Tree, Mimidi)			
584.	1256 <i>Xanthorrhoea preissii</i> (Grass tree, Palga)			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct

Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
IA	Protected under international agreement			
S	Other specially protected fauna			
1	Priority 1			
2	Priority 2			
3	Priority 3			
4	Priority 4			
5	Priority 5			

¹ For NatureMap's purposes, species flagged as endemic are those whose records are wholly contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

NatureMap Species Report

Created By Guest user on 12/03/2020

Kingdom Animalia
Current Names Only Yes
Core Datasets Only Yes
Method 'By Circle'
Centre 115° 59' 09" E, 32° 16' 50" S
Buffer 5km
Group By Species Group

Species Group	Species	Records
Amphibian	6	86
Bird	106	1129
Invertebrate	30	106
Mammal	20	42
Reptile	20	90
TOTAL	182	1453

Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
Amphibian				
1.	25398 <i>Crinia georgiana</i> (Quacking Frog)			
2.	25399 <i>Crinia glauerti</i> (Clicking Frog)			
3.	25400 <i>Crinia insignifera</i> (Squelching Froglet)			
4.	25410 <i>Heleioporus eyrei</i> (Moaning Frog)			
5.	25415 <i>Limnodynastes dorsalis</i> (Western Banjo Frog)			
6.	25433 <i>Pseudophryne guentheri</i> (Crawling Toadlet)			
Bird				
7.	24260 <i>Acanthiza apicalis</i> (Broad-tailed Thornbill, Inland Thornbill)			
8.	24261 <i>Acanthiza chrysorrhoa</i> (Yellow-rumped Thornbill)			
9.	24262 <i>Acanthiza inornata</i> (Western Thornbill)			
10.	24265 <i>Acanthiza uropygialis</i> (Chestnut-rumped Thornbill)			
11.	24560 <i>Acanthorhynchus superciliosus</i> (Western Spinebill)			
12.	25535 <i>Accipiter cirrocephalus</i> (Collared Sparrowhawk)			
13.	25536 <i>Accipiter fasciatus</i> (Brown Goshawk)			
14.	24312 <i>Anas gracilis</i> (Grey Teal)			
15.	24316 <i>Anas superciliosa</i> (Pacific Black Duck)			
16.	24561 <i>Anthochaera carunculata</i> (Red Wattlebird)			
17.	24562 <i>Anthochaera lunulata</i> (Western Little Wattlebird)			
18.	24599 <i>Anthus australis</i> subsp. <i>australis</i> (Australian Pipit)			
19.	24285 <i>Aquila audax</i> (Wedge-tailed Eagle)			
20.	24340 <i>Ardea novaehollandiae</i> (White-faced Heron)			
21.	24341 <i>Ardea pacifica</i> (White-necked Heron)			
22.	24610 <i>Ardeotis australis</i> (Australian Bustard)			
23.	25566 <i>Artamus cinereus</i> (Black-faced Woodswallow)			
24.	24353 <i>Artamus cyanopterus</i> (Dusky Woodswallow)			
25.	<i>Barnardius zonarius</i>			
26.	24319 <i>Biziura lobata</i> (Musk Duck)			
27.	25715 <i>Cacatua roseicapilla</i> (Galah)			
28.	25716 <i>Cacatua sanguinea</i> (Little Corella)			
29.	42307 <i>Cacomantis pallidus</i> (Pallid Cuckoo)			
30.	24788 <i>Calidris ruficollis</i> (Red-necked Stint)		IA	
31.	25717 <i>Calyptorhynchus banksii</i> (Red-tailed Black-Cockatoo)			
32.	24731 <i>Calyptorhynchus banksii</i> subsp. <i>naso</i> (Forest Red-tailed Black Cockatoo)		T	
33.	24733 <i>Calyptorhynchus baudinii</i> (Baudin's Cockatoo, White-tailed Long-billed Black Cockatoo)		T	
34.	24734 <i>Calyptorhynchus latirostris</i> (Carnaby's Cockatoo, White-tailed Short-billed Black Cockatoo)		T	
35.	48400 <i>Calyptorhynchus</i> sp. (white-tailed black cockatoo)		T	
36.	24377 <i>Charadrius ruficapillus</i> (Red-capped Plover)			
37.	24321 <i>Chenonetta jubata</i> (Australian Wood Duck, Wood Duck)			

Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
38.	<i>Chroicocephalus novaehollandiae</i>			
39.	24431 <i>Chrysococcyx basalis</i> (Horsfield's Bronze Cuckoo)			
40.	25675 <i>Colluricincla harmonica</i> (Grey Shrike-thrush)			
41.	24399 <i>Columba livia</i> (Domestic Pigeon)	Y		
42.	25568 <i>Coracina novaehollandiae</i> (Black-faced Cuckoo-shrike)			
43.	25592 <i>Corvus coronoides</i> (Australian Raven)			
44.	25593 <i>Corvus orru</i> (Torresian Crow)			
45.	24671 <i>Coturnix pectoralis</i> (Stubble Quail)			
46.	25595 <i>Cracticus tibicen</i> (Australian Magpie)			
47.	25596 <i>Cracticus torquatus</i> (Grey Butcherbird)			
48.	24322 <i>Cygnus atratus</i> (Black Swan)			
49.	30901 <i>Dacelo novaeguineae</i> (Laughing Kookaburra)	Y		
50.	25673 <i>Daphoenositta chrysoptera</i> (Varied Sittella)			
51.	25607 <i>Dicaeum hirundinaceum</i> (Mistletoebird)			
52.	<i>Egretta novaehollandiae</i>			
53.	<i>Elanus axillaris</i>			
54.	<i>Eolophus roseicapillus</i>			
55.	24567 <i>Epthianura albiglans</i> (White-fronted Chat)			
56.	25621 <i>Falco berigora</i> (Brown Falcon)			
57.	25622 <i>Falco cenchroides</i> (Australian Kestrel, Nankeen Kestrel)			
58.	25624 <i>Falco peregrinus</i> (Peregrine Falcon)		S	
59.	24476 <i>Falco subniger</i> (Black Falcon)			
60.	25727 <i>Fulica atra</i> (Eurasian Coot)			
61.	24765 <i>Gallirallus philippensis</i> subsp. <i>mellori</i> (Buff-banded Rail)			
62.	25530 <i>Gerygone fusca</i> (Western Gerygone)			
63.	24443 <i>Grallina cyanoleuca</i> (Magpie-lark)			
64.	24295 <i>Haliastur sphenurus</i> (Whistling Kite)			
65.	47965 <i>Hieraaetus morphnoides</i> (Little Eagle)			
66.	24491 <i>Hirundo neoxena</i> (Welcome Swallow)			
67.	48587 <i>Hydroprogne caspia</i> (Caspian Tern)		IA	
68.	25661 <i>Lichmera indistincta</i> (Brown Honeyeater)			
69.	25651 <i>Malurus lamberti</i> (Variegated Fairy-wren)			
70.	24551 <i>Malurus pulcherrimus</i> (Blue-breasted Fairy-wren)			
71.	25654 <i>Malurus splendens</i> (Splendid Fairy-wren)			
72.	24583 <i>Manorina flavigula</i> (Yellow-throated Miner)			
73.	24598 <i>Merops ornatus</i> (Rainbow Bee-eater)			
74.	<i>Microcarbo melanoleucos</i>			
75.	25693 <i>Microeca fascians</i> (Jacky Winter)			
76.	24738 <i>Neophema elegans</i> (Elegant Parrot)			
77.	24407 <i>Ocyphaps lophotes</i> (Crested Pigeon)			
78.	25680 <i>Pachycephala rufiventris</i> (Rufous Whistler)			
79.	25681 <i>Pardalotus punctatus</i> (Spotted Pardalote)			
80.	25682 <i>Pardalotus striatus</i> (Striated Pardalote)			
81.	24648 <i>Pelecanus conspicillatus</i> (Australian Pelican)			
82.	48061 <i>Petrochelidon nigricans</i> (Tree Martin)			
83.	48066 <i>Petroica boodang</i> (Scarlet Robin)			
84.	24659 <i>Petroica goodenovii</i> (Red-capped Robin)			
85.	25698 <i>Phalacrocorax melanoleucos</i> (Little Pied Cormorant)			
86.	24667 <i>Phalacrocorax sulcirostris</i> (Little Black Cormorant)			
87.	24409 <i>Phaps chalcoptera</i> (Common Bronzewing)			
88.	48071 <i>Phylidonyris niger</i> (White-cheeked Honeyeater)			
89.	24596 <i>Phylidonyris novaehollandiae</i> (New Holland Honeyeater)			
90.	25720 <i>Platycercus icterotis</i> (Western Rosella)			
91.	24747 <i>Platycercus spurius</i> (Red-capped Parrot)			
92.	25721 <i>Platycercus zonarius</i> (Australian Ringneck, Ring-necked Parrot)			
93.	25704 <i>Podiceps cristatus</i> (Great Crested Grebe)			
94.	25722 <i>Polytelis anthopeplus</i> (Regent Parrot)			
95.	24771 <i>Porzana tabuensis</i> (Spotless Crane)			
96.	<i>Purpureicephalus spurius</i>			
97.	24776 <i>Recurvirostra novaehollandiae</i> (Red-necked Avocet)			
98.	48096 <i>Rhipidura albiscapa</i> (Grey Fantail)			
99.	25614 <i>Rhipidura leucophrys</i> (Willie Wagtail)			
100.	25534 <i>Sericornis frontalis</i> (White-browed Scrubwren)			
101.	30948 <i>Smicronis brevirostris</i> (Weebill)			
102.	25590 <i>Streptopelia senegalensis</i> (Laughing Turtle-Dove)	Y		
103.	25705 <i>Tachybaptus novaehollandiae</i> (Australasian Grebe, Black-throated Grebe)			
104.	24331 <i>Tadorna tadornoides</i> (Australian Shelduck, Mountain Duck)			
105.	30870 <i>Taeniopygia guttata</i> (Zebra Finch)			
106.	24845 <i>Threskiornis spinicollis</i> (Straw-necked Ibis)			
107.	25549 <i>Todiramphus sanctus</i> (Sacred Kingfisher)			

Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
108.	25723 <i>Trichoglossus haematodus</i> (Rainbow Lorikeet)			
109.	48147 <i>Turnix varius</i> (Painted Button-quail)			
110.	24852 <i>Tyto alba</i> subsp. <i>delicatula</i> (Barn Owl)			
111.	24386 <i>Vanellus tricolor</i> (Banded Lapwing)			
112.	25765 <i>Zosterops lateralis</i> (Grey-breasted White-eye, Silvereye)			
Invertebrate				
113.	<i>Amblyomma triguttatum</i>			
114.	<i>Aname tepperi</i>			
115.	<i>Araneus cyphoxis</i>			
116.	<i>Asadipus kunderang</i>			
117.	<i>Austracantha minax</i>			
118.	<i>Backbourkia heroine</i>			
119.	<i>Ballarra longipalpus</i>			
120.	<i>Cyclosa trilobata</i>			
121.	<i>Dingosa serrata</i>			
122.	<i>Eucyrtops latior</i>			
123.	48579 <i>Euoplos inornatus</i> (inornate trapdoor spider (northern Jarrah Forest))		P3	
124.	<i>Holconia westralia</i>			
125.	48935 <i>Idiosoma sigillatum</i> (Swan Coastal Plain shield-backed trapdoor spider)		P3	
126.	<i>Isopeda leishmanni</i>			
127.	<i>Lamponusa gleneagle</i>			
128.	<i>Missulena granulosa</i>			
129.	<i>Nephila edulis</i>			
130.	<i>Oxyopes rubicundus</i>			
131.	<i>Ozarchaea westraliensis</i>			
132.	<i>Paralampona marangaroo</i>			
133.	<i>Raveniella cirrata</i>			
134.	<i>Raveniella peckorum</i>			
135.	<i>Supunna funerea</i>			
136.	<i>Supunna picta</i>			
137.	<i>Synothele durokoppin</i>			
138.	<i>Synothele michaelseni</i>			
139.	<i>Urodacus novaehollandiae</i>			
140.	<i>Urodacus woodwardii</i>			
141.	<i>Venator immansueta</i>			
142.	34113 <i>Westralunio carteri</i> (Carter's Freshwater Mussel)		T	
Mammal				
143.	25449 <i>Antechinus flavipes</i> (Yellow-footed Antechinus)			
144.	24162 <i>Bettongia penicillata</i> subsp. <i>ogilbyi</i> (Woylie, Brush-tailed Bettong)		T	
145.	24092 <i>Dasyurus geoffroii</i> (Chuditch, Western Quoll)		T	
146.	24041 <i>Felis catus</i> (Cat)	Y		
147.	48588 <i>Isodon fusciventer</i> (Quenda, southwestern brown bandicoot)		P4	
148.	24132 <i>Macropus fuliginosus</i> (Western Grey Kangaroo)			
149.	24223 <i>Mus musculus</i> (House Mouse)	Y		
150.	24155 <i>Perameles eremiana</i> (Desert Bandicoot, walliya)		X	
151.	24165 <i>Petropseudes dahli</i> (Rock Ringtail Possum, Wogoit)		P3	
152.	48070 <i>Phascogale tapoatafa</i> subsp. <i>wambenger</i> (South-western Brush-tailed Phascogale, Wambenger)		S	
153.	24164 <i>Potorous platyops</i> (Broad-faced Potoroo)		X	
154.	24166 <i>Pseudocheirus occidentalis</i> (Western Ringtail Possum, ngwayir)		T	
155.	24245 <i>Rattus rattus</i> (Black Rat)	Y		
156.	24145 <i>Setonix brachyurus</i> (Quokka)		T	
157.	24259 <i>Sus scrofa</i> (Pig)	Y		
158.	24167 <i>Tarsipes rostratus</i> (Honey Possum, Noolbenger)			
159.	25521 <i>Trichosurus vulpecula</i> (Common Brushtail Possum)			
160.	24157 <i>Trichosurus vulpecula</i> subsp. <i>arnhemensis</i> (northern brushtail possum (Kimberley))		T	
161.	24158 <i>Trichosurus vulpecula</i> subsp. <i>vulpecula</i> (Common Brushtail Possum)			
162.	24040 <i>Vulpes vulpes</i> (Red Fox)	Y		
Reptile				
163.	42368 <i>Acritoscincus trilineatus</i> (Western Three-lined Skink)			
164.	24990 <i>Aprasia pulchella</i> (Granite Worm-lizard)			
165.	24991 <i>Aprasia repens</i> (Sand-plain Worm-lizard)			
166.	30893 <i>Cryptoblepharus buchananii</i>			
167.	25039 <i>Ctenotus fallens</i>			
168.	25047 <i>Ctenotus impar</i>			
169.	25766 <i>Delma fraseri</i> (Fraser's Legless Lizard)			
170.	25131 <i>Lerista distinguenda</i>			
171.	25133 <i>Lerista elegans</i>			
172.	25005 <i>Lialis burtonis</i>			

Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
173.	25184 <i>Menetia greyii</i>			
174.	25240 <i>Morelia spilota subsp. imbricata</i> (Carpet Python)			
175.	25192 <i>Morethia obscura</i>			
176.	25252 <i>Notechis scutatus</i> (Tiger Snake)			
177.	25253 <i>Parasuta gouldii</i>			
178.	24907 <i>Pogona minor subsp. minor</i> (Dwarf Bearded Dragon)			
179.	25259 <i>Pseudonaja affinis subsp. affinis</i> (Dugite)			
180.	42416 <i>Pseudonaja mengdeni</i> (Western Brown Snake)			
181.	25203 <i>Tiliqua occipitalis</i> (Western Bluetongue)			
182.	25519 <i>Tiliqua rugosa</i>			

Conservation Codes

- T - Rare or likely to become extinct
- X - Presumed extinct
- IA - Protected under international agreement
- S - Other specially protected fauna
- 1 - Priority 1
- 2 - Priority 2
- 3 - Priority 3
- 4 - Priority 4
- 5 - Priority 5

¹ For NatureMap's purposes, species flagged as endemic are those whose records are wholly contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

List of Registered Original Sites

ID	Name	Site Restriction	Boundary Restriction	Restrictions	Status	Category	Coordinates	Area
396	07 - AARDP RRDRDN	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger names aila le fro DAA	403514 6432467 N one 50 Relia le
448	01 - A RRDR	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger names aila le fro DAA	403350 6431996 N one 50 Relia le
449	02 - A RRDR	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger names aila le fro DAA	403039 6429389 N one 50 Relia le
450	03 - A RRDR	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger names aila le fro DAA	402915 6428941 N one 50 Relia le
16096	B RD 08	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger names aila le fro DAA	406429 6432829 N one 50 nrelia le
16100	B RD 12	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger names aila le fro DAA	407153 6432454 N one 50 nrelia le
16101	B RD 13	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger names aila le fro DAA	407100 6432337 N one 50 nrelia le
16102	B RD 14	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger names aila le fro DAA	406931 6432348 N one 50 Relia le
16104	B RD 16	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger names aila le fro DAA	406729 6432419 N one 50 nrelia le
18187	on in i a - ndijon road s atter 11	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger names aila le fro DAA	402958 6428173 N one 50 Relia le
18188	on in i a - ndijon road s atter 12	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger names aila le fro DAA	402961 6428042 N one 50 Relia le
18191	on in i a - ndijon road s atter 15	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger names aila le fro DAA	406725 6424750 N one 50 Relia le



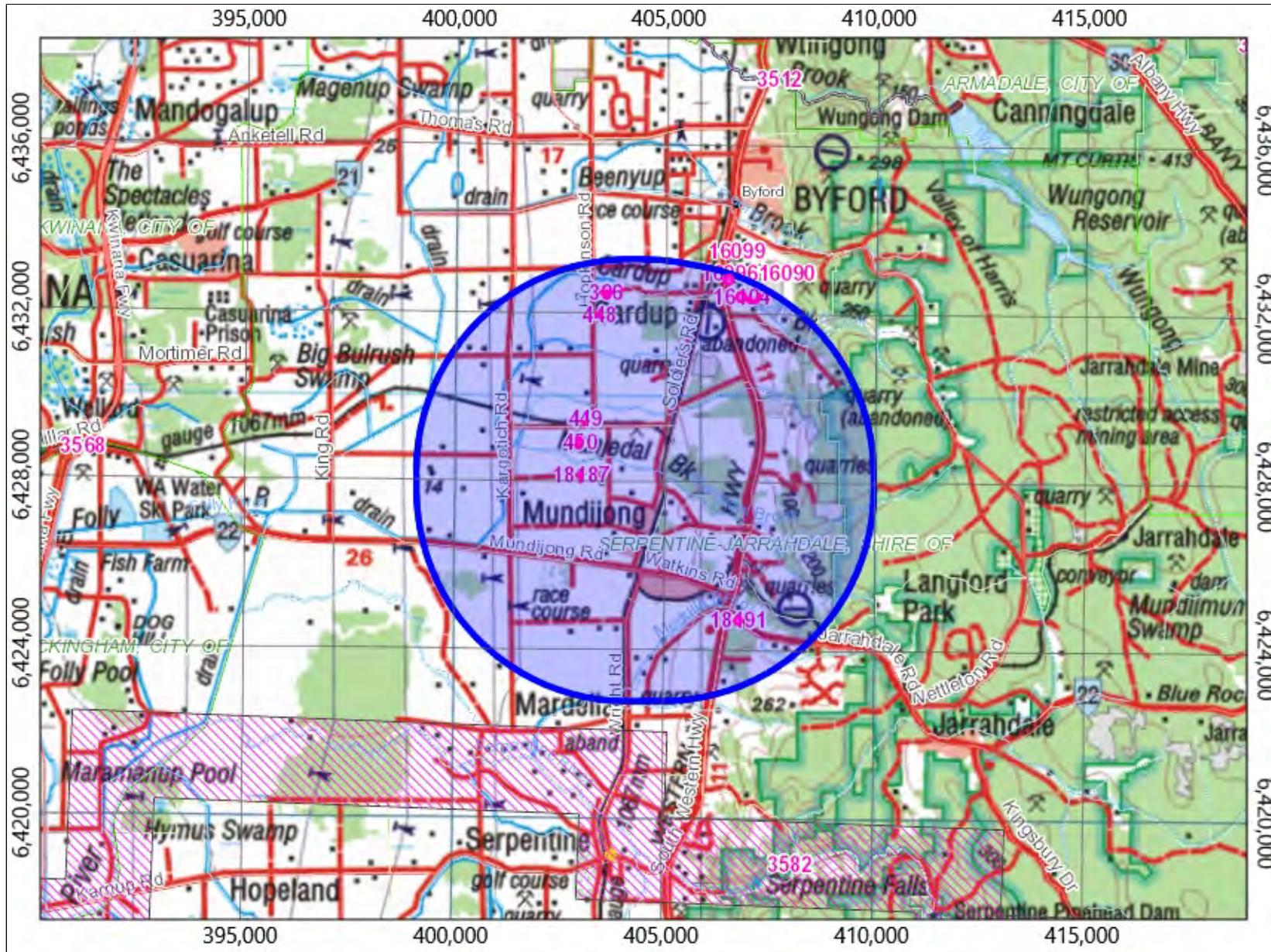
Original Heritage Sites

List of Registered Original Sites

10.1.9 - attachment 1

For further information on this information please see the Department of Planning, Lands and Heritage's Disclaimer statement at <https://dpl.wa.gov.au/attachment-site>

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Property	Noted elsewhere	Coordinate	Image ID
23917	Bford Archaeological Reserve 004	No	No	No other Restrictions	Registered site	Artefacts matter	Registered elsewhere on the DAA	403917 6432563 N one 50 Relia le	



- Legend
- Registered Aboriginal Site
 - Search Area
 - Town
 - Road
 - River
 - Local Government Authority

Scale 5:2 (1:160,000)

Scale 1:160,000

Scale 1:50,000 DA94



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Criteria

27 Heritage Places in Capefile - Project Area B 5 Bffer A50 D 20200226

Disclaimer

The Aboriginal Heritage Act 1972 preserves all Aboriginal sites in Western Australia whether or not they are registered. Aboriginal sites listed that are not recorded on the Register of Aboriginal Sites and so are registered sites are no longer listed.

The information provided is made available in good faith and is predominantly based on the information provided to the Department of Planning Lands and Heritage by third parties. The information is provided solely on the basis that readers will be responsible for their own assessment as to the accuracy of the information. If you find any errors or omissions in our records in LinkedIn or apps it would be appreciated if you email the details to the Department at originalheritage@dpla.wa.gov.au and we will make every effort to rectify it as soon as possible.

North West Settlement - A Disposal

Original Heritage Register is on land that is or adjacent to the following: Nindjoo and Searee Entitlements Naalara Boojandi and Searee Entitlement

On 8 June 2015, the State Heritage Commission passed all State Heritage Commission and certain State Heritage Commission entitlements to enter into a Noonan Standard Heritage Register. The Northern Area Aboriginal Heritage Register is also intended to be entered into and the Northern Area Aboriginal Heritage Register is also intended to be entered into and the Northern Area Aboriginal Heritage Register is also intended to be entered into.

The State Heritage Commission in the State Heritage Commission passes all State Heritage Commission and certain State Heritage Commission entitlements to enter into a Noonan Standard Heritage Register. The Northern Area Aboriginal Heritage Register is also intended to be entered into and the Northern Area Aboriginal Heritage Register is also intended to be entered into and the Northern Area Aboriginal Heritage Register is also intended to be entered into.

Since 8 June 2015, the Department of Planning Lands and Heritage, in relation to the Northern Area Aboriginal Heritage Register and related Aboriginal Heritage Register, has been working to ensure that the Northern Area Aboriginal Heritage Register is entered into and the Northern Area Aboriginal Heritage Register is also intended to be entered into.

For more information on the Northern Area Aboriginal Heritage Register, please contact the Northern Area Aboriginal Heritage Register. The Northern Area Aboriginal Heritage Register is also intended to be entered into and the Northern Area Aboriginal Heritage Register is also intended to be entered into.

For more information on the Northern Area Aboriginal Heritage Register, please contact the Northern Area Aboriginal Heritage Register at originalheritage@dpla.wa.gov.au.

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Coordinate Area
Coordinates are based on the DA 94 Data. Area is shown as a code in brackets following the coordinates.

Heritage Register

Heritage Register (NB that so-called heritage areas are not part of the Heritage Register)
The Department of Planning Lands and Heritage is pleased to advise that the following

- Registered Heritage Areas have been assessed as meeting the criteria of the Aboriginal Heritage Act 1972.
- Heritage Register Areas in the following categories:
 - Protected Data Not a Heritage Area has been assessed as not meeting the criteria of the Aboriginal Heritage Act 1972.
 - Proposed Information has been received in relation to the Heritage Register Assessment as not completed at this stage to determine if it meets the criteria of the Aboriginal Heritage Act 1972.

Assessment and Restrictions

- Heritage Register Areas: No Availability of Information that the Department of Planning Lands and Heritage holds in relation to the Heritage Register Area is not restricted in any way.
- Heritage Register Areas: Some of the information that the Department of Planning Lands and Heritage holds in relation to the Heritage Register Area is restricted if it is considered that all sensitive information will only be available if the Department of Planning Lands and Heritage receives written approval from the information providers to provide the information. For more information please contact OriginalHeritage@dpla.wa.gov.au.
- Heritage Register Areas: No Availability of Information is shown as a result of the information lodged with the Registrar.
- Heritage Register Areas: Some of the information that the Department of Planning Lands and Heritage holds in relation to the Heritage Register Area is restricted if it is considered that all sensitive information will only be available if the Department of Planning Lands and Heritage receives written approval from the information providers to provide the information. For more information please contact the Department of Planning Lands and Heritage.
- Restrictions
 - No Restrictions: Anyone can view the information.
 - Available to the public: Only the information that is restricted is available to the public.

The Department is responsible for the Heritage Register and the Department of Planning Lands and Heritage is pleased to advise that the Heritage Register Areas have been assessed as meeting the criteria of the Aboriginal Heritage Act 1972.

Background

The Heritage Register Areas are part of the Heritage Register and are used to identify and protect the heritage values of the State. The Heritage Register Areas are used to identify and protect the heritage values of the State. The Heritage Register Areas are used to identify and protect the heritage values of the State.

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ID	Name	Heritage Listed	Boundary Listed	Restrictions	Status	Category	Notes	Coordinates	Area	
3310	ARD P	No	No	No other Restrictions	Registered Data Not a site	Artefacts	atter a p	Registered no led e older na es a aila le fro DAA	404190 6432718 N one 50 nrelia le	00206
3313	ND N	No	No	No other Restrictions	Registered	Artefacts	atter a p	Registered no led e older na es a aila le fro DAA	406065 6426234 N one 50 nrelia le	00209
3590	W B	No	No	No other Restrictions	Registered	Artefacts	atter	Registered no led e older na es a aila le fro DAA	407195 6427120 N one 50 nrelia le	02416
3591	ARRABA	No	No	No other Restrictions	Registered	Artefacts	atter	Registered no led e older na es a aila le fro DAA	406870 6425980 N one 50 nrelia le	02417
3648	DR RD N	No	No	No other Restrictions	Registered	Artefacts	atter Ar Deposit BP Datin 1620BP	Registered no led e older na es a aila le fro DAA	404684 6428480 N one 50 Relia le	02329
16103	B RD 15	No	No	No other Restrictions	Registered Data Not a site	Artefacts	atter	Registered no led e older na es a aila le fro DAA	406819 6432419 N one 50 nrelia le	
16105	B RD 17	No	No	No other Restrictions	Registered Data Not a site	Artefacts	atter	Registered no led e older na es a aila le fro DAA	406789 6432669 N one 50 nrelia le	
16106	B RD 18	No	No	No other Restrictions	Registered Data Not a site	Artefacts	atter	Registered no led e older na es a aila le fro DAA	406893 6432675 N one 50 Relia le	
16107	B RD 19	No	No	No other Restrictions	Registered Data Not a site	Artefacts	atter	Registered no led e older na es a aila le fro DAA	406911 6432560 N one 50 Relia le	
16108	ARD P BR	No	No	No other Restrictions	Registered Data Not a site		t olo i al	Registered no led e older na es a aila le fro DAA	407530 6431805 N one 50 Relia le	
17923	2	No	No	No other Restrictions	Registered Data Not a site	Artefacts	atter	Registered no led e older na es a aila le fro DAA	403038 6427638 N one 50 Relia le	
18189	on in i a - ndijon road s atter 13	No	No	No other Restrictions	Registered Data Not a site	Artefacts	atter	Registered no led e older na es a aila le fro DAA	403043 6427990 N one 50 Relia le	

List of entries

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Property	Notes	Registered	Coordinates	Area
18190	Indijon Road - 14	No	No	No other Restrictions	Data Not available	Artefacts	atter	Registered no other na	404475 6425300	1.50 Relia
18192	Indijon Road - 16	No	No	No other Restrictions	Data Not available	Artefacts	atter	Registered no other na	407050 6424150	1.50 Relia
23914	Bford Ar aeolo i al re 001	No	No	No other Restrictions	Data Not available	Artefacts	atter odified ree	Registered no other na	405373 6432652	1.50 Relia
23915	Bford Ar aeolo i al re 002	No	No	No other Restrictions	Data Not available	Artefacts	atter	Registered no other na	404363 6432537	1.50 Relia
23916	Bford Ar aeolo i al re 003	No	No	No other Restrictions	Data Not available	Artefacts	atter	Registered no other na	403847 6432559	1.50 Relia
23920	BA - 001	No	No	No other Restrictions	Data Not available	Artefacts	atter	Registered no other na	404022 6432479	1.50 Relia
23921	BA - 002	No	No	No other Restrictions	Data Not available	Artefacts	atter	Registered no other na	404809 6432444	1.50 Relia
32591	-01	No	No	No other Restrictions	od ed	Artefacts	atter Ar Deposit	Registered no other na	404402 6428854	1.50 Relia
32615	-04	No	No	No other Restrictions	od ed	Artefacts	atter Ar Deposit	Registered no other na	403317 6428377	1.50 Relia
32616	-03	No	No	No other Restrictions	od ed	Artefacts	atter Ar Deposit	Registered no other na	403046 6428302	1.50 Relia
32617	-06	No	No	No other Restrictions	od ed	Artefacts	atter Ar Deposit	Registered no other na	403112 6426496	1.50 Relia
32619	-02	No	No	No other Restrictions	od ed	Artefacts	atter Ar Deposit	Registered no other na	403470 6428279	1.50 Relia



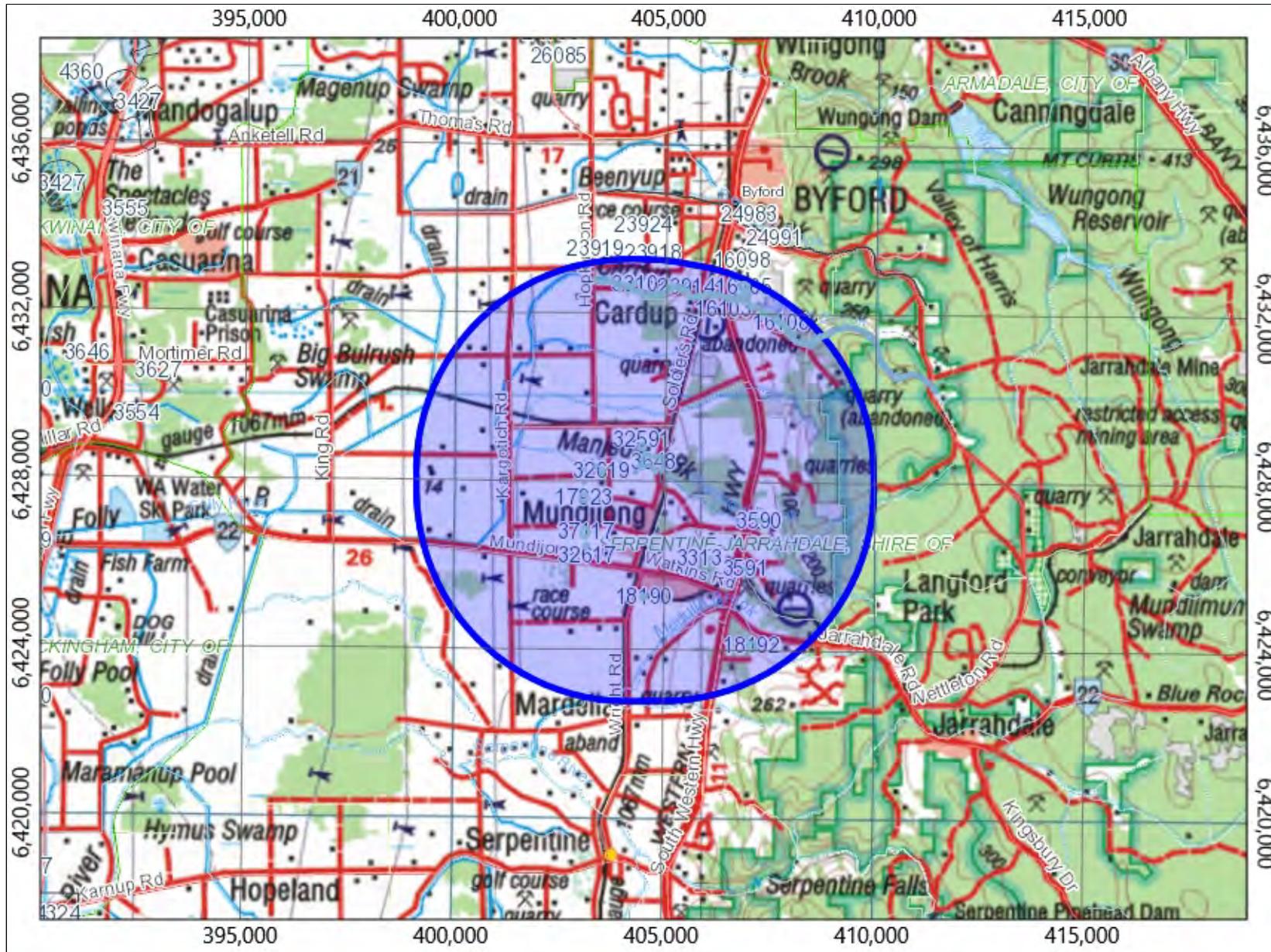
Original Heritage Register

List of Heritage Places

10.1.9 - attachment 1

For further information on this information please see the Department of Planning, Lands and Heritage's Disclaimer statement at <https://dpl.wa.gov.au/about-us/e-site>

ID	Name	Heritage Restricted	Boundary Restricted	Restrictions	Status	Category	Registered no	Registered e	Registered o	Registered l	Registered d	Registered e	Registered r	Registered D
37115	-09	No	No		od ed		Re istered no	lder na	es a	aila le	404263	6428245	N	
							fro	DAA			one 50	Relia	le	
37116	-08	No	No		od ed		Re istered no	lder na	es a	aila le	404730	6428251	N	
							fro	DAA			one 50	Relia	le	
37117	-07	No	No		od ed		Re istered no	lder na	es a	aila le	403071	6426813	N	
							fro	DAA			one 50	Relia	le	



- Legend
- Other Heritage Place
 - Search Area
 - Town
 - Road
 - River
 - Local Government Authority

Scale 1:164,000

Map scale 1:164,000

Scale 1:164,000



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Appendix D – Flora data

Flora species list

Site photographs

Flora likelihood of occurrence

Flora taxa recorded in the project during the 2018 and 2020 field surveys

Family	Taxon	Common Name	Status	2018	2020
Apocynaceae	<i>Gomphocarpus fruticosus</i>	Narrowleaf Cottonbush	*DP		x
Araceae	<i>Zantedeschia aethiopica</i>	Arum Lily	*DP	x	
Asparagaceae	<i>Asparagus asparagaceae</i>	Bridal Creeper	*DP		x
Asparagaceae	<i>Thysanotus dichotomus</i>	Branching Fringe Lily			x
Asteraceae	<i>Hypochaeris radicata</i>	Flat Weed	*		x
Casuarinaceae	<i>Allocasuarina fraseriana</i>	Sheoak			x
Colchicaceae	<i>Burchardia congesta</i>				x
Cucurbitaceae	<i>Citrullus amarus</i>		*		x
Cyperaceae	<i>Baumea juncea</i>	Bare Twigrush			x
Cyperaceae	<i>Lepidosperma</i> sp.			x	
Dilleniaceae	<i>Hibbertia hypericoides</i>	Yellow Buttercups			x
Fabaceae	<i>Acacia longifolia</i>		*		x
Fabaceae	<i>Acacia pulchella</i> var. <i>glaberrima</i>				x
Fabaceae	<i>Chamaecytisus palmensis</i>	Tagasaste	*		x
Fabaceae	<i>Jacksonia sternbergiana</i>	Stinkwood			x
Myrtaceae	<i>Agonis flexuosa</i>	Peppermint			x
Myrtaceae	<i>Corymbia calophylla</i>	Marri		x	x
Myrtaceae	<i>Corymbia citriodora</i>	Lemon-scented Gum	*Planted		x
Myrtaceae	<i>Corymbia maculata</i>	Spotted Gum	*Planted		x
Myrtaceae	<i>Eucalyptus ?lane-poolei</i>	Salmon White Gum	*Planted	x	
Myrtaceae	<i>Eucalyptus camaldulensis</i>	River Redgum	*Planted	x	
Myrtaceae	<i>Eucalyptus cladocalyx</i>	Sugar Gum	*Planted	x	x
Myrtaceae	<i>Eucalyptus marginata</i>	Jarrah		x	x
Myrtaceae	<i>Eucalyptus robusta</i>	Red Mahogany	*Planted		x
Myrtaceae	<i>Eucalyptus rudis</i>	Flooded Gum			x
Myrtaceae	<i>Eucalyptus</i> sp.		*Planted	x	x
Myrtaceae	<i>Kunzea glabrescens</i>	Spearwood			x
Myrtaceae	<i>Melaleuca preissiana</i>	Moonah			x
Myrtaceae	<i>Melaleuca raphiophylla</i>	Swamp Paperbark			x
Poaceae	<i>Briza maxima</i>	Blowfly Grass	*		x
Poaceae	<i>Bromus diandrus</i>	Great Brome	*		x
Poaceae	<i>Cenchrus clandestinus</i>	Kikuyu Grass	*	x	x
Poaceae	<i>Ehrharta calycina</i>	Perennial veldt Grass	*		x
Poaceae	<i>Eragrostis curvula</i>	African Lovegrass	*	x	x
Poaceae	<i>Lagurus ovatus</i>	Hare's Tail Grass	*		x
Proteaceae	<i>Banksia attenuata</i>	Slender Banksia			x
Proteaceae	<i>Banksia grandis</i>	Bull Banksia			x

Family	Taxon	Common Name	Status	2018	2020
Proteaceae	<i>Banksia littoralis</i>	Swamp Banksia			x
Proteaceae	<i>Banksia menziesii</i>	Firewood Banksia			x
Proteaceae	<i>Grevillea vestita</i>			x	x
Proteaceae	<i>Xylomelum occidentale</i>	Woody Pear		x	x
Restionaceae	<i>Desmocladius flexuosus</i>				x
Solanaceae	<i>Solanum nigrum</i>	Black Berry Nightshade	*	x	
Typhaceae	<i>Typha</i> sp.	Bulrush		x	
Xanthorrhoeaceae	<i>Xanthorrhoea preissii</i>	Grass Tree			x

Site Photographs

Photograph	Description
	<p>Parkland cleared – paddock dominated by <i>*Eragrostis curvula</i></p>
	<p>Parkland cleared – paddock dominated by <i>*Eragrostis curvula</i> and other weedy pasture grasses and herbaceous species with a row of planted trees (mostly white gums).</p>

Photograph	Description
 A photograph showing a cleared parkland area with several Jarrah trees (Eucalyptus marginata) standing in a grassy field. The trees have dark, gnarled trunks and dense green foliage. The ground is covered with dry grass and fallen branches.	<p>Parkland cleared – Remnant stands of Jarrah (<i>Eucalyptus marginata</i>) trees</p>
 A photograph showing a cleared parkland area with several Marri trees (Corymbia calophylla) standing in a grassy field. The trees have thick, dark, textured trunks and dense green foliage. The ground is covered with dry grass and fallen branches.	<p>Parkland cleared – Remnant stands of Marri (<i>Corymbia calophylla</i>) trees</p>

Photograph	Description
	<p>Pool of water dominated by <i>Lepidosperma</i> sp., <i>Typha</i> sp., and <i>Cenchrus clandestinus</i> situated in the northeast corner of the Project Area</p>
	<p>Photo taken from northeast corner of the Project Area facing a southwest direction over the pool of water dominated by weed species</p>

Photograph	Description
	<p>Degraded Melaleuca closed shrubland in the central part of the project area</p>
	<p>Degraded Jarrah/Marri/Allocasuarina in the northern part of the project area</p>

Photograph	Description
 A photograph of a rural landscape. In the foreground, there is a pile of brush and a large, dense, blue-green shrub. The middle ground shows a dry, yellowish field with a metal structure (possibly a well or pump) and a row of concrete pipes laid out on the ground. The background features a line of trees under a blue sky with scattered clouds.	<p>Current land use</p>

Flora likelihood of occurrence assessment guidelines

Likelihood of occurrence	Guideline
Known	Species recorded within study area from field survey results
Likely	Species previously recorded within 2 km and large areas of suitable habitat occur in the study area
Possible	Species previously recorded within 2 km and areas of suitable habitat occur/may occur in the study area
Unlikely	Species previously recorded within 2 km, but suitable habitat does not occur in the study area
Highly unlikely	Species not previously recorded within 2 km, suitable habitat does not occur in the study area and/or the study area is outside the natural distribution of the species
Other considerations	Intensity of the survey, availability of access, growth form type, recorded flowering times, cryptic nature of species

Flora likelihood of occurrence assessment for conservation significant flora

Family	Taxon	BC Act/ DBCA	EPBC Act	Description and closest record information (if available) (WA Herbarium 1998-, DAWE 2020)	Likelihood of occurrence	Search
Dasygongonaceae	<i>Calectasia cyanea</i>	T	CE	Rhizomatous, clump forming, woody perennial, herb, 0.1-0.6 m high, to 0.3 m wide. Fl. blue/purple, Jun to Oct. White, grey or yellow sand, gravel.	Highly Unlikely	NM
Proteaceae	<i>Synaphea</i> sp. Fairbridge Farm (D. Papenfus 696)	T	CE	Dense, clumped shrub, to 0.3 m high, to 0.4 m wide. Flowers yellow, Oct. Sandy with lateritic pebbles. Near winter-wet flats, in low woodland with weedy grasses.	Highly Unlikely	NM, EPBC
Proteaceae	<i>Synaphea</i> sp. Serpentine (G.R. Brand 103)	T	CE	Perennial, erect, clumped shrub to 60 cm high by 50 cm wide. Flowers yellow, Aug-Nov. Narrow geographic range from west of Byford to south of Serpentine. Grey, brown sandy loam or clay in seasonally wet areas (DPaW 2017).	Unlikely	NM , EPBC
Ericaceae	<i>Andersonia gracilis</i>	T	E	Slender erect or open straggly shrub, 0.1-0.5 m high. Flowers white-pink-purple from September to November. White/grey	Highly Unlikely	EPBC
Orchidaceae	<i>Caladenia huegelii</i>	T	E	Tuberous, perennial, herb, 0.25-0.6 m high. Fl. green & cream & red, Sep to Oct. Grey or brown sand, clay loam.	Unlikely	EPBC
Orchidaceae	<i>Diuris purdiei</i>	T	E	Tuberous, perennial, herb, 0.15-0.35 m high. Flowers yellow, Sep to Oct. Grey-black sand, moist. Winter-wet swamps.	Highly Unlikely	NM, EPBC

Family	Taxon	BC Act/ DBCA	EPBC Act	Description and closest record information (if available) (WA Herbarium 1998-, DAWE 2020	Likelihood of occurrence	Search
Orchidaceae	<i>Drakaea elastica</i>	T	E	Tuberous, perennial, herb, 0.12-0.3 m high. Flowers red & green & yellow, Oct to Nov. White or grey sand. Low-lying situations adjoining winter-wet swamps.	Highly Unlikely	NM, EPBC
Myrtaceae	<i>Eucalyptus x balanites</i>	T	E	(Mallee), to 5 m high, bark rough, flaky. Flowers white, Oct to Dec or Jan to Feb. Sandy soils with lateritic gravel.	Highly Unlikely	EPBC
Proteaceae	<i>Grevillea curviloba subsp. incurva</i>	T	E	Prostrate to erect shrub, 0.1-2.5 m high. Flowers white-cream, Aug to Sep. Sand, sandy loam. Winter-wet heath.	Highly Unlikely	EPBC
Malvaceae	<i>Lasiopetalum pterocarpum</i>	T	E	Open, multi-stemmed shrub (with distinctly winged fruit), to 1.2 m high. Flowers pink, Aug to Dec. Dark red-brown loam or clayey sand over granite. On sloping banks near creeklines.	Highly Unlikely	EPBC
Cyperaceae	<i>Lepidosperma rostratum</i>	T	E	Rhizomatous, tufted perennial, grass-like or herb (sedge), 0.5 m high. Flowers brown. Peaty sand, clay.	Highly Unlikely	NM
Proteaceae	<i>Synaphea</i> sp. Pinjarra Plain (A.S. George 17182)	T	E	Erect, clumped shrub (sub-shrub), to 0.8 m high. Flowers yellow, Sep to Nov. Grey sandy loam or clay, grey-brown clayey sand, brown clayey loam, laterite. Flats, seasonally wet areas, railroad reserves often with wet depressions or drains.	Unlikely	NM
Orchidaceae	<i>Thelymitra stellata</i>	T	E	Tuberous, perennial, herb, 0.15-0.25 m high. Flowers yellow & brown, Oct to Nov. Sand, gravel, lateritic loam.	Highly Unlikely	EPBC
Solanaceae	<i>Anthocercis gracilis</i>	T	V	Erect, spindly shrub, to 0.6(-1) m high. Flowers yellow-green, Sep to Oct. Sandy or loamy soils. Granite outcrops	Highly Unlikely	EPBC
Orchidaceae	<i>Diuris micrantha</i>	T	V	Tuberous, perennial, herb, 0.3-0.6 m high. Flowers yellow & brown, Sep to Oct. Brown loamy clay. Winter-wet swamps, in shallow water.	Highly Unlikely	EPBC
Orchidaceae	<i>Drakaea micrantha</i>	T	V	Tuberous, perennial, herb, 0.15-0.3 m high. Fl. red & yellow, Sep to Oct. White-grey sand.	Unlikely	EPBC
Cyperaceae	<i>Eleocharis keigheryi</i>	T	V	Rhizomatous, clumped perennial, grass-like or herb (sedge), to 0.4 m high. Flowers green, Aug to Nov. Clay, sandy loam. Emergent in freshwater: creeks, claypans.	Highly Unlikely	EPBC
Cyperaceae	<i>Tetralia australiensis</i>	T	V	Rhizomatous, tufted perennial, grass-like or herb (sedge), to 1 m high. Flowers brown, Nov to Dec.	Unlikely	NM
Hemerocallidaceae	<i>Johnsonia pubescens</i> subsp. <i>cygnorum</i>	P2		Tufted perennial, herb, 0.15-0.25 m high. Flowers white-green, Sep. Grey-white-yellow sand. Flats, seasonally-wet sites.	Unlikely	NM

Family	Taxon	BC Act/ DBCA	EPBC Act	Description and closest record information (if available) (WA Herbarium 1998-, DAWE 2020)	Likelihood of occurrence	Search
Asteraceae	<i>Millotia tenuifolia</i> var. <i>laevis</i>	P2		Ascending to erect annual, herb, 0.02-0.1 m high. Fl. yellow, Sep to Oct. Granite or laterite soils.	Unlikely	NM
Stylidiaceae	<i>Levenhookia pulcherrima</i>	P3		Annual (ephemeral), herb, 0.03-0.7 m high. Fl. pink-red, Oct to Nov. Sand.	Unlikely	NM
Asteraceae	<i>Angianthus drummondii</i>	P3		Erect annual, herb, to 0.1 m high. Flowers yellow, Oct to Dec. Grey or brown clay soils, ironstone. Seasonally wet flats.	Highly Unlikely	NM
Asteraceae	<i>Pithocarpa corymbulosa</i>	P3		Erect to scrambling perennial, herb, 0.5-1 m high. Flowers white, Jan to Apr. Gravelly or sandy loam. Amongst granite outcrops.	Highly Unlikely	NM
Cyperaceae	<i>Schoenus capillifolius</i>	P3		Semi-aquatic tufted annual, grass-like or herb (sedge), 0.05 m high. Flowers green, Oct to Nov. Brown mud. Claypans.	Highly Unlikely	NM
Cyperaceae	<i>Schoenus</i> sp. Waroona (G.J. Keighery 12235)	P3		Tufted annual, grass-like or herb (sedge), 0.02-0.06 m high. Flowers brown-red-green, Oct to Nov. Clay or sandy clay. Winter-wet flats.	Highly Unlikely	NM
Fabaceae	<i>Jacksonia gracillima</i>	P3		Spreading, compact shrub 100 cm high, to 100 cm wide. Standard orange with darker band near base, wings orange, keel darker orange. Buds very angular. Swan Coastal plain, winter wet Bassendean Sands. Littered, grey, peaty, loamy sand. Open Low Woodland B over Dense Heath B over Low Sedges (Muir 1977).	Highly Unlikely	NM
Myrtaceae	<i>Babingtonia urbana</i>	P3		Erect shrub up to 1.2 m with many slender branches and pink flowers. Brown clay loam, grey peaty sand over clay. Wetlands, seasonal damplands.	Unlikely	NM
Stylidiaceae	<i>Stylidium aceratum</i>	P3		Fibrous rooted annual, herb, 0.05-0.09 m high, leaves spathulate. Flowers pink/white, Oct to Nov. Sandy soils. Swamp heathland.	Highly Unlikely	NM
Myrtaceae	<i>Verticordia lindleyi</i> subsp. <i>lindleyi</i>	P4		Erect shrub, 0.2-0.75 m high. Flowers pink, May or Nov to Dec or Jan. Sand, sandy clay. Winter-wet depressions.	Highly Unlikely	NM

Appendix E – Fauna data

Fauna species list

Black cockatoo habitat trees

Fauna likelihood of occurrence

Fauna recorded during the 2018 and 2020 field surveys

Family	Taxon	Common Name	Status	2018	2020
Birds					
Cacatuidae	<i>Calyptorhynchus banksii naso</i>	Forest Red-tailed Black Cockatoo	Vu		x
Columbidae	<i>Phaps chalcoptera</i>	Common Bronzewing			x
Corvidae	<i>Corvus coronoides</i>	Australian Raven		x	x
Cracticidae	<i>Cracticus tibicen</i>	Australian Magpie		x	x
Dicruridae	<i>Grallina cyanoleuca</i>	Magpie-lark		x	x
Dicruridae	<i>Rhipidura leucophrys</i>	Willie Wagtail		x	x
Halcyonidae	<i>*Dacelo novaeguineae</i>	Laughing Kookaburra	*	x	
Meliphagidae	<i>Anthochaera carunculata</i>	Red Wattlebird		x	x
Meliphagidae	<i>Gavicalis virescens</i>	Singing Honeyeater			x
Psittacidae	<i>Cacatua roseicapilla</i>	Galah		x	x
Psittacidae	<i>Platycercus zonarius</i>	Australian Ringneck		x	x
Psittacidae	<i>Trichoglossus moluccanus</i>	Rainbow Lorikeet	*	x	x
Zosteropidae	<i>Zosterops lateralis</i>	Silvereye		x	x
Mammals					
Bovidae	<i>*Ovis aries</i>	Sheep	*	x	x
Canidae	<i>*Vulpes vulpes</i>	Red Fox	*	x	x
Felidae	<i>*Felis catus</i>	Cat	*	x	
Leporidae	<i>*Oryctolagus cuniculus</i>	Rabbit	*	x	x
Peramelidae	<i>Isoodon fusciventer</i>	Quenda/Southwestern Brown Bandicoot	P4	x	x
Amphibians					
Myobatrachidae	<i>Crinia insignifera</i>	Squelching froglet		x	

Results of the Black Cockatoo Habitat Assessment – Potential habitat trees

Tree Species	DBH (mm)	Hollows (#)	Hollow size	Feeding Evidence	Breeding Evidence	Roosting Evidence	Comment	Easting	Northing
Eucalyptus rudis	960	0	0	no	no	no		404161.10	6427828.65
Corymbia calophylla	710	0	0	yes	no	no	Old foraging evidence - Forest red-tailed black cockatoo	404193.09	6428058.45
Corymbia calophylla	540	0	0	yes	no	no	Old foraging evidence - Forest red-tailed black cockatoo	404194.29	6428059.76
Eucalyptus marginata	750	0	0	no	no	no		404186.07	6428108.79
Corymbia calophylla	700	0	0	no	no	no		404135.43	6428081.35
Corymbia calophylla	650	0	0	yes	no	no	Old foraging evidence - Forest red-tailed black cockatoo	404075.29	6428226.86
Corymbia calophylla	830	0	0	no	no	no		404076.22	6428238.20
Corymbia calophylla	730	0	0	no	no	no		404077.22	6428244.30
Corymbia calophylla	560	1	0	no	no	no		404070.35	6428250.78
Corymbia calophylla	680	2	0	no	no	no		404065.33	6428249.14
Corymbia calophylla	600	0	0	no	no	no		404066.68	6428244.43
Corymbia calophylla	730	1	Small	yes	no	no	Old foraging evidence	404110.66	6428229.88
Eucalyptus marginata	610	0	0	no	no	no		404118.11	6428270.74
Eucalyptus rudis	900	0	0	no	no	no		404118.73	6428284.47
Corymbia calophylla	590	0	0	yes	no	no	Old foraging evidence	404093.25	6428278.58
Eucalyptus rudis	650	0	0	no	no	no		404088.96	6428282.25
Eucalyptus marginata	650	0	0	no	no	no		404188.53	6428202.83
Corymbia calophylla	620	0	0	no	no	no		404232.15	6427829.89
Eucalyptus rudis	800	0	0	no	no	no		404249.94	6427827.86
Eucalyptus marginata	520	0	0	no	no	no		404279.46	6427844.61
Eucalyptus marginata	760	0	0	no	no	no		404275.35	6427859.04
Eucalyptus marginata	840	0	0	no	no	no		404319.29	6428166.91
Eucalyptus marginata	750	0	0	no	no	no		404313.75	6428202.22

Tree Species	DBH (mm)	Hollows (#)	Hollow size	Feeding Evidence	Breeding Evidence	Roosting Evidence	Comment	Easting	Northing
Eucalyptus marginata	940	0	0	no	no	no		404351.79	6428189.67
Eucalyptus marginata	710	0	0	no	no	no		404340.45	6428191.63
Corymbia calophylla	530	0	0	yes	no	no	Old foraging evidence	404436.82	6428191.54
Corymbia calophylla	530	0	0	yes	no	no	Old foraging evidence	404436.66	6428187.95
Corymbia calophylla	600	0	0	no	no	no		404468.85	6428207.49
Eucalyptus marginata	730	0	0	no	no	no		404590.78	6428208.40
Eucalyptus marginata	590	0	0	no	no	no		404640.28	6428212.59
Eucalyptus marginata	550	0	0	no	no	no		404668.54	6428199.57
Eucalyptus marginata	600	0	0	no	no	no		404681.32	6428194.63
Eucalyptus marginata	520	0	0	no	no	no		404690.71	6428198.21
Eucalyptus marginata	750	0	0	no	no	no		404704.73	6428196.90
Eucalyptus marginata	650	0	0	no	no	no		404717.99	6428198.22
Eucalyptus marginata	600	0	0	no	no	no		404716.98	6428199.61
Eucalyptus marginata	900	0	0	no	no	no		404741.69	6428209.26
Eucalyptus marginata	650	0	0	no	no	no		404748.90	6428200.01
Corymbia calophylla	970	0	0	no	no	no		404769.93	6428211.55
Corymbia calophylla	620	0	0	yes	no	no	Old foraging evidence	404796.97	6428196.71
Corymbia calophylla	680	0	0	yes	no	no	Old foraging evidence	404798.86	6428197.07
Corymbia calophylla	670	0	0	yes	no	no	Old foraging evidence	404800.93	6428197.85
Corymbia calophylla	560	0	0	no	no	no		404805.88	6428197.60
Corymbia calophylla	960	0	0	no	no	no		404821.67	6428198.74
Corymbia calophylla	570	0	0	no	no	no		404813.35	6428213.41
Corymbia calophylla	760	0	0	no	no	no		404818.99	6428212.61
Corymbia calophylla	680	0	0	no	no	no		404827.16	6428212.25
Corymbia calophylla	600	0	0	no	no	no		404830.47	6428214.12
Corymbia calophylla	680	0	0	yes	no	no	Old foraging evidence	404835.08	6428199.99

Tree Species	DBH (mm)	Hollows (#)	Hollow size	Feeding Evidence	Breeding Evidence	Roosting Evidence	Comment	Easting	Northing
Corymbia calophylla	820	0	0	yes	no	no	Old foraging evidence	404849.03	6428199.83
Corymbia calophylla	590	0	0	yes	no	no	Old foraging evidence	404846.36	6428215.00
Corymbia calophylla	730	0	0	yes	no	no	Old foraging evidence	404880.45	6428214.29
Corymbia calophylla	520	0	0	yes	no	no	Old foraging evidence	404885.19	6428216.47
Corymbia calophylla	650	0	0	no	no	no		404901.63	6428212.27
Corymbia calophylla	510	0	0	no	no	no		404906.85	6428201.05
Corymbia calophylla	510	0	0	no	no	no		404897.92	6428201.11
Eucalyptus marginata	900	3	Small to large	no	no	no	Partially stag and half regrowth	404380.86	6428125.95
Eucalyptus marginata	970	0	0	no	no	no		404380.51	6428099.68
Corymbia calophylla	900	0	0	yes	no	no	Old foraging evidence	404400.98	6427852.57
Eucalyptus marginata	540	0	0	no	no	no		404653.85	6428071.99
Eucalyptus marginata	730	0	0	no	no	no	Half trunk burnt out	404676.63	6428083.64
Eucalyptus marginata	900	0	0	no	no	no		404686.85	6428092.74
Eucalyptus marginata	545	0	0	no	no	no		404692.08	6428097.43
Eucalyptus marginata	680	0	0	no	no	no		404692.88	6428099.32
Eucalyptus marginata	660	0	0	no	no	no		404690.13	6428100.10
Eucalyptus marginata	830	0	0	no	no	no		404668.48	6428117.80
Eucalyptus marginata	530	0	0	no	no	no		404711.09	6428120.32
Eucalyptus marginata	760	0	0	no	no	no		404712.39	6428121.80
Eucalyptus marginata	750	0	0	no	no	no		404732.63	6428094.99
Eucalyptus marginata	730	0	0	no	no	no		404739.87	6428107.27
Eucalyptus marginata	660	0	0	no	no	no		404752.55	6428098.56
Eucalyptus marginata	520	0	0	no	no	no		404778.56	6428111.39
Eucalyptus marginata	880	0	0	no	no	no		404724.08	6428152.20
Eucalyptus marginata	545	0	0	no	no	no		404713.40	6428163.90

Tree Species	DBH (mm)	Hollows (#)	Hollow size	Feeding Evidence	Breeding Evidence	Roosting Evidence	Comment	Easting	Northing
Eucalyptus marginata	540	0	0	no	no	no		404754.14	6428184.80
Eucalyptus marginata	880	0	0	no	no	no		404794.60	6428173.22
Corymbia calophylla	805	0	0	yes	no	no	Recent foraging evidence - Forest red-tailed black cockatoo	404856.10	6428165.63
Corymbia calophylla	680	0	0	yes	no	no	Recent foraging evidence - Forest red-tailed black cockatoo	404861.20	6428162.21
Corymbia calophylla	755	2	Medium	yes	no	no	Potential hollows. Not sure how deep. Half dead branches. No chew marks	404871.46	6428144.24
Corymbia calophylla	720	0	0	yes	no	no	Potential roost trees. Lots of recent foraging - Forest red-tailed black cockatoo	404878.00	6428136.62
Corymbia calophylla	900	0	0	yes	no	no		404886.01	6428150.57
Corymbia calophylla	725	0	0	yes	no	no		404878.11	6428133.20
Corymbia calophylla	550	0	0	yes	no	no	Old foraging evidence	404880.59	6428185.39
Corymbia calophylla	510	0	0	yes	no	no		404881.19	6428187.60
Corymbia calophylla	525	0	0	yes	no	no	Fresh foraging evidence- Forest red-tailed black cockatoo	404888.10	6428188.14
Corymbia calophylla	630	0	0	yes	no	no		404887.79	6428187.06
Corymbia calophylla	500	0	0	yes	no	no		404892.61	6428194.10
Corymbia calophylla	590	0	0	no	no	no		404894.71	6428193.66

Parameters of fauna likelihood of occurrence assessment

Assessment outcome	Description
Present	Species recorded during the field survey or from recent, reliable records from within or close proximity to the survey area.
Likely	Species are likely to occur in the survey area where there is suitable habitat within the survey area and there are recent records of occurrence of the species in close proximity to the survey area. OR Species known distribution overlaps with the survey area and there is suitable habitat within the survey area.
Unlikely	Species assessed as unlikely include those species previously recorded within 5 km of the survey area however: There is limited (i.e. the type, quality and quantity of the habitat is generally poor or restricted) habitat in the survey area. The suitable habitat within the survey area is isolated from other areas of suitable habitat and the species has no capacity to migrate into the survey area. OR Those species that have a known distribution overlapping with the survey area however: There is limited habitat in the survey area (i.e. the type, quality and quantity of the habitat is generally poor or restricted). The suitable habitat within the survey area is isolated from other areas of suitable habitat and the species has no capacity to migrate into the survey area.
Highly unlikely	Species that are considered highly unlikely to occur in the survey area include: Those species that have no suitable habitat within the survey area. Those species that have become locally extinct, or are not known to have ever been present in the region of the survey area.

Fauna likelihood of occurrence assessment

Species Name	Status		Search	Description of habitat requirements	Likelihood
	BC Act/ DBCA	EPBC Act			
<i>Botaurus poiciloptilus</i> (Australasian Bittern)		En		The Australasian Bittern occurs mainly in densely vegetated freshwater wetlands and, rarely, in estuaries or tidal wetlands. The species favours foraging in tall, dense vegetation in shallow permanent or seasonal fresh water. In the southwest of Western Australia the Bittern is now largely confined to coastal areas especially along the south coast	Unlikely The Project Area does not provide key habitat for this species.

Species Name	Status		Search	Description of habitat requirements	Likelihood
	BC Act/ DBCA	EPBC Act			
				where it is found in beds of tall rush mixed with or near short fine sedge or open pools (Burbridge 2004). It also occurs around swamps, lakes, pools, rivers and channels fringed with lignum Muehlenbeckia, canegrass Eragrostis or other dense vegetation (Marchant & Higgins 1990). It occasionally ventures into areas of open water or onto banks.	
<i>Calidris ferruginea</i> (Curlew Sandpiper)		Cr, Mi, Ma	EPBC	Curlew Sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms. They are also recorded inland, though less often, including around ephemeral and permanent lakes, dams, waterholes and bore drains, usually with bare edges of mud or sand. They occur in both fresh and brackish waters. Occasionally they are recorded around floodwaters (DotE 2016).	Unlikely The Project Area does not provide key habitat for this species.
<i>Calidris ruficollis</i> (Red-necked Stint)	IA	Mi, Ma	NM	The Red-necked Stint can be found in fresh and saline water, but primarily in coastal regions (Nevill 2013). It is mostly found in areas including sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores. Occasionally they have been recorded on exposed or ocean beaches, and on stony or rocky shores, reefs or shoals. They also occur in saltworks and sewage farms; saltmarsh; ephemeral or permanent shallow wetlands near the coast or inland, including lagoons, lakes, swamps, riverbanks, waterholes, bore drains, dams, soaks and pools in saltflats. They have occasionally been recorded on dry gibber plains, with little or no perennial vegetation. It has been observed at the Nullarbor Plain, Reid, Stoke's Inlet, Grassmere Lake, Warden Lake, Dalyup and Yellilup Swamp, Swan River, Bengel Swamp, Guraga Lake, Wittecarra, Harding River, coastal Gascoyne, the Pilbara and the Kimberley (DotE 2016).	Highly Unlikely No suitable habitat present.

Species Name	Status		Search	Description of habitat requirements	Likelihood
	BC Act/ DBCAs	EPBC Act			
<i>Calyptorhynchus banksii</i> subsp. <i>naso</i> (Forest Red-tailed Black Cockatoo)	Vu	Vu	NM	Forest Red-tailed Black Cockatoo typically occurs in dense Jarrah (<i>Eucalyptus marginata</i>), Karri (<i>E. diversicolor</i>) and Marri (<i>Corymbia calophylla</i>) forests, however the species also occurs in a range of other forest and woodland types, including Blackbutt (<i>E. patens</i>), Wandoo (<i>E. wandoo</i>), Tuart (<i>E. gomphocephala</i>), Albany Blackbutt, Yate (<i>E. cornuta</i>), and Flooded Gum (<i>E. rudis</i>) (DSEWPaC, 2012). Habitats also tend to have an understorey of <i>Banksia</i> spp., <i>Persoonia</i> spp., <i>Allocasuarina</i> spp. The Forest Red-tailed Black Cockatoo generally nests in hollows in live or dead trees of marri, karri, wandoo, bullich, blackbutt, tuart and jarrah (DSEWPaC 2012).	Present The Project Area provides suitable foraging habitat and potential roosting and breeding habitat. This species is known to occur in the local area and evidence of feeding was observed on marri nuts within the Project Area.
<i>Calyptorhynchus baudinii</i> (Baudin's Cockatoo, White-tailed Long-billed Black Cockatoo)	En	En	NM	Baudin's Black Cockatoo occurs in high-rainfall areas, usually at sites that are heavily forested and dominated by Marri (<i>Corymbia calophylla</i>) and <i>Eucalyptus</i> species, especially Karri (<i>E. diversicolor</i>) and Jarrah (<i>E. marginata</i>). The species also occurs in woodlands of Wandoo (<i>E. wandoo</i>), Blackbutt (<i>E. patens</i>), Flooded Gum (<i>E. rudis</i>), and Yate (<i>E. cornuta</i>). Baudin's Black Cockatoo breeds in the Jarrah, Marri and Karri forests of the deep south-west in areas averaging more than 750 mm of rainfall annually. The range of the species extends from Albany northward to Gidgegannup and Mundaring (east of Perth), and inland to the Stirling Ranges and near Boyup Brook. Preferred roosts are in areas with a dense canopy close to permanent sources of water that provide the birds with protection from weather conditions (DSEWPaC, 2012).	Likely The Project Area provides suitable foraging and roosting habitat and potential breeding habitat for this species. The Project Area is located within the known foraging range for this species however it is outside of the currently documented breeding range for this species.
<i>Calyptorhynchus latirostris</i> (Carnaby's Cockatoo, White-tailed Short-billed Black Cockatoo)	En	En	NM	This species mainly occurs in uncleared or remnant native eucalypt woodlands and in shrubland or kwongan heathland dominated by Hakea, Dryandra, Banksia and Grevillea species. The species also occurs in forests containing Marri (<i>Corymbia calophylla</i>), Jarrah (<i>Eucalyptus marginata</i>) or Karri (<i>E. diversicolor</i>). Breeding usually occurs in the Wheatbelt region of Western Australia, with flocks moving to	Present The Project Area provides suitable foraging and roosting habitat and potential breeding habitat for this species. This species is known to occur in the local area and evidence of

Species Name	Status		Search	Description of habitat requirements	Likelihood
	BC Act/ DBCAs	EPBC Act			
				the higher rainfall coastal areas to forage after the breeding season. Feeds on the seeds of a variety of native plants, including Allocasuarina, Banksia, Dryandra, Eucalyptus, Grevillea and Hakea, and some introduced plants (DSEWPaC, 2012).	feeding was observed on marri nuts within the Project Area. The project Area is located within the known breeding range for this species.
<i>Falco peregrinus</i> (Peregrine Falcon)	OS		NM	The Peregrine Falcon is seen occasionally anywhere in the southwest of WA. It is found everywhere from woodlands to open grasslands and coastal cliffs - though less frequently in desert regions. The species nests primarily on ledges of cliffs, shallow tree hollows, and ledges of building in cities. (Morcombe, 2004).	Likely The Project Area provides suitable habitat for this species. The species is known from the area with the closest known record approximately 1 km east of the Project Area, along the creek system that abuts the Project Area.
<i>Hydroprogne caspia</i> (Caspian Tern)	IA	Mi, Ma	NM	The Caspian Tern is mostly found in sheltered coastal embayments (harbours, lagoons, inlets, bays, estuaries and river deltas) and those with sandy or muddy margins are preferred. They also occur on near-coastal or inland terrestrial wetlands that are either fresh or saline, especially lakes (including ephemeral lakes), waterholes, reservoirs, rivers and creeks. They also use artificial wetlands, including reservoirs, sewage ponds and saltworks. In offshore areas the species prefers sheltered situations, particularly near islands, and is rarely seen beyond reefs. In WA, the Caspian Tern is widespread in coastal regions, from the Great Australian Bight to the Dampier Peninsula (DotE 2016).	Unlikely The Project Area does not provide key habitat for this species.
<i>Leipoa ocellata</i> (Malleefowl)	Vu	Vu	EPBC	The Malleefowl generally occurs in semi-arid areas of WA, from Carnarvon to south east of the Eyre Bird Observatory (south-east WA). It occupies shrublands and low woodlands that are dominated by mallee vegetation, as well as native pine (<i>Callitris</i> spp.) woodlands, Acacia shrublands, Broombush (<i>Melaleuca uncinata</i>) vegetation or coastal heathlands. The nest is a large mound of sand or soil and	Highly unlikely This species is considered to be locally extinct.

Species Name	Status		Search	Description of habitat requirements	Likelihood
	BC Act/ DBCA	EPBC Act			
				organic matter (Jones and Goth 2008; Morcombe, 2004). Few records are present on the SCP and are historical observations.	
<i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew)	Vu, IA	Cr, Mi	EPBC	The Eastern Curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass. Occasionally, the species occurs on ocean beaches (often near estuaries), and coral reefs, rock platforms, or rocky islets. The birds are often recorded among saltmarsh and on mudflats fringed by mangroves, sometimes within the mangroves, and in coastal saltworks and sewage farms (Marchant & Higgins 1993). They are found commonly along the north coast of WA, but rarely south of Shark Bay (Morcombe 2004). They are uncommon further south of Geraldton (Nevill 2013).	Highly Unlikely No suitable habitat present.
<i>Rostratula australis</i> (Australian Painted Snipe)	En	En	EPBC	The Australian Painted Snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. Typical sites include those with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire; often with scattered clumps of lignum Muehlenbeckia, canegrass, or sometimes tea-tree. It sometimes uses areas that are lined with trees, or that have some scattered fallen or washed-up timber (DotE 2016). In the south west it can be found around Carnarvon and wetlands north of Perth, particularly those west of Moora and Gingin (Nevill 2013).	Highly Unlikely Limited suitable habitat within the Project Area. This species is generally known to occur north of Perth.
<i>Euoplos inornatus</i> (inornate trapdoor spider (northern Jarrah Forest))	P3		NM	No information available.	Unlikely There are only 17 known records of this species, with the closest known record approximately 2 km east of the

Species Name	Status		Search	Description of habitat requirements	Likelihood
	BC Act/ DBCAs	EPBC Act			
					Project Area (2006). No information is available for this species but given the highly degraded nature of the Project Area it is unlikely this species is present.
<i>Idiosoma sigillatum</i> (Swan Coastal Plain shield-backed trapdoor spider)	P3			<i>Idiosoma sigillatum</i> has a relatively widespread although strictly bioregion- and substrate-specific distribution along the SCP of south-western WA, from Dalyellup north to at least Ledge Point (including Rottnest Island and Garden Island). The eastern limit of its range along the sandy foothills of the Darling Escarpment, from Boyanup north to at least Gingin. <i>Idiosoma sigillatum</i> is the dominant idiopid trapdoor spider on the SCP, with a previously ubiquitous distribution throughout the Greater Perth region, where it can still be found in remnant habitats (e.g., Kings Park, Bold Park, and Shenton Park bushland). Burrows of this species usually occur in Banksia woodland and heathland on sandy soils, and are adorned with a typical 'moustache-like' arrangement of twig-lines.	Unlikely No suitable habitat present in the project area.
<i>Westralunio carteri</i> (Carter's Freshwater Mussel)	Vu	Vu	NM	<i>Westralunio carteri</i> is a species of Freshwater mussel that is endemic to the southwest of Western Australian.	Highly unlikely There are no permanent watercourses within the Project Area, therefore there is no suitable habitat present for this species.
<i>Bettongia penicillata</i> subsp. <i>ogilbyi</i> (Woylie, Brush-tailed Bettong)	Cr	En	NM, EPBC	Preferred habitat for the Woylie includes dense undergrowth, logs and rock-cavities and occasionally in burrows (Burbidge 2004). Scattered Woylie populations may be found throughout the Jarrah forest in the south-west corner of WA. Extant naturally occurring populations of the species are restricted to three small wheatbelt reserves in WA – Dryandra Woodland, Tutanning Nature Reserve and	Unlikely The Project Area occurs in an area where the species or species habitat is likely to occur (DEE 2018). There are no confirmed records of this species within 20 km of the

Species Name	Status		Search	Description of habitat requirements	Likelihood
	BC Act/ DBCAs	EPBC Act			
				Perup Forest. All are characterised by the presence of thickets of the plant <i>Gastrolobium</i> (Van Dyck and Strahan 2008). The species historically occurred in a wide variety of habits, however is now restricted to areas where predation has been controlled (or excluded).	Project Area. Given the cleared and highly degraded nature of the Project Area it is considered unlikely for this species to be present.
<i>Dasyurus geoffroii</i> (Chuditch, Western Quoll)	T	V	NM, EPBC	The Chuditch inhabits eucalypt forest (especially Jarrah, <i>Eucalyptus marginata</i>), dry woodland and mallee shrublands. In Jarrah forest, Chuditch populations occur in both moist, densely vegetated, steeply sloping forest and drier, open, gently sloping forest. Most diurnal resting sites in sclerophyll forest consist of hollow logs or earth burrows (Van Dyke & Strahan, 2008). The species can travel large distances, has a large home range and is sparsely populated through a large portion of its range.	Unlikely This species requires large areas of connected habitat to persist. The habitat in the Project Area is not considered key habitat for this species given it is predominantly cleared and lacking an understorey. However, there are a number of records of this species within 10 km of the Project Area, with the closest less than 2 km north. There is potential for this species to occur opportunistically within the Project Area as a number of fauna habitat corridors, including a creekline occur adjacent to the Project Area.
<i>Isoodon fusciventer</i> (Quenda, southwestern brown bandicoot)	P4		NM	The Quenda prefers dense scrubby, often swampy, vegetation with dense cover up to one metre high. However, it also occurs in woodlands, and may use less ideal habitat where this habitat occurs adjacent to the thicker, more desirable vegetation. The species often feeds in adjacent forest and woodland that is burnt on a regular basis and in areas of pasture and cropland lying close to dense cover (Van Dyck and Strahan, 2008).	Present Diggings attributed to the Quenda was observed within the Project Area during the survey. Given the lack of understorey species, it is likely this species inhabits nearby bushland reserves and may

Species Name	Status		Search	Description of habitat requirements	Likelihood
	BC Act/ DBCA	EPBC Act			
					utilise the Project Area for foraging.
<i>Phascogale tapoatafa</i> subsp. <i>wambenger</i> (South-western Brush-tailed Phascogale, Wambenger)	OS		NM	The South-western Brush-tailed Phascogale prefers dry sclerophyll forests and open woodlands with a generally sparse ground-storey, which contain suitable nesting resources such as tree hollows, rotted stumps and tree cavities (Van Dyck and Strahan, 2008). The species range extends from just north of Perth and into the south west (Van Dyck and Strahan, 2008).	Unlikely The jarrah and marri trees may provide some habitat for this species, particularly given their close proximity to a creekline which provides a fauna corridor in an area which has been significantly cleared. The closest known record is approximately 4 km south-west of the Project Area (2003). However, given the cleared and highly degraded nature of the Project Area, the remaining vegetation is not considered significant habitat for this species.
<i>Pseudocheirus occidentalis</i> (Western Ringtail Possum, ngwayir)	Cr	Vu	NM, EPBC	The Western Ringtail Possum occurs in and near coastal Peppermint Tree (<i>Agonis flexuosa</i>) forest and Tuart (<i>Eucalyptus gomphocephala</i>) dominated forest with a Peppermint Tree understorey from Bunbury to Albany. Also occurs in Jarrah (<i>Eucalyptus marginata</i>) forest and Jarrah-Marri (<i>Corymbia calophylla</i>) forest associated with Peppermint Tree (Van Dyck and Strahan, 2008).	Highly unlikely The species is not known from the Swan Coastal Plain north of Mandurah.
<i>Setonix brachyurus</i> (Quokka)	Vu	Vu	NM, EPBC	The Quokka prefer dense forests and thickets, streamside vegetation, heaths and shrublands of <i>Agonis linearifolia</i> -dominated swamps in the Jarrah forest. The northern extent of the current distribution on the mainland is in the Jarrah forest immediately south-east of the Perth metropolitan area, to southward through the southern Jarrah, Marri and Karri forests to the south coast, but largely confined	Unlikely The species is considered to be locally extinct on the Swan Coastal Plain however there are some recent records (2011) from the nearby Darling Ranges in Mundaring (within 10-15

Species Name	Status		Search	Description of habitat requirements	Likelihood
	BC Act/ DBCA	EPBC Act			
				throughout to areas receiving an annual rainfall of 1,000 millimetres or more (Van Dyck and Strahan, 2008).	km).Given the cleared and degraded nature of the Project it is considered unlikely for this species to be present.

ANNEXURE 6
Geotechnical Investigation
Brown Geotechnical

PRELIMINARY GEOTECHNICAL INVESTIGATION

For a LOCAL STRUCTURE PLAN

**LOTS 10–14, 50 & 101
KEIRNAN STREET
MUNDIJONG
WESTERN AUSTRALIA**

**FEBRUARY 2020
Ref: 19061.1**

**FOR
DJM MUNDIJONG PTY LTD**



Brown Geotechnical

CONDITIONS RELATING TO THIS REPORT

1. This report has been prepared for the sole use of DJM Mundijong Pty Ltd. It has been issued in accordance with the agreed terms and scope detailed in the proposal for the investigation. No responsibility or liability to any third party is accepted for any damages arising out of the use of this report.
2. This report has been prepared by suitably qualified and experienced personnel for the purposes stated herein. Every care is taken with the report as it relates to interpretation of sub-surface conditions, discussion of findings and recommendations given. No responsibility for the consequences of extrapolation by others is accepted by the company.
3. Findings and conclusions produced in the report are based on the investigation of the sub-surface through isolated locations. Conditions between investigated sites are based on extrapolation, interpretation and professional estimates. Unexpected variations in ground conditions often occur which cannot always be anticipated. The conclusions and recommendations in the report were considered accurate at the time of issue and based on certain assumptions at the time. Conditions and assumptions change with time and may affect the accuracy of the report.
4. Certain content within this report is based on information provided by the client and/or other parties and the accuracy of this information cannot be guaranteed.
5. These conditions must be read as part of the report and must be reproduced with all future copies.
6. The recommendations of this report should be considered a starting point. Recommendations should be continuously reviewed during the earthworks stage as sub-surface information and results from monitoring become available. It is strongly recommended that the Company be retained to provide consultancy and/or inspections during the earthwork stages.

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Appendix B	Test Hole Logs
Appendix C	Perth Sand Penetrometer Plots
Appendix D	Laboratory Test Certificates

1 Introduction

In November 2018 Brown Geotechnical was commissioned by Peter Webb & Associates on behalf of the client – DJM Mundijong Pty Ltd to undertake a preliminary geotechnical investigation for the development of a Local Structure Plan at Lots 11, 12, 13 and 14 Keirnan Street, Mundijong. This was followed by a request by Peter Webb & Associates in December 2019 to extend the investigation to cover Lots 10, 50 and 101. This report presents the results of both investigations conducted at the site. Fieldwork commenced at Lots 11, 12, 13 and 14 on 16th November 2018, followed by the fieldwork for Lots 10, 50 and 101 on 21 January 2020. Details of the proposed development were supplied by planners Peter Webb & Associates.

Note: It should be noted that this is a preliminary geotechnical investigation for the development of a Local Structure Plan. In portions of the site where soils are non-homogenous, or where boundaries lines are drawn on Figures, for example between zones of different soil types or site classification, additional investigation should be undertaken. The conclusions in this report are based on limited sampling and testing, and should be used as starting point for further detailed investigations as the project proceeds.

2 Brief

The brief discussed with the planners required the report to address:

- Subsurface conditions,
- The presents of uncontrolled fill,
- The existing soil classification,
- Any earthworks required to obtain a classification suitable for development - including estimated additional fill sand required,
- Estimated CBR for road pavement design, parameters for retaining wall design,
- Suitability of existing soils for use in the development,
- Estimated blending ratios of screened topsoil,
- Soil permeability within proposed drainage basins as indicated on the preliminary concept plan supplied (Appendix A)
- Drainage issues.

Some test holes were requested along the degraded stream channel to 3m, but collapse or hard digging restricted the depth obtained in some cases.

3 Desk Studies

The site covers approximately 36ha and consists of six large paddocks. Five of the paddocks being approx. 4ha each and Lot 50 being 11.67ha. Lang Road Reserve and the eastern portion of Lot 101 are both approx. 2ha.

The paddocks are mostly grass covered with some areas of trees. A dried-up stream channel trending east to west crosses the southern and central portion of the site. The only existing residence and outbuildings are on Lot 10.

The geological map for the area [2] shows the site to be underlain by the Guildford Formation consisting of clay, sand, silt and gravels, with the Bassendean Sands Formation concentrated towards the centre and west.

The Perth Groundwater Map [3] does not quite cover the site but indicates minimum groundwater levels (approx. 400m to the west) to be 1.7m below ground level, and historical maximum levels (approx. 2km north) to be about 1m below ground level. The terrain and ground levels at these locations are fairly similar to the site under investigation. It is understood that pre-development groundwater monitoring is currently being carried out on the site by others.

The site is relatively level, with the ground level rising gently from 31m AHD along the western boundary to 39m AHD in the east.

4 Fieldwork and Laboratory Testing

4.1 Scope of Work

As detailed in the Brown Geotechnical proposal, the following scope of work was undertaken:

- Tests holes excavated for soil descriptions, extending to 3m depth along the surface water feature.
- Groundwater levels noted in test holes.
- Perth sand penetrometer (PSP) tests to determine soil density in sands.
- Collection of soil samples for laboratory testing to determine geotechnical properties of the soils.
- Topsoil testing to determine possible blending ratio with clean sand fill.
- In-situ permeability testing carried out to determine the drainage characteristics of soils and in the proposed drainage basins.

Test locations are shown on Figure 1, with test hole logs enclosed in Appendix B and PSP plots in Appendix C.

4.2 Laboratory Testing

Soil samples were delivered to the NATA accredited Liquid Labs WA and Western Geotechnical Laboratory Services for geotechnical testing. The laboratory test certificates are presented in Appendix D.

5 Geotechnical Results

5.1 Subsurface Condition

Subsurface conditions encountered in the test holes and inferred from laboratory test results and PSP plots are described as follows:

5.1.1 Topsoil and Fill

Test holes encountered topsoil consisting of grey silty sand with organics, locally with tree roots. The topsoil varied in thickness from 0.05m to 0.2m, the average across the site being 0.1m.

No uncontrolled fill was encountered in test holes and there were no obvious signs of old structures, foundations or infill areas within the paddocks, apart from the existing residence and outbuildings on Lot 10.

5.1.2 Sand

Medium grained, sand with moderate to low silt content was encountered in all test holes below the topsoil. Penetrometer tests show the material to be medium dense, generally becoming dense below about 1.5m. The thickness varied from approximately 0.5m along the southern boundary to over 2m where the clayey soil was absent in the centre and south west, (refer Figure 2). The silt content decreases slightly with depth and reduces to less than 5% in the central and north west portion of the site.

5.1.3 Sandy Gravel with Clay

Very dense, fine to medium grained sandy gravel with clay was encountered below the sand in the southern third and the north east corner of the site (refer Figure 2). Test results show the material to have a moderate to low fines content, intermediate to low plasticity with a low expansive nature. The material often became hard after about 1m due to pockets of iron rich cementation resulting in slow excavation and occasionally caused refusal of the 5 tonne excavator. This was particularly noticeable in TH13 and TH14 along the dry stream bed.

5.1.3 Clayey Sand with Gravel

The sandy gravel often transitioned into a clayey sand with gravel after approximately 1m. The transition was usually gradual, with the gravel content decreasing with depth. Test results show the material to have a moderate fines content, intermediate to low plasticity with a low expansive nature. The material was seen directly below the sand at a depth of about 1.5m in portions of the western site (refer Figure 2).

5.1.4 Groundwater

Groundwater was encountered in most test holes. Groundwater depths and reduced levels are shown in Table 1. Ground levels have been taken from a site feature survey supplied by the client. Groundwater levels for TH24 to TH44 would be expected to be slightly lower as the investigation was carried out in January, two months later and in to the drier months.

Table 1 - Groundwater Depth

Location	Groundwater Depth (m BGL)	Ground Level (m AHD)	Groundwater Level (m AHD)
TH01	2.2	37.8	35.6
TH02	1.2	36.4	35.2
TH03	1.7	36.6	34.9
TH04	dry	-	-
TH05	dry	-	-
TH06	dry	-	-
TH07	dry	-	-
TH08	1.4	39.1	37.7
TH09	1.3	39.3	38.0
TH10	1.5	39.9	38.4
TH11	1.6	39.1	37.5
TH12	1.6	38.5	36.9
TH13	0.6	37.1	36.5
TH13a	1.2	37.6	36.4
TH13b	1.2	37.6	36.4
TH14	0.7	37.4	36.7
TH15	dry	-	-
TH16	1.8	38.1	36.3
TH17	1.8	38.0	36.2
TH18	1.6	37.6	36.0
TH19	1.6	35.3	33.7
TH20	1.4	35.2	33.8
TH21	1.1	36.0	34.9
TH22	0.6	35.8	35.2
TH23	1.0	35.3	34.6
TH27	2.0	31.3	29.3
TH28	1.9	31.3	29.4
TH32	1.9	32.6	30.7
TH36	2.4	35.2	32.8
TH37	1.9	33.4	31.5
TH40	2.4	34.9	32.5
TH43	2.3	34.6	32.3

The maximum groundwater level encountered was 0.6m below ground level (bgl) in the bed of the dried-up stream, at 36.5mAHD in TH13 and 35.2mAHD in TH22.

The highest groundwater level with respect to Australian Height Datum was at 38.4mAHD in TH10 at the south east corner of the site (1.5m bgl). Groundwater levels decreased to the north and north west. Much of the western portion was dry to over 2m.

The approximate hydraulic gradient is to the west north west. Groundwater levels at test hole locations are shown on Figure 3.

5.2 Laboratory Test Results

Laboratory test results are summarized in Table 2 and 3.

Table 2 – Classification Test Results

Test Hole No.	Depth (m)	LL (%)	PL (%)	PI (%)	Particle Size Distribution					MMDD (t/m ³)	CBR (%)
					Fines (%)	Sand			Gravel (%)		
						Fine (%)	Medium (%)	Coarse (%)			
TH02	1.0-1.5	32	16	16	21	14	43	10	12	-	-
TH04	0-0.15	NP	NP	NP	4	96			0	-	-
TH05	0.3-1.0	NP	NP	NP	12	10	60	18	0	1.93	25
TH07	0.3-0.9	46	17	29	13	7	20	7	53	-	-
TH10	0-0.15	NP	NP	NP	5	95			0	-	-
TH15	0.3-1.0	NP	NP	NP	3	17	70	10	0	1.68	25
TH16	0-0.1.0	NP	NP	NP	3	97			0	-	-
TH19	0.5-1.5	NP	NP	NP	4	14	72	10			
TH23	0-0.2	NP	NP	NP	6	94			0	-	-
TH25	0.5-1.5	NP	NP	NP	6	8	75	11	0	-	-
TH30	1.9-2.1	24	11	13	17	73			**10	-	-
TH36	0.3-1.0	NP	NP	NP	10	10	73	7	0	1.92	45
TH37	0-0.15	NP	NP	NP	8	92			0	-	-

*Non-plastic **Field estimate

Table 3 – Topsoil Test Results

Test Hole No.	Depth	Organic Content (%)	Ash Content (%)	Blending Ratio Topsoil : Clean Sand
TH04	0.0 to 0.15m	1.9	98.1	1:1
TH10	0.0 to 0.15m	3.2	96.8	1:1
TH16	0.0 to 0.1m	2.2	97.8	1:1
TH23	0.0 to 0.2m	5.2	94.8	1:2
TH37	0.0 to 0.15m	8.2	91.8	1:3

*Tests conducted with grass roots removed

5.3 Soil Permeability

Permeability test results are summarized in Table 4.

Table 4 – Permeability Test Results

Test Location	Testing Material	In-situ Permeability Test Result (m/s)	Drainage Characteristics
P1 (TH15)	Medium dense sand trace silt	*1x10 ⁻³ m/s	Good
P2 (TH06)	Medium dense sand with silt	7x10 ⁻⁴ m/s	Good
P3 (TH19)	Medium dense sand trace silt	*1x10 ⁻³ m/s	Good
P4 (TH02)	Dense clayey sand	**1x10 ⁻⁹ m/s	Poor
P5 (TH25)	Medium dense sand with silt	5.5x10 ⁻⁴ m/s	Good
P6 (TH39)	Medium dense sand with silt	6.5x10 ⁻⁴ m/s	Good
P7 (TH36)	Medium dense sand with silt	7.2x10 ⁻⁴ m/s	Good

*Estimated: Falling head test. Water level dropped faster than readings could be taken.

**Estimated: Minimal Soakage

6 Analysis and Conclusions

6.1 Subsurface Conditions

The topsoil has an average thickness of 0.1m. Once the grass and roots are removed the topsoil is relatively low in organic content. It should be suitable for use as engineering fill when screened and blended with clean sand fill at a ratio of approximately 1:2 to 1:3 (screened topsoil : clean sand). Further testing following screening could bring the ratio down to 1:1 for some portions of the site.

Below the topsoil, the site is covered by at least 0.6m of medium grained sand with silt. The silt content is about 8-12%. The sand is cohesionless and drainage characteristics are good. The silt content decreases to less than 5% in the central and north west (refer Figure 2).

The sand is underlain by a clayey subgrade across the southern third of the site, in the north east corner and portions of the west. The material consists of dense clayey sand and / or sandy gravel with clay to at least 2.0m. The soils have a moderate to low plastic fines content, an intermediate to low plasticity and a low expansive nature. The drainage in the clayey soils are poor. The sandy gravel with clay often becomes hard with iron cementation below about 1.2m which caused refusal of the 5 tonne excavator in some holes at around 1.6m to 2m.

No uncontrolled fill was encountered in test holes.

With respect to the desk study and geological information obtained prior to the fieldwork, it appears that the Bassendean Sand Formation is not only present in the centre of the site, but also extends across to the north western and south western areas to at least 2m depth.

6.2 Groundwater

Groundwater was encountered across most of the site in the November investigation (TH01-TH23), except along the northern boundary where test holes were dry to over 2m depth. The depth to groundwater on average was about 1.5m below the existing surface, except along the dried stream bed where it was noted at 0.6m depth. In the January investigation (TH24-TH44) groundwater were noticeably lower and as only encountered along the lower areas in the degraded stream channel. Groundwater depths at test holes and the approximate hydraulic gradient for the site are shown in Figure 3.

The Perth Groundwater Map does not quite cover the site, but it shows minimum groundwater levels (approx. 400m to the west) to be 1.7m below ground level, and historical maximum levels (approx. 2km north) to be about 1m below ground level. The terrain and ground levels at these locations are fairly similar to this site.

6.3 Degraded Surface Water Channel

The degraded channel was dry during the fieldwork. November test holes carried out in and adjacent to the stream bed encountered groundwater to within 0.6m of the surface. TH2 and TH10 were the only test holes to obtain the required depth of 3m, with clayey sand at the base. The remaining test holes either collapsed due to water ingress (TH22) or encountered an iron rich cemented layer at about 1.5m (TH13 and TH14). Additional test holes 5m north and south of TH13, (TH13a and TH13b) broke through the cemented layer which proved to be about 0.25m thick. The groundwater appeared to be perching on the cemented layer.

6.4 Site Classification and Fill Requirements

Based on this preliminary geotechnical investigation, test hole spacing and limited testing, the classification for the site in accordance with AS 2870 – 2011 can be divided in to two classes. The portion underlain by a clayey subgrade with moderate to low plastic fines content, low plasticity and low expansive nature within 1.8m of the surface has an existing classification of Class 'S'. The portion underlain by sand in excess of 1.8m thick has an existing classification of Class 'A' (refer Figure 2 and Table 5).

To obtain a site classification of Class 'A' in all areas, additional sand fill will be required. The thickness of additional fill varies from 0.5m to 1.1m and is shown on Figure 2.

Further investigation will be required to determine the exact boundaries between the site classification zones for specific Lots. The amount of sand fill required may also vary.

Table 5 – Definition of Site Classifications (Australian Standard AS2870-2011)

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement for moisture changes ($y_s < 20\text{mm}$).
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes ($y_s 20\text{-}40\text{mm}$).
H1	Highly reactive clay site, which can experience moderate to high ground movement from moisture changes ($y_s 40\text{-}60\text{mm}$)
H2	Highly reactive clay site, which can experience high ground movement from moisture changes ($y_s 60\text{-}75\text{mm}$)
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes ($y_s > 75\text{mm}$)
P	Sites which include: soft soils, such as soft clays or silts or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

y_s : Characteristic Surface Movement

6.5 Earthworks

6.5.1 Introduction

All earthworks should be undertaken in accordance with AS3798-1996 “Guidelines on earthworks for commercial and residential developments” [4]. This section should act as a guide to likely earthwork requirements for the site, pending a detailed investigation.

6.5.2 Topsoil and Fill Management

A thin layer of topsoil is present across the site. It is not suitable for foundation support and should be removed along with trees and roots then replaced with clean sand fill. The topsoil may be used in landscaping following the removal of any tree roots, unless screened and blended as described below. A geotechnical inspection will be required to confirm topsoil stripping.

6.5.1 Blending of Topsoil for use as Engineering Fill

Topsoil in most areas of the site appears to be of lower quality i.e. lower in organic and fines content. An option would be to blend the screened topsoil with clean sand fill to reduce the organic and fines content to acceptable levels for use in residential or commercial development. Limited testing on non-screened topsoil, but with grass and roots removed, suggest a ratio of approximately 1:2 to 1:3 (screened topsoil : clean sand) to be appropriate. Further testing following screening could bring the ration down to 1:1 for portions of the site.

Ongoing tests for organic and fines content would be required post screening and on the blended soil to confirm suitability for use in the development.

6.5.2 Proof Rolling

Following the removal of topsoil, prior to footing placement or placing any additional fill on site, the surface should be proof rolled to achieve at least 95% SMDD for residential and 98% SMDD for commercial developments.

6.5.3 Imported Fill Material

Any sand fill imported to obtain site formation levels should be compacted in layers not more than 300mm thick to at least 95% SMDD for residential and 98% SMDD for commercial developments. In-situ density tests should be carried out to calibrate a PSP to specific densities of the compacted material to check fill compaction. Moisture conditioning (wetting) of the sand may be required to optimise compaction. Imported sand should ideally contain less than 5% non-plastic fines to maintain good drainage conditions.

Following excavation for foundations, the bases of pad and strip footings should also be compacted to achieve at least 95% SMDD for residential and 98% SMDD for commercial developments.

6.5.4 Earthwork Inspections

A geotechnical engineer should inspect the site following the removal of vegetation, trees, roots and unsuitable materials, and to confirm the compaction of the subsurface following proof rolling. Inspections and auditing of the earthworks should be carried out by a geotechnical engineer to enable confirmation of the final site classification.

6.6 Suitability of In-situ Soils as Engineering Fill

The majority of the in-situ sands, particularly in the central and north western area, contain low fines content and zero plasticity. The soils will be suitable for use as engineering fill in the future development.

The sand with silt overlying the clayey soils are also suitable for use as engineering fill, however the slightly higher silt content may influence permeability following proof rolling and compaction. Blending with sand of lower fines content may be required after further testing.

The sandy gravel with clay could also be blended with clean sand to reduce the fines. The material may be appropriate as a base layer above the existing clayey sand if major earthworks are required and removal of the existing sand is necessary.

6.7 Design CBR

Assuming the subgrade material below the road pavement or car park areas will be the natural in-situ near surface sand, testing indicates a design CBR of 25 is suitable pavement design. Pavements founded within imported sand fill will require CBR testing during earthworks.

6.8 Retaining Wall Parameters

The site is gently sloping to the west and some retaining maybe required in the development. The following retaining wall parameters have been based on a compacted dense sand soil with $\phi=40^\circ$.

$$\gamma=19 \text{ kN/m}^3$$

$$K_o=0.36$$

$$K_a=0.22$$

$$K_p=4.6$$

The parameters detailed above assume design of the retaining structure and compaction of the foundations are in accordance with AS 4678-2002 [5], and that backfill material is composed of clean cohesionless sand.

6.9 Site Permeability and Drainage Recommendations

The in-situ sands contain moderate to low fines, zero plasticity and are free draining. The drainage condition within the sands prior to proof rolling is good. Permeability between $7 \times 10^{-4} \text{m/s}$ and $1 \times 10^{-3} \text{m/s}$ was recorded.

Groundwater levels over much of the site are quite high and this may impact on suitability of some areas of the site to allow for the use of soakwells. Additional sand fill may be required in some areas, especially where the clayey subgrade approaches the existing surface. A suitably designed drainage system would allow for the use of soakwells if sufficient height, say at least 1.2m, is obtained above the clayey subgrade and the groundwater. Further permeability testing and groundwater monitoring is recommended as part of the detailed geotechnical investigation to refine these observations.

The sites for the proposed drainage basins as indicated on the concept plan (Appendix A), have good drainage characteristics. The relatively shallow depth of groundwater in the vicinity of the western drainage basin should be addressed at the design stage.

If clean fill sand is to be imported on to the site to raise site formation levels, permeability can vary depending on the source, and could vary between 1×10^{-3} and a $1 \times 10^{-5} \text{m/s}$ based on observed results on typical Perth fill sands.

Permeability and drainage conditions may be reduced during earthworks due to compaction of in-situ and imported sands. Over compaction during earthworks can seriously reduce soil permeability. It is recommended that further permeability testing be carried out following earthworks to confirm parameters used during drainage design.

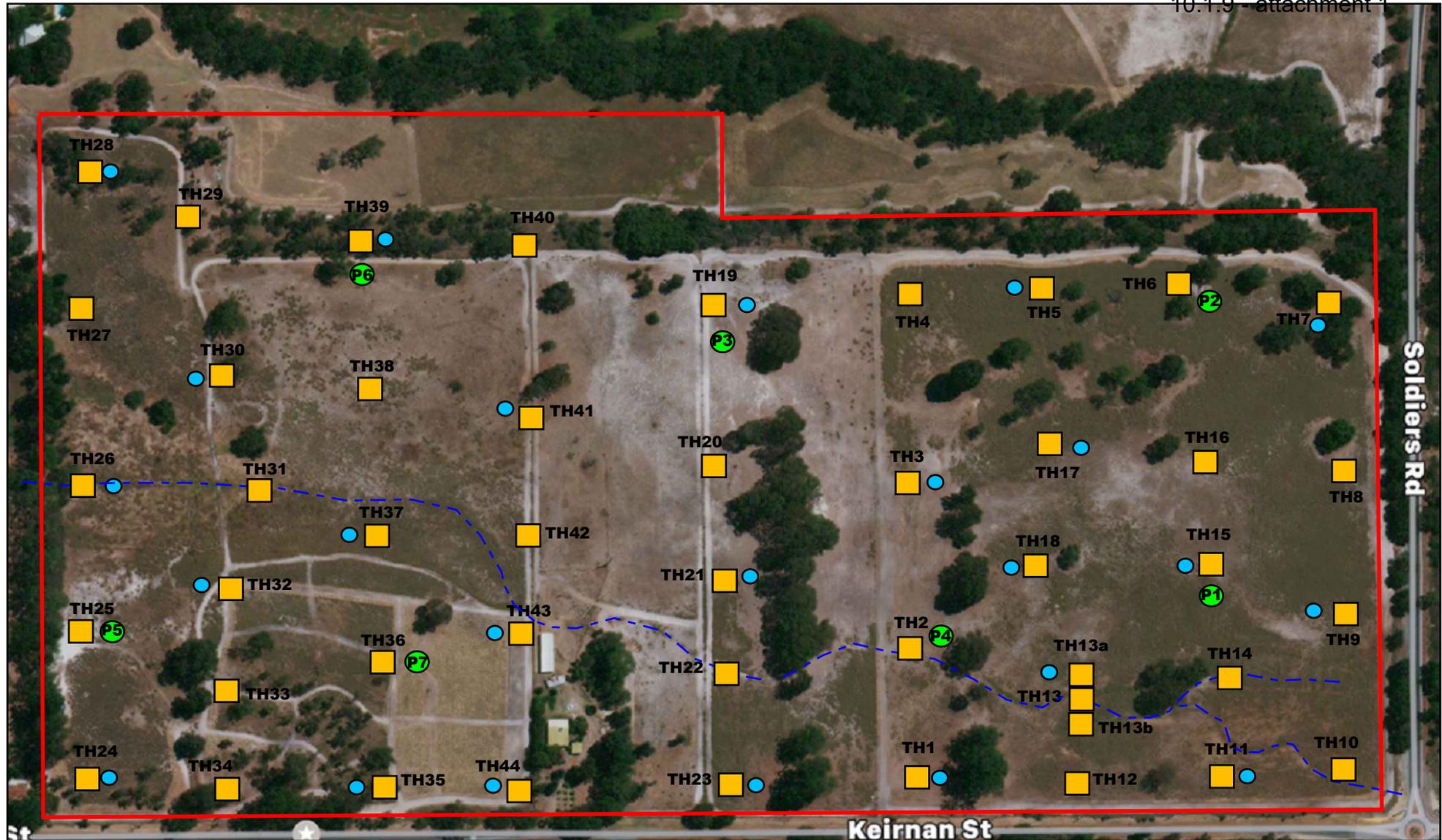
BROWN GEOTECHNICAL

Ken Brown
Geotechnical Engineer

REFERENCES

1. Standards Australia AS 2870 (2011). Residential Slabs and Footings – Construction.
2. Geological Survey of Western Australia. 1:50,000 Environmental Geology Series, Perth.
3. Department of Water. *Perth Groundwater Map*
4. Standards Australia AS3798-2011. “Guidelines on earthworks for commercial and residential developments”.
5. Standards Australia AS 4678-2002. Earth-Retaining Structures.

FIGURES



- Test Hole Locations	- Permeability Tests	- Penetrometer Tests	- Degraded Stream Channel
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BG

Brown
Geotechnical

Date	Description	Drawn	Checked	Approved
04.02.2020	Site Location Plan	KB	KB	KB

TEST HOLE LOCATIONS
LOTS 10 - 14, 50 & 101 KEIRNAN STREET MUNDIJONG

CLIENT
DJM MUNDIJONG PTY LTD

Drawing No. 19061.1
Scale: NTS
Sheet Size: A4
Job No: 19061
FIGURE 1



1.1m - Approx. thickness of fill sand required to obtain Class 'A'

BG
Brown
Geotechnical

Date	Description	Drawn	Checked	Approved
04.02.2020	Subsoil & Site Classification	KB	KB	KB

SUBSOIL CONDITIONS
SITE CLASSIFICATION

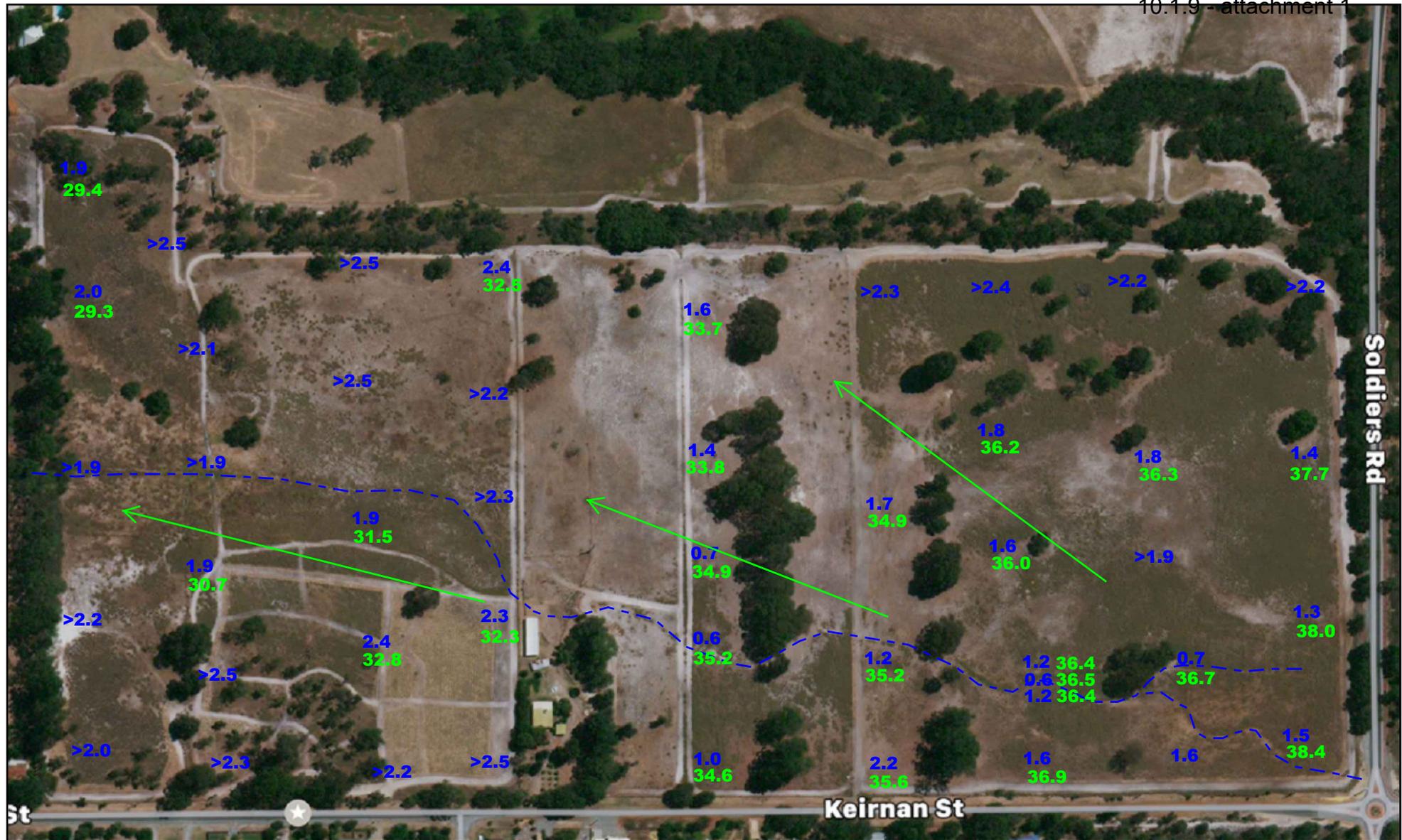
LOTS 10 - 14, 50 & 101 KEIRNAN STREET
MUNDIJONG

Ordinary Council Meeting - 14 December 2020

CLIENT

DJM MUNDIJONG PTY LTD

Drawing No.19061.2
Scale: NTS
Sheet Size: A4
Job No: 19061
FIGURE 2



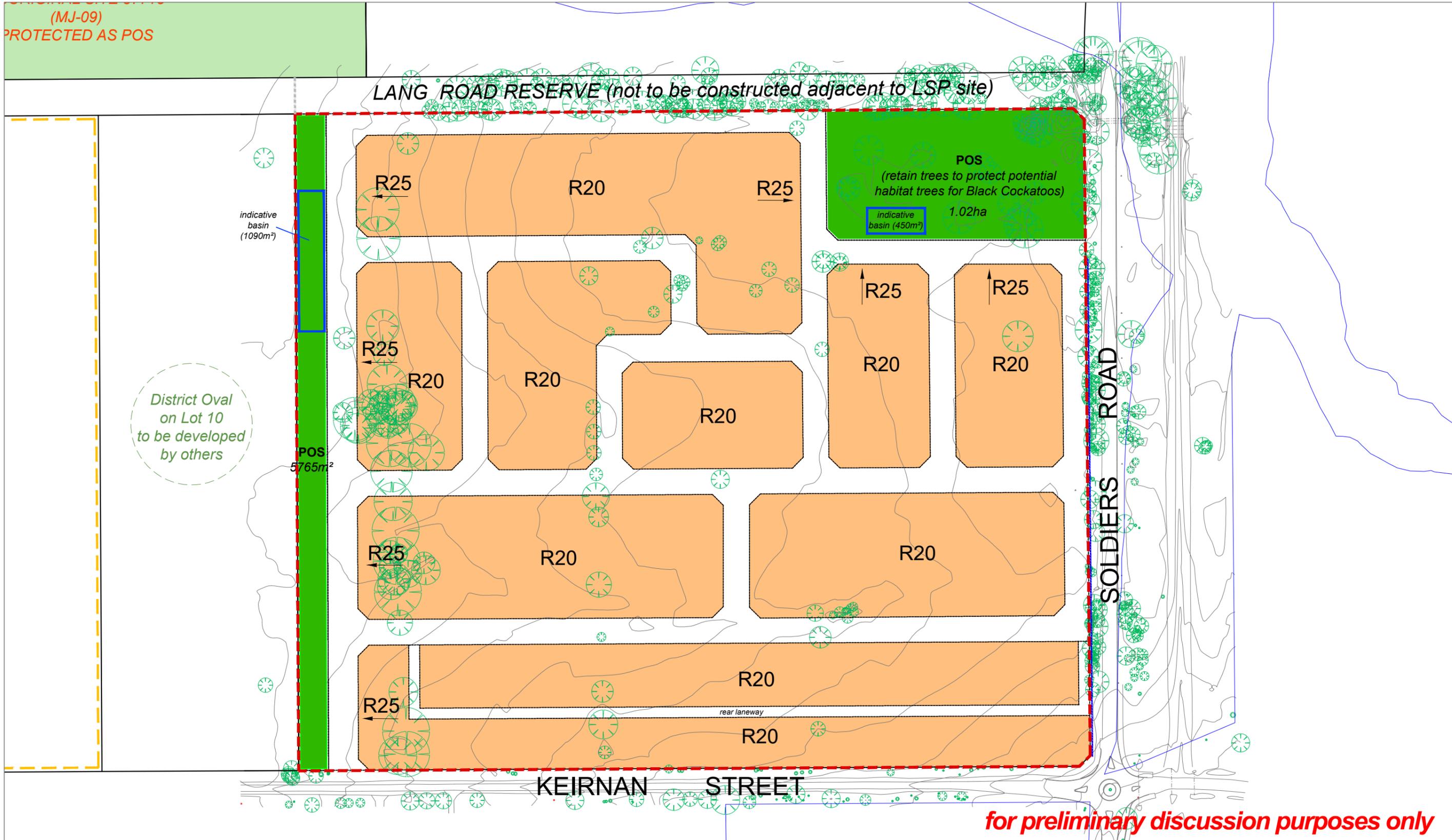
1.0m - Groundwater - Depth Below Ground Level 36.0 - Groundwater - mAHd ← - Approx. Hydraulic Gradient - Degraded Stream Channel

<h1>BG</h1> <p>Brown Geotechnical</p>	Date	Description	Drawn	Checked	Approved	GROUNDWATER LEVELS	CLIENT	Drawing No.19061.3
	04.02.2020	Groundwater Levels	KB	KB	KB			Scale: NTS
						LOTS 10 - 14, 50 & 101 KEIRNAN STREET MUNDIJONG Ordinary Council Meeting - 14 December 2020	DJM MUNDIJONG PTY LTD Job No: 19061 ATTACHMENT 3	Sheet Size: A4

APPENDIX A

Concept Plan

Local Structure Plan



LOCAL STRUCTURE PLAN - CONCEPT

LOTS 11 TO 14 KEIRNAN STREET

MUNDIJONG

DJM MUNDIJONG PTY LTD

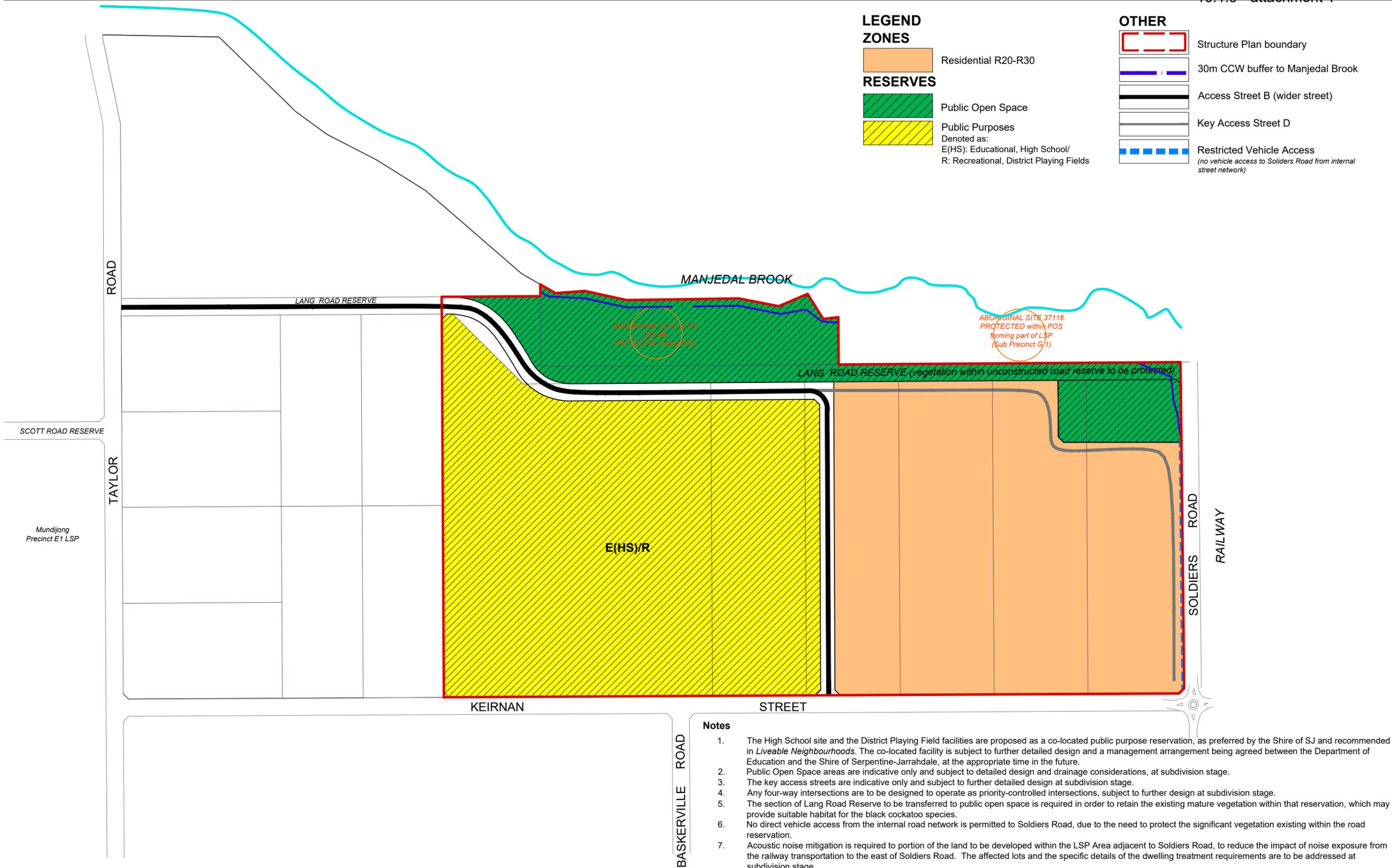


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10-09-2018

PETER WEBB AND ASSOCIATES



CONSULTANTS IN TOWN PLANNING & URBAN DESIGN
PO BOX 920 SUBIACO WA 6904 TEL: 9388 7111
UNIT 2/19 YORK STREET SUBIACO FAX: 9388 7240



LEGEND

ZONES

Residential R20-R30

RESERVES

Public Open Space

Public Purposes
Denoted as:
E(HS): Educational, High School/
R: Recreational, District Playing Fields

OTHER

- Structure Plan boundary
- 30m CCW buffer to Manjedal Brook
- Access Street B (wider street)
- Key Access Street D
- Restricted Vehicle Access
(no vehicle access to Soldiers Road from internal street network)

Notes

1. The High School site and the District Playing Field facilities are proposed as a co-located public purpose reservation, as preferred by the Shire of SJ and recommended in *Liveable Neighbourhoods*. The co-located facility is subject to further detailed design and a management arrangement being agreed between the Department of Education and the Shire of Serpentine-Jarrahdale, at the appropriate time in the future.
2. Public Open Space areas are indicative only and subject to detailed design and drainage considerations, at subdivision stage.
3. The key access streets are indicative only and subject to further detailed design at subdivision stage.
4. Any four-way intersections are to be designed to operate as priority-controlled intersections, subject to further design at subdivision stage.
5. The section of Lang Road Reserve to be transferred to public open space is required in order to retain the existing mature vegetation within that reservation, which may provide suitable habitat for the black cockatoo species.
6. No direct vehicle access from the internal road network is permitted to Soldiers Road, due to the need to protect the significant vegetation existing within the road reservation.
7. Acoustic noise mitigation is required to portion of the land to be developed within the LSP Area adjacent to Soldiers Road, to reduce the impact of noise exposure from the railway transportation to the east of Soldiers Road. The affected lots and the specific details of the dwelling treatment requirements are to be addressed at subdivision stage.

LOCAL STRUCTURE PLAN

Keirnan Street, Mundijong (LSP Area G2)
DJM MUNDIJONG PTY LTD



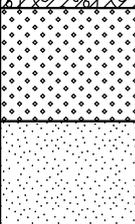
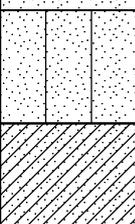
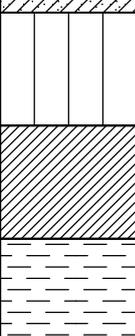
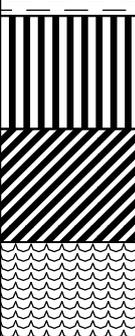
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PETER WEBB AND ASSOCIATES
CONSULTANTS IN TOWN PLANNING & URBAN DESIGN

APPENDIX B

Test Hole Logs

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS	
			GRAPH	LETTER		
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS (LITTLE OR NO FINES)	CLEAN GRAVELS		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	
		(LITTLE OR NO FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	
		GRAVELS WITH FINES		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES	
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	(APPRECIABLE AMOUNT OF FINES)	GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES		
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS (LITTLE OR NO FINES)	CLEAN SANDS		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	
		(LITTLE OR NO FINES)		SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES	
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	(LITTLE OR NO FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
			(APPRECIABLE AMOUNT OF FINES)		SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50	(LITTLE OR NO FINES)		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	
		(LITTLE OR NO FINES)		CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS	
		(LITTLE OR NO FINES)		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	
	MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50	(LITTLE OR NO FINES)		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			(LITTLE OR NO FINES)		CH	INORGANIC CLAYS OF HIGH PLASTICITY
			(LITTLE OR NO FINES)		OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS	

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 37.8 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28207 115.98908

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
		37.5	0.5		SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist		
		37.0	1.0		GPS	SANDY GRAVEL: Dense, fine to medium grained, light brown, with clay, moist		
		36.5	1.5					
		36.0	2.0		SC	CLAYEY SAND: Very dense, fine to medium grained, brown and orange brown, with gravel, moist. Wet below 2.2m		
		35.5	2.2			COLLAPSE in gravel Borehole TH01 terminated at 2.3m		
			2.5					
		35.0						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 36.4 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28133 115.98714

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist		
		36.0	0.5					
					SC	CLAYEY SAND: Dense, fine to medium grained, light brown mottled orange brown, moist.		
		35.5	1.0					
						Wet below 1.2m		
		35.0	1.5					
							LL=32 PL=16 Fines=21% Sand=67% Gravel=12%	Side walls collapsing below groundwater level
		34.5	2.0					
		34.0	2.5					
		33.5	3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20

Borehole TH02 terminated at 3m



Brown Geotechnical

BOREHOLE NUMBER TH03

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 36.6 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28038 115.98709

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		36.5				TOPSOIL: Grey silty sand with organics		
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist		
		36.0	0.5					
						becoming dense at approx. 1m		
		35.5	1.0					
						orange brown below 1.5m		
		35.0	1.5					
						collapsing in satuated sands		
			2.0					
		34.5				COLLAPSE Borehole TH03 terminated at 2m		
			2.5					
		34.0						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH04

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 37.7 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.27925 115.98709

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
		37.5			SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist orange brown below 0.3m	Fines=4% Sand=96% Organics=1.9%	
	Not Encountered		0.5					
		37.0						
			1.0			becoming dense at approx. 1m		
		36.5						
			1.5					
		36.0						
			2.0					
		35.5						
			2.5			COLLAPSE Borehole TH04 terminated at 2.3m		
		35.0						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 38.8 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.27919 115.98805

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
		38.5			SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist		
			0.5			orange brown below 0.3m	MC=10% DD=1.93Mg/m ³ LL=NP PL=NP Fines=12% Sand=88% (medium=60%) Gravel=0% CBR=25	
		38.0						
	Not Encountered							
		37.5						
			1.5			becoming dense at approx. 1.5m		
		37.0						
			2.0					
		36.5						
			2.5			COLLAPSE in sand above 1.5m Borehole TH05 terminated at 2.4m		
		36.0						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH06

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 38.9 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.27919 115.98885

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist		
		38.5	0.5			orange brown below 0.5m		
	Not Encountered	38.0	1.0					
		37.5	1.5					
		37.0	2.0		SC	CLAYEY SAND: Very dense, fine to medium grained, light brown, with gravel, moist.		
		36.5	2.5			COLLAPSE in sand Borehole TH06 terminated at 2.2m		
		36.0	3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 38.9 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.27929 115.98988

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics and occasional roots		
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist, with occasional roots to 0.5m		
		38.5	0.5			orange brown below 0.5m		
	Not Encountered	38.0	1.0					
					GPS	SANDY GRAVEL: Dense, fine to medium grained, light brown & orange brown, with silt, clay and pockets of Fe cementation, moist	LL=46 PL=17 Fines=13% Sand=34% Gravel=53%	
		37.5	1.5					
		37.0	2.0					
						REFUSAL on very dense Fe rich gravel Borehole TH07 terminated at 2.2m		
		36.5	2.5					
		36.0	3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 39.1 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28017 115.99004

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		39.0				TOPSOIL: Grey silty sand with organics		
			0.5		SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist orange brown below 0.4m		
		38.5						
			1.0					
		38.0						
	▼ 1.4m		1.5		GPS	SANDY GRAVEL: Dense, fine to medium grained, light brown & orange brown, with clay, with pockets of Fe cementation, wet		
		37.5						
			2.0			REFUSAL on very dense Fe rich gravel Borehole TH08 terminated at 1.8m		
		37.0						
			2.5					
		36.5						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 39.3 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28116 115.99000

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
		39.0	0.5		SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist		
		38.5				orange brown below 0.7m becoming dense at approx. 0.8m		
		38.0	1.0					
			1.5					
		37.5						
			2.0			COLLAPSE in satuated sand Borehole TH09 terminated at 1.8m		
		37.0						
			2.5					
		36.5						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 39.9 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28201 115.99008

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES _____

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics	Fines=5% Sand=95% Organics=3.2%	
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist		
		39.5	0.5					
					GPS	SANDY GRAVEL: Dense, fine to medium grained, light brown, with clay, moist		
		39.0	1.0					
					SC	CLAYEY SAND: Very dense, fine to medium grained, brown and orange brown, trace gravel, wet.		
		38.5	1.5					
		38.0	2.0					
		37.5	2.5					
		37.0	3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20

Borehole TH10 terminated at 3m



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 39.1 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28204 115.98915

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		39.0				TOPSOIL: Grey silty sand with organics		
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist		
		38.5			GPS	SANDY GRAVEL: Dense, fine to medium grained, light brown, with clay, moist		
		37.5			SC	CLAYEY SAND: Very dense, fine to medium grained, brown and orange brown, trace gravel, wet.		
						COLLAPSE in saturated gravel above SC Borehole TH11 terminated at 2m		

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH12

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 38.5 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28208 115.98817

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
		38.0	0.5		SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist light brown & orange brown below 0.5m		
		37.5	1.0					
		37.0	1.5		GPS	SANDY GRAVEL: Dense, fine to medium grained, light brown & orange brown, with silt, clay and pockets of Fe cementation, moist		
		36.5	2.0			Very slow excavating Borehole TH12 terminated at 2m		
		36.0	2.5					
		35.5	3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH13

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 37.1 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28155 115.98806

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		37.0				TOPSOIL: Grey silty sand with organics		
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist		
		36.5	0.5		GPS	SANDY GRAVEL: Very dense, fine to medium grained, light brown & orange brown, trace silt & clay, with pockets of Fe cementation, wet		
	0.6m					REFUSAL on Fe rich cemented sandy gravel		
		36.0	1.0					High inflow of water flooding Test Hole
			1.5			Borehole TH13 terminated at 1.4m		
		35.5						
			2.0					
		35.0						
			2.5					
		34.5						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH13b

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 37.6 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28150 115.98906

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		37.5				TOPSOIL: Grey silty sand with organics		
					SP-SM	SAND: Medium dense, medium grained, grey and orange brown, with silt, moist		
		37.0	0.5					
						Fe rich cemented sandy gravel (excavation slow)		
		36.5	1.0					
					GPS	SANDY GRAVEL: Very dense, fine to medium grained, light brown & orange brown, with clay, with pockets of Fe cementation, wet		
		36.0	1.5					
						Test Hole Flooding Borehole TH13b terminated at 2m		
		35.5	2.0					
								High inflow of water flooding Test Hole
		35.0	2.5					
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 37.4 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28148 115.98907

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist		
					GPS	SANDY GRAVEL: Very dense, fine to coarse grained, brown, with clay, with pockets of Fe cementation, wet		
						REFUSAL on cemented layer Borehole TH14 terminated at 1.6m		

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 38.2 DATUM m AHD

DRILLING CONTRACTOR SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28080 115.98908

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
		38.0			SP	SAND: Medium dense, medium grained, grey, trace silt, moist	MC=18% DD=1.68Mg/m ³ LL=NP PL=NP Fines=3% Sand=97% (medium=70%) Gravel=0% CBR=25	
	Not Encountered	37.5	0.5					
			1.0		SP-SM	SAND: Very dense, dark brown (Fe rich), with silt, moist		
		37.0			SP	SAND: Medium dense, medium grained, grey, trace silt, moist		
		36.5	1.5			orange brown below 1.7m		
			2.0			COLLAPSE in grey sand above 1.7m Borehole TH15 terminated at 1.9m		
		36.0						
			2.5					
		35.5						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 38.1 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28026 115.98890

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		38.0				TOPSOIL: Grey silty sand with organics	Fines=3% Sand=97% Organics=2.2%	
			0.5		SP	SAND: Medium dense, medium grained, grey, trace silt, moist		
		37.5						
			1.0			becoming dense at approx. 1m		
		37.0						
			1.5					
		36.5				orange brown below 1.6m		
			2.0			COLLAPSE Borehole TH16 terminated at 1.9m		
		36.0						
			2.5					
		35.5						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH17

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 38.0 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28007 115.98805

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
					SP	SAND: Medium dense, medium grained, grey, trace silt, moist		
		37.5	0.5					
		37.0	1.0			becoming dense at approx. 1m		
		36.5	1.5			orange brown below 1.6m		
						COLLAPSE Borehole TH17 terminated at 1.9m		
		36.0	2.0					
		35.5	2.5					
		35.0	3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20

▼
1.8m



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 37.6 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28083 115.98794

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		37.5				TOPSOIL: Grey silty sand with organics		
					SP	SAND: Medium dense, medium grained, grey, trace silt, moist		
		37.0	0.5					
		36.5	1.0					
		36.0	1.5					
	▼				SP-SM	SAND: Very dense, dark brown (Fe rich), with silt, moist		
					SP	SAND: Medium dense, medium grained, orange brown, trace silt, wet		
			2.0					
		35.5				COLLAPSE in grey sand above 1.6m Borehole TH18 terminated at 2m		
			2.5					
		35.0						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 35.3 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.27944 115.98586

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		35.0	0.5		SP	SAND: Medium dense, medium grained, grey, trace silt, moist		
		34.5	1.0					
		34.0	1.5					
		33.5	2.0			reddish & orange brown below 1.6m		
						Borehole TH19 terminated at 2m		
		33.0	2.5					
		32.5	3.0					

Fines=4%
Sand=96%
(medium=72%)
Gravel=0%

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH20

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 35.2 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28027 115.98584

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		35.0			SP	TOPSOIL: Grey silty sand with organics		
		34.5	0.5			SAND: Medium dense, medium grained, grey, trace silt, moist		
		34.0	1.0			becoming dense at approx. 1m		
		33.5	1.5			orange brown below 1.4m		
			2.0			COLLAPSE in sand above 1.4m Borehole TH20 terminated at 1.8m		
		33.0	2.5					
		32.5	3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH21

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 36.0 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28077 115.98584

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
					SP	SAND: Medium dense, medium grained, grey, trace silt, moist		
						becoming dense at approx. 1m		
						orange brown below 1.1m		
						COLLAPSE in sand above 0.7m Borehole TH21 terminated at 1.6m		

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH22

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 35.8 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28142 115.98586

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
		35.5	0.5		SP-SM	SAND: Medium dense, medium grained, grey, with silt, moist		
		35.0	1.0		GPS	SANDY GRAVEL: Dense, fine to medium grained, light brown, with clay, wet		
		34.5	1.5		SC	CLAYEY SAND: Very dense, fine to medium grained, brown and orange brown, with gravel, wet		
		34.0	2.0			COLLAPSE due to water ingress Borehole TH22 terminated at 1.6m		
		33.5	2.5					
		33.0	3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 16/11/18 COMPLETED 16/11/18 R.L. SURFACE 36.3 DATUM m AHD

DRILLING CONTRACTOR SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28209 115.98586

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics	Fines=6% Sand=94% Organics=5.2%	
		36.0	0.5		SP-SM	SAND: Medium dense, medium grained, grey brown, with silt, moist		
		35.5	1.0		GPS	SANDY GRAVEL: Dense, fine to medium grained, light brown, with clay, wet		
		35.0	1.5		SC	CLAYEY SAND: Very dense, fine to medium grained, brown and orange brown, with gravel, wet		
		34.5	2.0			Borehole TH23 terminated at 2m		
		34.0	2.5					
		33.5	3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 33.1 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -32.28226 115.98139

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		33.0				TOPSOIL: Grey silty sand with organics & occasional tree roots		
			0.5		SP-SM	SAND: Medium dense, medium grained, grey, with silt, dry		
		32.5				orange brown, moist below 0.9m, with occasional nodules of Fe cemented silty sand		
	Not Encountered	32.0	1.0					
		31.5	1.5					
			2.0					
		31.0				COLLAPSE Borehole TH24 terminated at 2m		
			2.5					
		30.5						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 31.9 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28123 115.98143

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, dry		
	Not Encountered	31.5	0.5					
		31.0	1.0				LL=NP PL=NP Fines=6% Sand=94% (medium=75%) Gravel=0%	
		30.5	1.5					
		30.0	2.0		SC	CLAYEY SAND: Very dense, fine to medium grained, grey brown, with gravel, moist.		
						COLLAPSE in sand Borehole TH25 terminated at 2.2m		
		29.5	2.5					
		29.0	3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 31.2 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28038 115.98148

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics with some tree roots		
					SP-SM	SAND: Medium dense, medium grained, light brown, with silt, dry		
	Not Encountered							
					SC	CLAYEY SAND: Very dense, fine to medium grained, light brown, with gravel, moist.		
						REFUSAL Borehole TH26 terminated at 1.9m		

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 31.3 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.27934 115.98146

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
		31.0	0.5		SP-SM	SAND: Medium dense, medium grained, grey brown, with silt, dry		
		30.5	1.0		SC	CLAYEY SAND: Very dense, fine to medium grained, light brown, with gravel, moist.		
		30.0	1.5					
		29.5	2.0					
		29.0	2.0			wet below 2m		
		29.0	2.3			COLLAPSE Borehole TH27 terminated at 2.3m		
		28.5	2.5					
		28.5	3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH28

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 31.3 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.27854 115.98151

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics, tree roots		
		31.0			SP-SM	SAND: Medium dense, medium grained, grey, with silt, dry. Tree roots to 0.6m		
			0.5					
		30.5						
			1.0			becoming dark grey below 1m		
		30.0						
			1.5			light brown, locally orange brown, moist below 1.3m		
		29.5						
			2.0			wet below 1.9m		
						COFFEE ROCK: Fe cemented silty sand		
		29.0				REFUSAL		
			2.5			Borehole TH28 terminated at 2.1m		
		28.5						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20

1.9m



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 33.2 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.27885 115.98206

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics & occasional tree roots		
		33.0			SP-SM	SAND: Medium dense, medium grained, grey, with silt, dry		
			0.5			orange brown below 0.6m		
		32.5						
			1.0					
	Not Encountered	32.0						
			1.5					
		31.5						
			2.0					
		31.0						
			2.5					
						Borehole TH29 terminated at 2.5m		
		30.5						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 32.7 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.27959 115.98235

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
		32.5			SP-SM	SAND: Medium dense, medium grained, grey, with silt, dry		
			0.5					
		32.0						
	Not Encountered		1.0					
		31.5						
			1.5					
		31.0				brown moist below 1.7m, with occasional nodules of Fe cemented silty sand		
			2.0		SC	CLAYEY SAND: Very dense, fine to medium grained, grey brown, with gravel, moist.	LL=24 PL=11 Fines=17%	
		30.5				REFUSAL Borehole TH30 terminated at 2.1m		
			2.5					
		30.0						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 32.2 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28033 115.98238

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		32.0				TOPSOIL: Grey silty sand with organics		
			0.5		SP-SM	SAND: Medium dense, medium grained, light brown, with silt, dry		
	Not Encountered	31.5						
			1.0					
		31.0						
			1.5		SC	CLAYEY SAND: Very dense, fine to medium grained, light brown, with gravel, moist.		
		30.5						
			2.0			REFUSAL Borehole TH31 terminated at 1.9m		
		30.0						
			2.5					
		29.5						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 32.6 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28075 115.98248

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		32.5			SP-SM	SAND: Medium dense, medium grained, light brown, with silt, dry		
		32.0	0.5					
		31.5	1.0					
		31.0	1.5					
		30.5	2.0		SC	CLAYEY SAND: Very dense, fine to medium grained, light brown, with gravel, wet.		
			2.5			REFUSAL Borehole TH32 terminated at 2.2m		
		30.0	3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 36.2 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28150 115.98247

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
		36.0			SP-SM	SAND: Medium dense, medium grained, grey, with silt, dry		
			0.5			orange brown below 0.3m		
		35.5						
			1.0					
	Not Encountered	35.0						
			1.5					
		34.5				moist		
			2.0					
		34.0						
			2.5			Borehole TH33 terminated at 2.5m		
		33.5						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH34

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 35.1 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28221 115.98242

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		35.0				TOPSOIL: Grey silty sand with organics		
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, dry orange brown below 0.3m		
	Not Encountered		0.5					
		34.5						
			1.0					
		34.0						
			1.5					
		33.5						
			2.0					
		33.0						
			2.5			COLLAPSE Borehole TH34 terminated at 2.3m		
		32.5						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 36.1 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28212 115.98354

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		36.0				TOPSOIL: Grey silty sand with organics		
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, dry		
			0.5			orange brown below 0.4m		
		35.5						
	Not Encountered		1.0					
		35.0						
			1.5			moist		
		34.5						
			2.0					
		34.0						
			2.5					
		33.5						
			3.0					
						COLLAPSE Borehole TH35 terminated at 2.2m		

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 35.2 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28143 115.98359

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
		35.0			SP-SM	SAND: Medium dense, medium grained, light brown, with silt, dry		
			0.5			orange brown below 0.5m	MC=10% DD=1.92Mg/m³ LL=NP PL=NP Fines=10% Sand=90% (medium=73%) Gravel=0% CBR=45%	
		34.5						
			1.0					
		34.0						
			1.5					
		33.5						
			2.0			moist		
		33.0						
			2.5		SC	CLAYEY SAND: Very dense, fine to medium grained, light brown, with gravel, wet.		
						Borehole TH36 terminated at 2.5m		
		32.5						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH37

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 33.4 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28075 115.98367

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics	Fines=8% Organics=8.2%	
					SP-SM	SAND: Medium dense, medium grained, light brown, with silt, dry grey brown below 0.3m		
					SC	CLAYEY SAND: Very dense, fine to medium grained, light brown, with gravel, moist. wet below 1.9m		
						REFUSAL Borehole TH37 terminated at 2.2m		

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH38

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 34.6 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.27991 115.98354

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		34.5				TOPSOIL: Grey silty sand with organics		
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, dry orange brown below 0.4m		
	Not Encountered		0.5					
		34.0						
			1.0					
		33.5						
			1.5			moist		
		33.0						
			2.0					
		32.5						
			2.5			Borehole TH38 terminated at 2.5m		
		32.0						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH39

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 34.9 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.27912 115.98357

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, dry		
		34.5	0.5			orange brown below 0.4m		
		34.0	1.0					
	Not Encountered	33.5	1.5					
		33.0	2.0			moist		
		32.5	2.5					
						Borehole TH39 terminated at 2.5m		
		32.0						
		3.0						

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH40

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 34.9 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.27922 115.98439

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, dry		
		34.5	0.5			orange brown below 0.4m		
		34.0	1.0					
		33.5	1.5					
		33.0	2.0			moist		
		32.5	2.5			very silty / trace clay below 2.3m		
						Borehole TH40 terminated at 2.5m		
		32.0	3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH41

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 35.2 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.27992 115.98443

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
						TOPSOIL: Grey silty sand with organics		
		35.0			SP-SM	SAND: Medium dense, medium grained, grey, with silt, dry		
			0.5			orange brown below 0.3m		
		34.5						
	Not Encountered		1.0					
		34.0						
			1.5					
		33.5				moist		
			2.0					
		33.0						
			2.5			COLLAPSE Borehole TH41 terminated at 2.2m		
		32.5						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 34.3 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28073 115.98443

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP-SM	SAND: Medium dense, medium grained, grey, with silt, dry		
		34.0						
			0.5					
		33.5						
	Not Encountered		1.0					
		33.0						
			1.5			moist below 1.5m		
		32.5				light brown & orange brown below 1.7m		
			2.0			very silty, wet below 1.9m		
		32.0						
			2.5			COLLAPSE Borehole TH42 terminated at 2.3m		
		31.5						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 34.6 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28123 115.98450

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
		34.5				TOPSOIL: Grey silty sand with organics		
			0.5		SP-SM	SAND: Medium dense, medium grained, light brown, with silt, dry		
		34.0				orange brown with occasional gravel below 1.0m		
		33.5			SC	CLAYEY SAND: Very dense, fine to medium grained, mottled grey & brown, with gravel & Fe nodules, moist.		
		33.0						
		32.5						
			2.0					
						wet below 2.3m		
			2.5			REFUSAL Borehole TH43 terminated at 2.4m		
		32.0						
			3.0					

BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20



Brown Geotechnical

BOREHOLE NUMBER TH44

CLIENT DJM Mundijong Pty Ltd PROJECT NAME Keirnan Street

PROJECT NUMBER 18036 / 19061 PROJECT LOCATION Mundijong

DATE STARTED 23/1/20 COMPLETED 23/1/20 R.L. SURFACE 35.7 DATUM m AHD

DRILLING CONTRACTOR _____ SLOPE 90° BEARING ---

EQUIPMENT 5 tonne excavator HOLE LOCATION -31.28207 115.98439

HOLE SIZE 0.5m x 1.5m LOGGED BY KB CHECKED BY KB

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations	
		35.5			SP-SM	SAND: Medium dense, medium grained, grey, with silt, dry			
			0.5				grey brown below 0.6m		
		35.0							
	Not Encountered		1.0						
		34.5							
			1.5						
		34.0			SC	CLAYEY SAND: Very dense, fine to medium grained, mottled grey & brown, with some gravel, moist.			
			2.0						
		33.5							
			2.5			Borehole TH44 terminated at 2.5m			
		33.0							
			3.0						

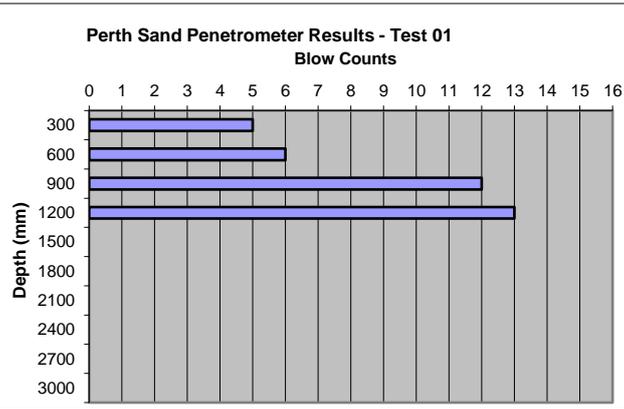
BOREHOLE / TEST PIT MUNDIJONG.GPJ GINT STD AUSTRALIA.GDT 10/2/20

APPENDIX C

Perth Sand Penetrometer Plots

Perth Sand Penetrometer Test Plots

Depth (mm)	Blow Counts
300	5
600	6
900	12
1200	13
1800	
2100	
2400	
2700	
3000	



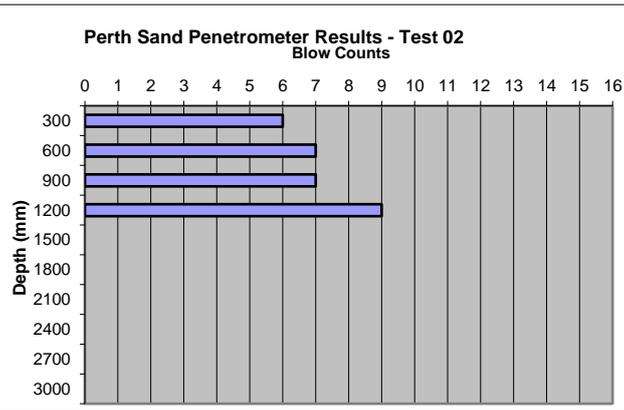
Job Name: Keirman St
Mundijong

Job No: 18036

Date: 16/11/2018

Location: TH01

Depth (mm)	Blow Counts
300	6
600	7
900	7
1200	9
1800	
2100	
2400	
2700	
3000	



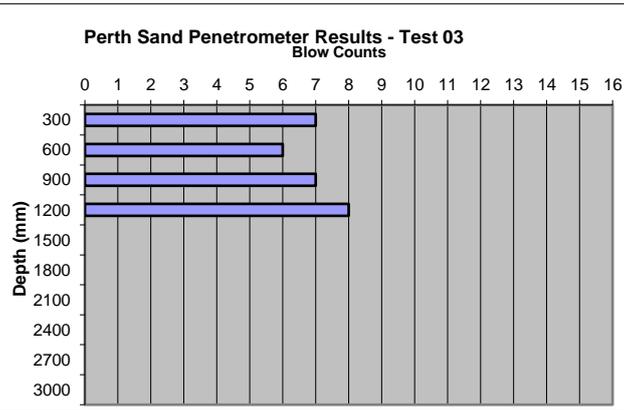
Job Name: Keirman St
Mundijong

Job No: 18036

Date: 16/11/2018

Location: TH03

Depth (mm)	Blow Counts
300	7
600	6
900	7
1200	8
1800	
2100	
2400	
2700	
3000	



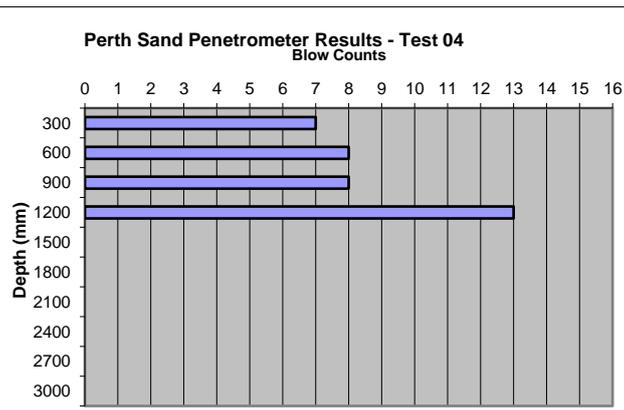
Job Name: Keirman St
Mundijong

Job No: 18036

Date: 16/11/2018

Location: TH05

Depth (mm)	Blow Counts
300	7
600	8
900	8
1200	13
1800	
2100	
2400	
2700	
3000	



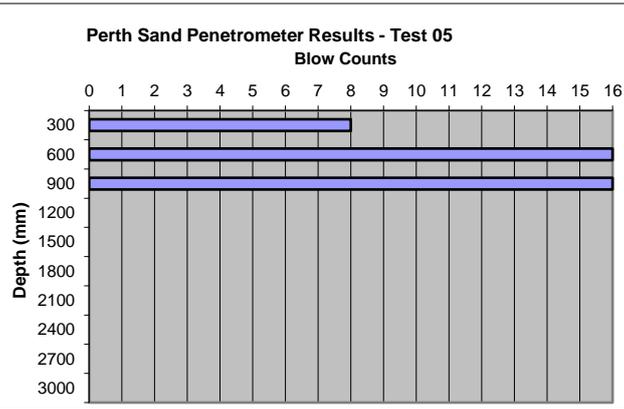
Job Name: Keirman St
Mundijong

Job No: 18036

Date: 16/11/2018

Location: TH07

Depth (mm)	Blow Counts
300	8
600	16
900	16
1200	
1500	
1800	
2100	
2400	
2700	
3000	



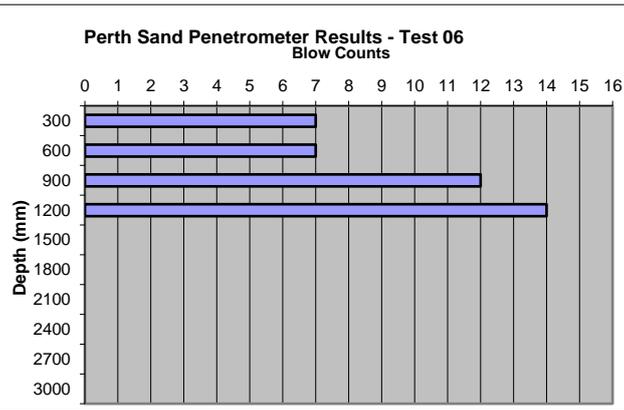
Job Name: Keirman St
Mundijong

Job No: 18036

Date: 16/11/2018

Location: TH09

Depth (mm)	Blow Counts
300	7
600	7
900	12
1200	14
1500	
1800	
2100	
2400	
2700	
3000	



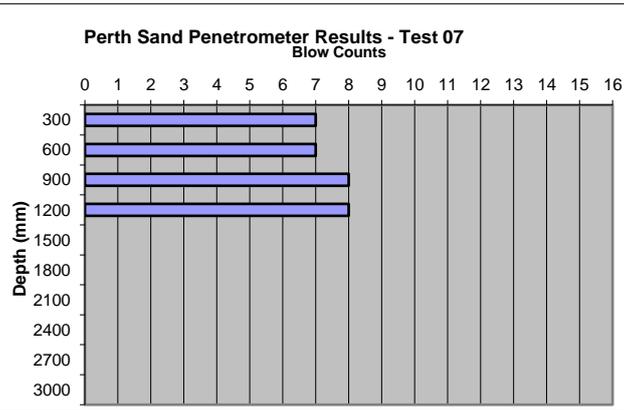
Job Name: Keirman St
Mundijong
Road

Job No: 18036

Date: 16/11/2018

Location: TH11

Depth (mm)	Blow Counts
300	7
600	7
900	8
1200	8
1500	
1800	
2100	
2400	
2700	
3000	



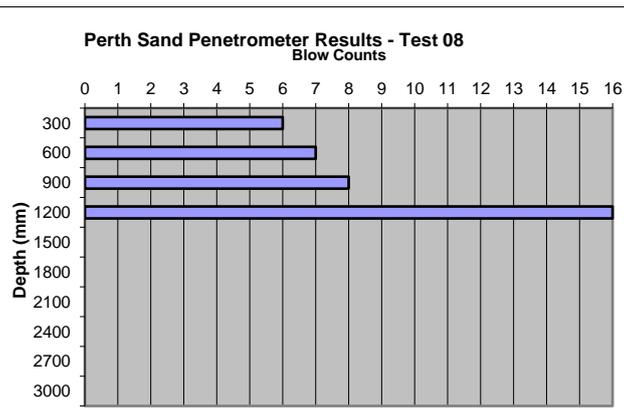
Job Name: Keirman St
Mundijong
Road

Job No: 18036

Date: 16/11/2018

Location: TH13

Depth (mm)	Blow Counts
300	6
600	7
900	8
1200	16
1500	
1800	
2100	
2400	
2700	
3000	



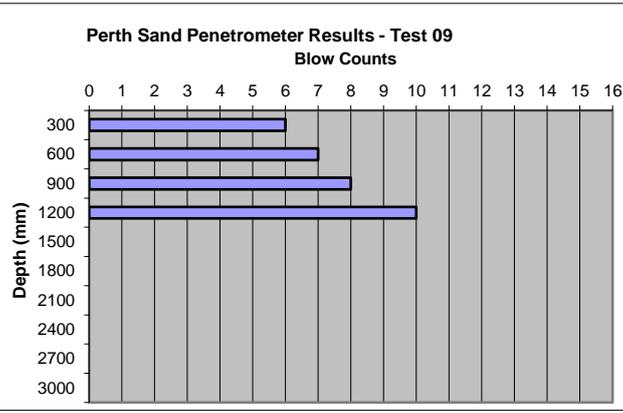
Job Name: Keirman St
Mundijong
Road

Job No: 18036

Date: 16/11/2018

Location: TH15

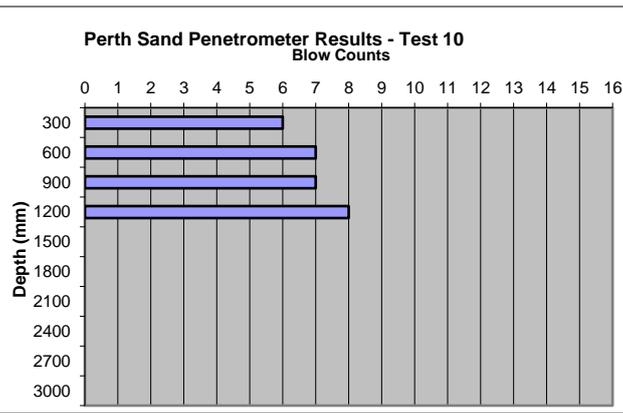
Depth (mm)	Blow Counts
300	6
600	7
900	8
1200	10
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St
Mundijong

Job No: 18036
Date: 16/11/2018
Location: TH17

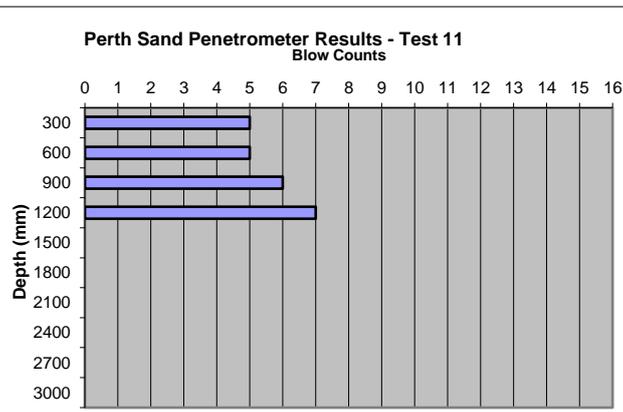
Depth (mm)	Blow Counts
300	6
600	7
900	7
1200	8
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St
Mundijong

Job No: 18036
Date: 16/11/2018
Location: TH18

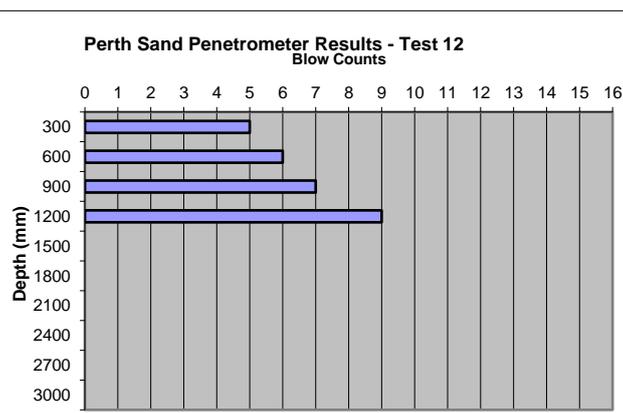
Depth (mm)	Blow Counts
300	5
600	5
900	6
1200	7
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St
Mundijong

Job No: 18036
Date: 16/11/2018
Location: TH19

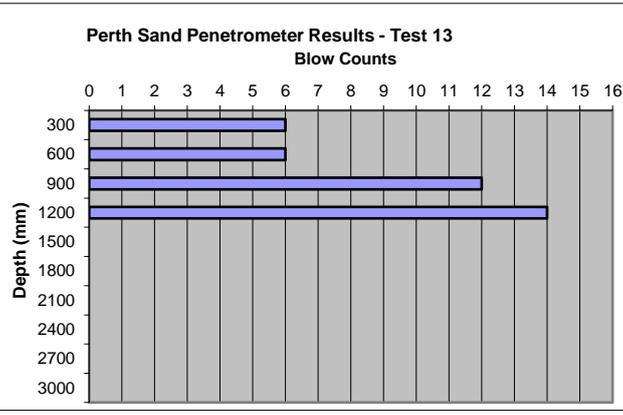
Depth (mm)	Blow Counts
300	5
600	6
900	7
1200	9
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St
Mundijong

Job No: 18036
Date: 16/11/2018
Location: TH21

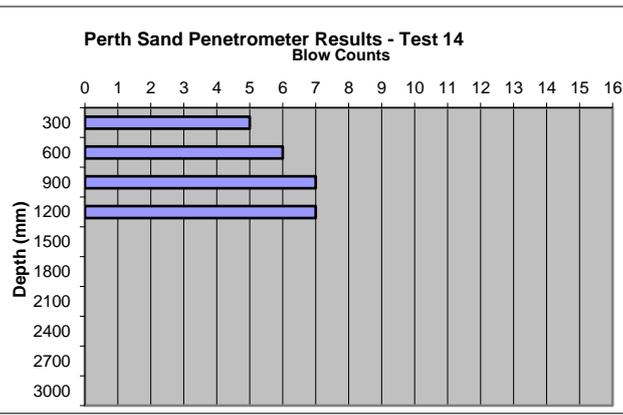
Depth (mm)	Blow Counts
300	6
600	6
900	12
1200	14
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St
Mundijong

Job No: 18036
Date: 16/11/2018
Location: TH23

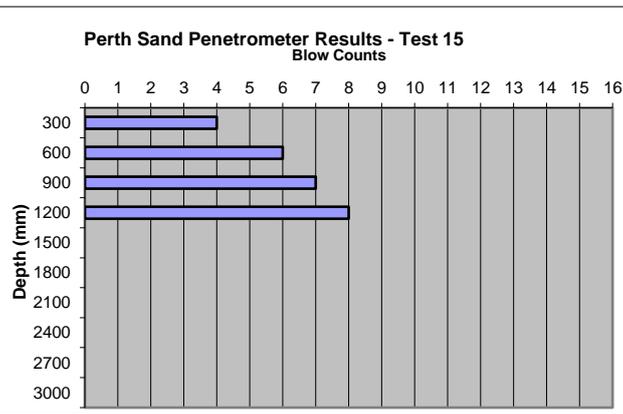
Depth (mm)	Blow Counts
300	5
600	6
900	7
1200	7
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St
Mundijong

Job No: 19061
Date: 21/01/2020
Location: TH24

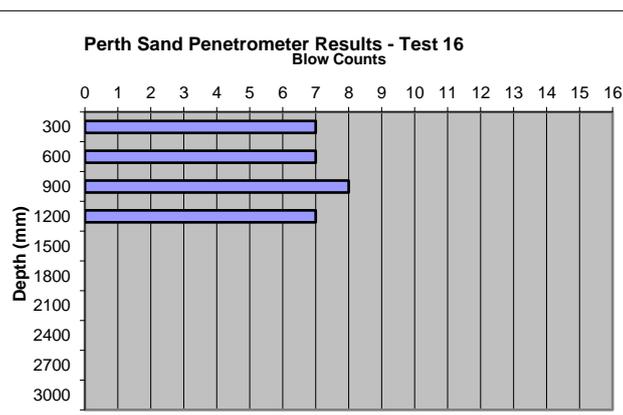
Depth (mm)	Blow Counts
300	4
600	6
900	7
1200	8
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St
Mundijong

Job No: 19061
Date: 21/01/2020
Location: TH26

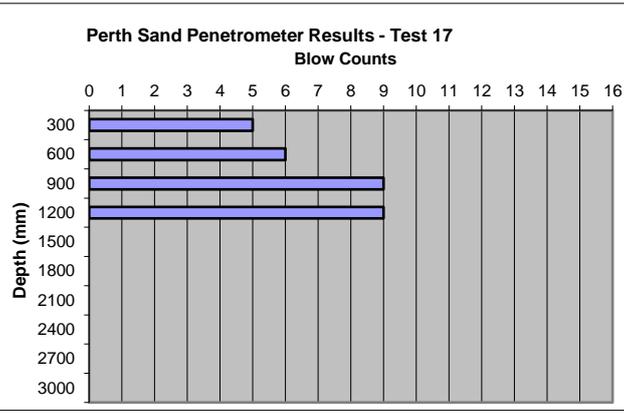
Depth (mm)	Blow Counts
300	7
600	7
900	8
1200	7
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St
Mundijong

Job No: 19061
Date: 21/01/2020
Location: TH28

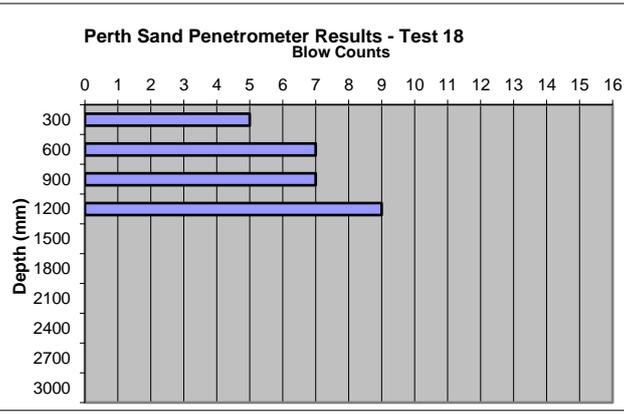
Depth (mm)	Blow Counts
300	5
600	6
900	9
1200	9
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St Mundijong

Job No: 19061
Date: 23/01/2020
Location: TH30

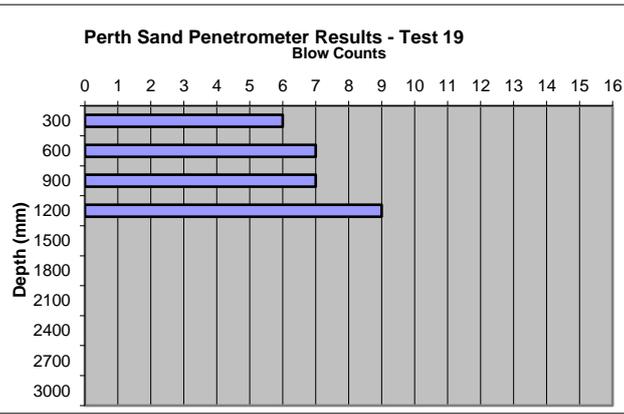
Depth (mm)	Blow Counts
300	5
600	7
900	7
1200	9
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St Mundijong

Job No: 19061
Date: 23/01/2020
Location: TH32

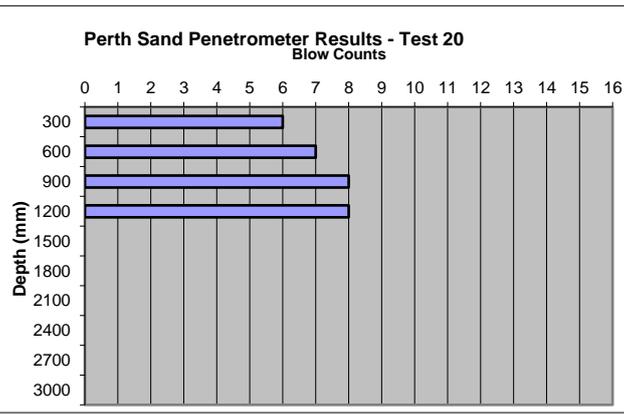
Depth (mm)	Blow Counts
300	6
600	7
900	7
1200	9
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St Mundijong

Job No: 19061
Date: 23/01/2020
Location: TH35

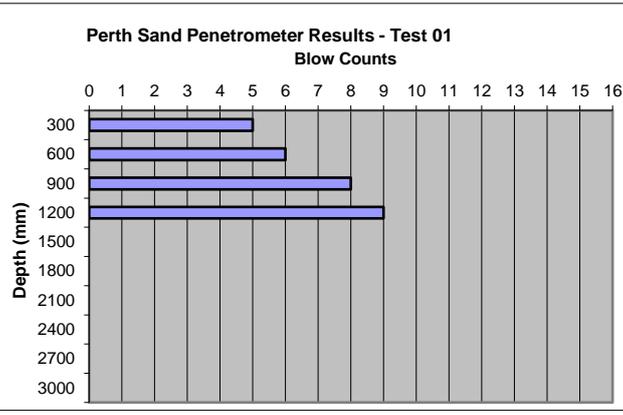
Depth (mm)	Blow Counts
300	6
600	7
900	8
1200	8
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St Mundijong

Job No: 19061
Date: 23/01/2020
Location: TH37

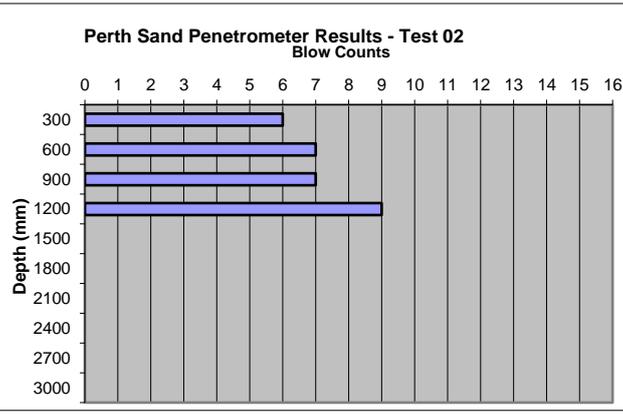
Depth (mm)	Blow Counts
300	5
600	6
900	8
1200	9
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St Mundijong

Job No: 19061
Date: 23/01/2020
Location: TH39

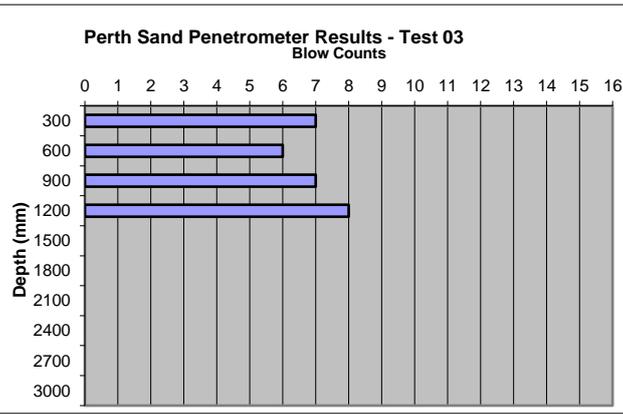
Depth (mm)	Blow Counts
300	6
600	7
900	7
1200	9
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St Mundijong

Job No: 19061
Date: 23/01/2020
Location: TH41

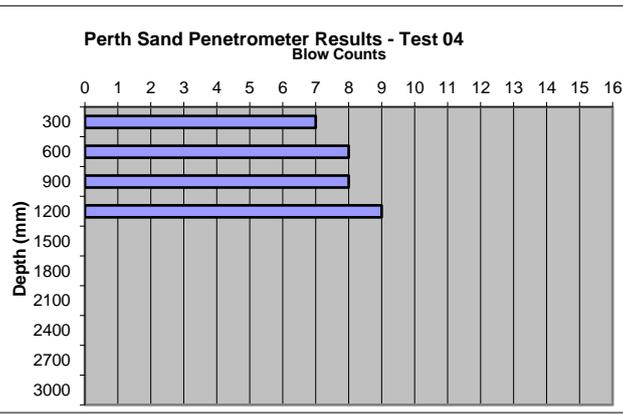
Depth (mm)	Blow Counts
300	7
600	6
900	7
1200	8
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St Mundijong

Job No: 19061
Date: 23/01/2020
Location: TH43

Depth (mm)	Blow Counts
300	7
600	8
900	8
1200	9
1500	
1800	
2100	
2400	
2700	
3000	



Job Name: Keirnan St Mundijong

Job No: 19061
Date: 23/01/2020
Location: TH44

APPENDIX D

Laboratory Test Certificates

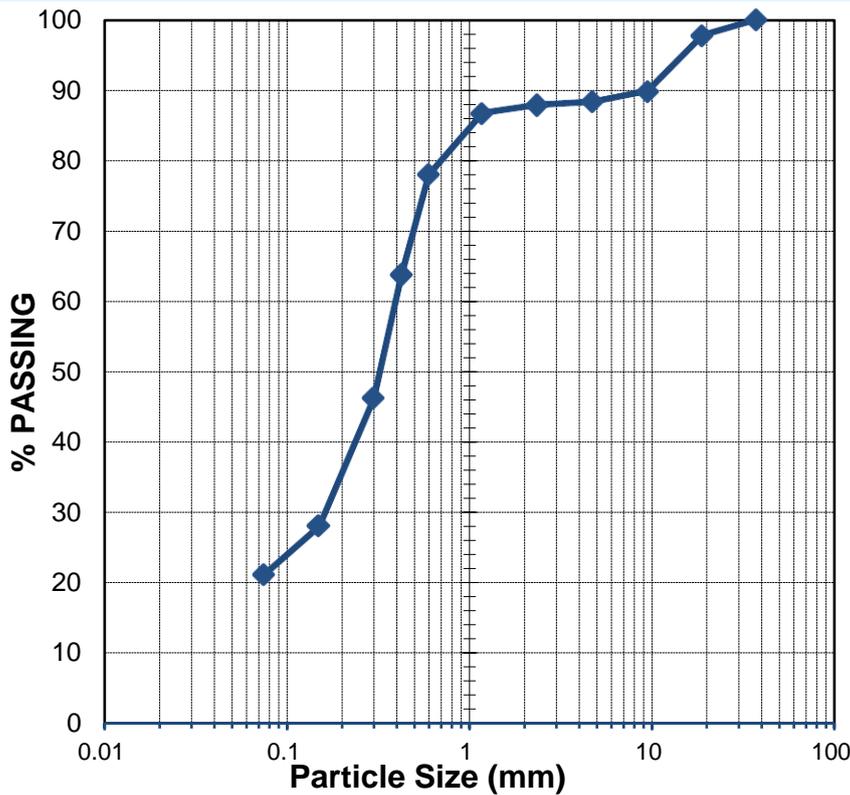


SOIL CLASSIFICATION TEST REPORT

Client	Brown Geotechnical	Ticket No.	S2587
Client Address	PO Box 278 Como	Report No.	LLS18/5440_1_PSDPI
Project	Keirnan Street	Sample No.	LLS18/5440
Sampling Location	Mundijong	Sampled By	Client
Sample Identification	TH2 1.0-1.5m		
Sampling Method	Sampled by Client, Tested as Received	Preparation Method	AS1289.1.1
Sample History	Air Dried	Wet or Dry Sieved	Dry Sieved

PARTICLE SIZE DISTRIBUTION - ANALYSIS BY SIEVING

AS 1289.3.6.1



Sieve Size (mm)	Percent Passing Sieve (%)
75.00	
53.00	
37.50	100
19.00	98
9.50	90
4.75	88
2.36	88
1.180	87
0.600	78
0.425	64
0.300	46
0.150	28
0.075	21

CONSISTENCY LIMITS

AS 1289.3.9.1	AS 1289.3.2.1	AS1289.3.3.2	AS 1289.3.4.1		
Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Mould Length (mm)	Condition of Dried Specimen
32	16	16	5.5	250	-

Comments: _____



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Accreditation No. 19872

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Approved Signatory

Name: Matt van Herk
Function: Laboratory Manager
Issue Date: 26-November-2018

Ordinary Council Meeting - 14 December 2020

ORGANIC CONTENT - TEST REPORT

ASTM D 2974-14 - TEST METHOD C

Client	Brown Geotechnical	Ticket No.	S2587
Client Address	PO Box 278 Como, WA 6952	Report No.	LLS18/5441-5447_1_ORG
Project	Keirnan Street	Sample No.	LLS18/5441-5447
Location	Mundijong	Sampled By	Client
Sample Identification	Various - See Below	Date Tested	24/11/2018
Preparation Method	ASTM D 2974-14	Tested By	NL
Sampling Method:	Sampled by Client, Tested as Received	Furnance Temperature (°)	440

LOSS ON IGNITION METHOD

Sample Number	Sample ID	Ash Content (%)	Organic Content (%)
LLS18/5441	TH4 0.0-0.15m	98.1	1.9
LLS18/5443	TH10 0.0-0.15m	96.8	3.2
LLS18/5445	TH16 0.0-0.1m	97.8	2.2
LLS18/5447	TH23 0.0-0.2m	94.8	5.2

Comments:



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Accreditation No. 19872

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Approved Signatory



Name
Function
Issue Date

M. van Herk
Laboratory Manager
26-November-2018

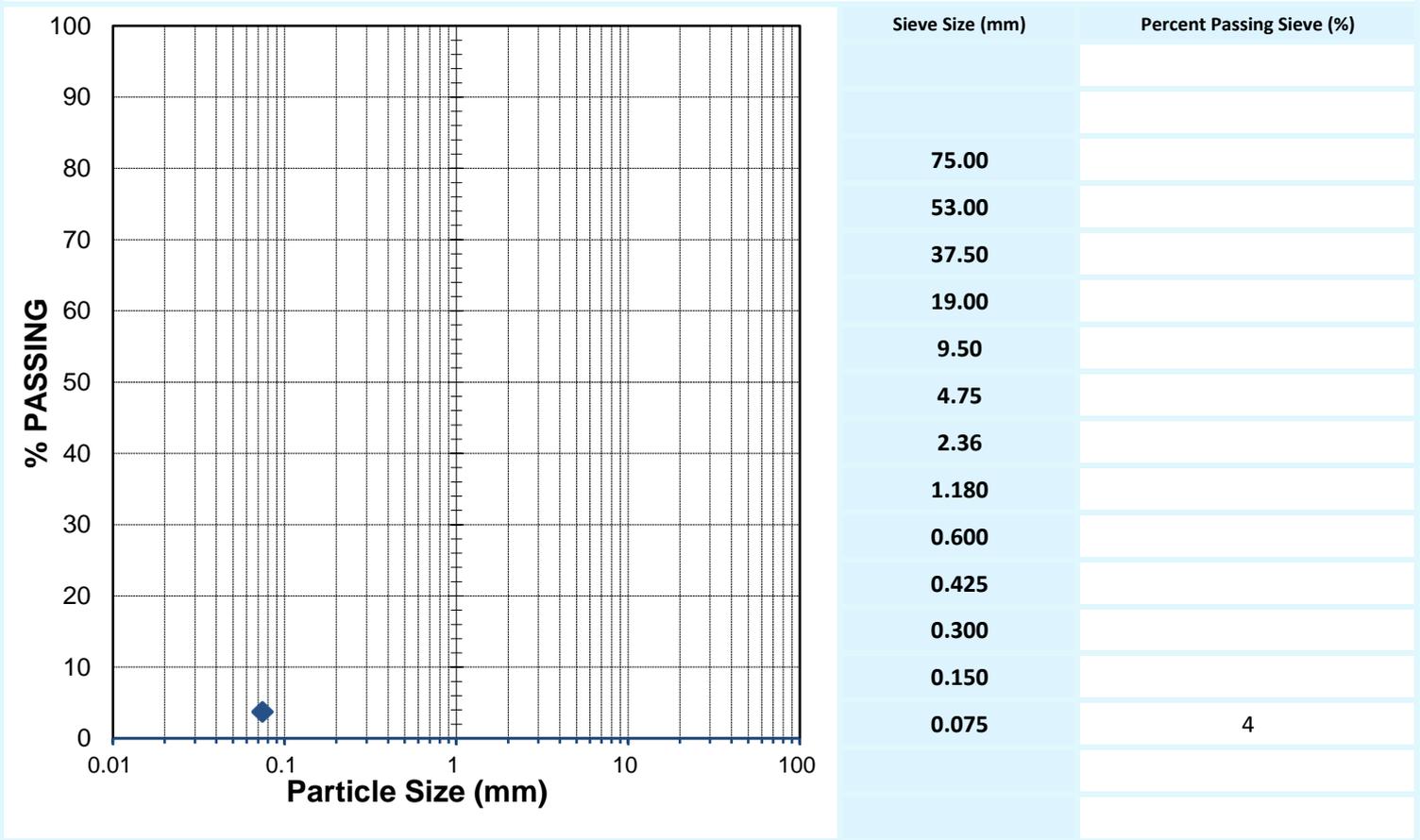


SOIL CLASSIFICATION TEST REPORT

Client	Brown Geotechnical	Ticket No.	S2587
Client Address	PO Box 278, Como WA	Report No.	LLS18/5441_1_%FINES
Project	Keirnan Street	Sample No.	LLS18/5441
Sampling Location	Mundijong	Sampled By	Client
Sample Identification	TH04 0.0-0.15m		
Sampling Method	Sampled by Client, Tested as Received	Preparation Method	AS1289.1.1
Sample History	Air Dried	Wet or Dry Sieved	Dry Sieved

PARTICLE SIZE DISTRIBUTION - ANALYSIS BY SIEVING

AS 1289.3.6.1



Comments: *Client request of % fines only*



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Accreditation No. 19872
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Matt van Herk
Approved Signatory

Name: Matt van Herk
Function: Laboratory Manager
Issue Date: 26-November-2018

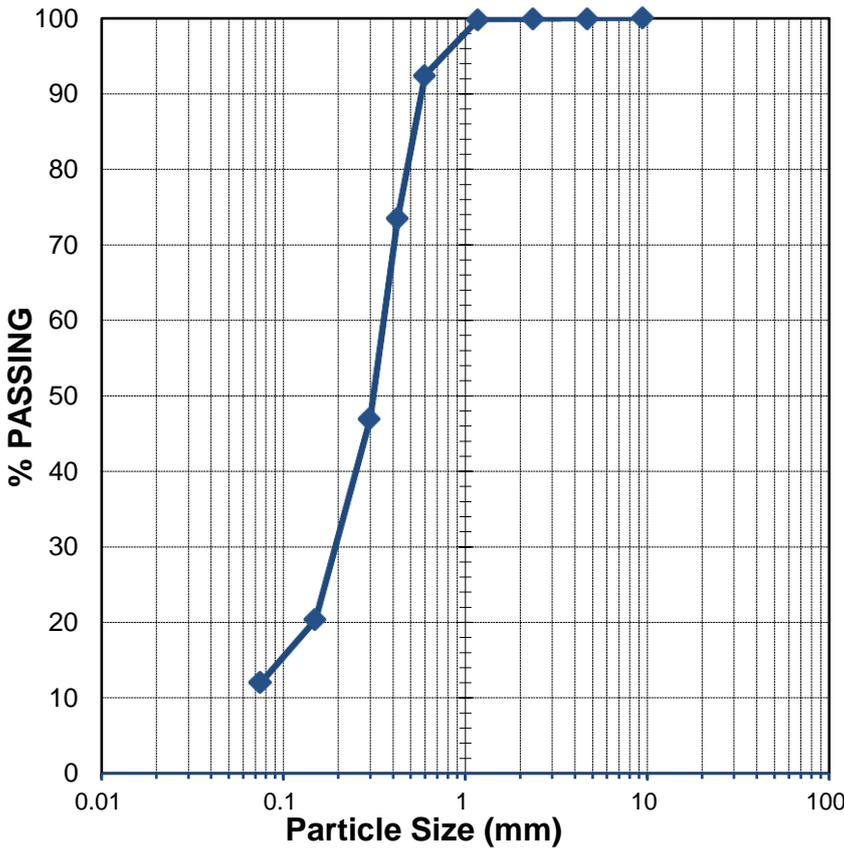


SOIL CLASSIFICATION TEST REPORT

Client	Brown Geotechnical	Ticket No.	S2587
Client Address	PO Box 278 Como, WA 6952	Report No.	LLS18/5442_1_PSD
Project	Keirnan Street	Sample No.	LLS18/5442
Sampling Location	Mundijong	Sampled By	Client
Sample Identification	TH5 0.3-1.0m		
Sampling Method	Sampled by Client, Tested as Received	Preparation Method	AS1289.1.1
Sample History	Air Dried	Wet or Dry Sieved	Dry Sieved

PARTICLE SIZE DISTRIBUTION - ANALYSIS BY SIEVING

AS 1289.3.6.1



Sieve Size (mm)	Percent Passing Sieve (%)
75.00	
53.00	
37.50	
19.00	
9.50	100
4.75	100
2.36	100
1.180	100
0.600	92
0.425	73
0.300	47
0.150	20
0.075	12

Comments:



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Matt van Herk
Approved Signatory

Name: Matt van Herk
Function: Laboratory Manager
Issue Date: 26-November-2018



MODIFIED DRY DENSITY & MOISTURE CONTENT RELATION OF SOIL TEST REPORT

AS 1289.5.2.1

Client	Brown Geotechnical	Ticket No.	S2597
Client Address	PO Box 278 Como, WA 6952	Report No.	LLS18/5442_1_MMDD
Project	Keirnan Street	Sample No.	LLS18/5442
Sampling Location	Mundijong	Date Received	17/11/2018
Sample Identification	TH5 0.3-1.0m	Date Tested	19/11/2018
Sampling Method	Sampled by Client, Tested as Received	Preparation Method	AS1289.1.1
Liquid Limit Method	Visual/tactile assessment by competent technician	Sample Curing Time	2 Hours

Overflow Material

Retained 19.0mm (%)	0
Retained 37.5mm (%)	-

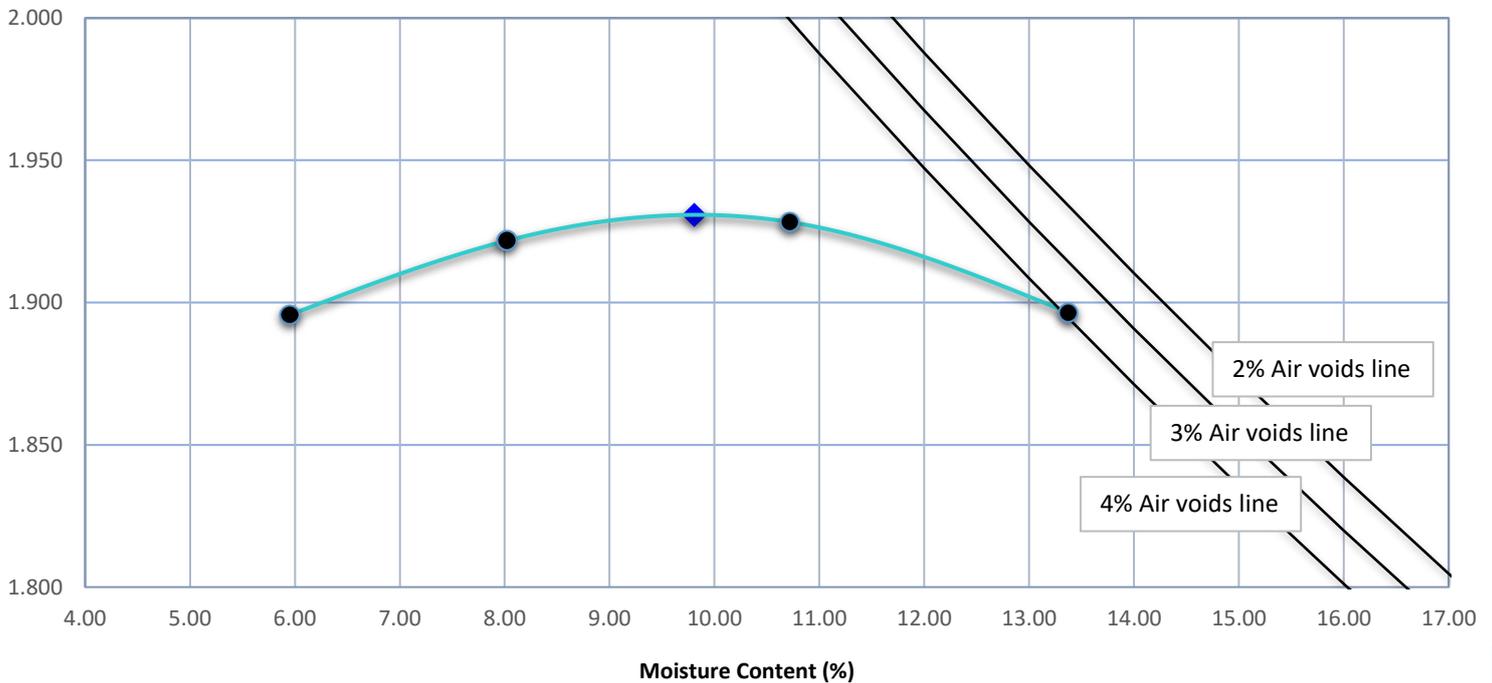
AS 1289.5.2.1, 2.1.1, 1.1

Laboratory Moisture & Density Results

Moisture Content (%)	8.0	10.7	13.4	6.0
Dry Density (t/m ³)	1.922	1.928	1.896	1.896

Plot: Dry Density vs. Moisture Content

Dry Density (t/m³)



Modified Maximum Dry Density (t/m³) 1.93

Modified Optimum Moisture Content (%) 10.0

Comments:

The above air void lines are derived from a calculated apparent particle density of 2.681 t/m³



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Accreditation No. 19872

WORLD RECOGNISED ACCREDITATION This document may not be reproduced except in full.

Approved Signatory:

Name: Matt van Herk
Function: Laboratory Manager
Date: 26-November-2018



CALIFORNIA BEARING RATIO TEST REPORT

AS 1289.2.1.1, 5.2.1, 6.1.1

Client	Brown Geotechnical	Ticket No.	S2587
Client Address	PO Box 278 Como WA	Report No.	LLS18/5442_1_SCBR
Project	Keirnan Street	Sample No.	LLS18/5442
Sampling Location	Mundijong	Sampled By	Client
Sample Identification	TH5 0.3-1.0m	Sample Description	Silty Sand
Date Sampled	-	Date Tested	24/11/2018
Sampling Method:	Sampled by Client, Tested as Received	Preparation Method	AS 1289.1.1

Compaction Details

% Retained 19.0mm	0	Excluded/Replaced	Excluded
Liquid Limit Determined by	Estimated	Curing Time (Hrs)	2.0
Maximum Dry Density (t/m ³)	1.93	Optimum Moisture (%)	10.0
Target Dry Density Ratio (%)	96	Target Moisture Ratio (%)	100

Specimen Conditions At Compaction

Dry Density (t/m ³)	1.85	Moisture Content (%)	10.0
Density Ratio (%)	96.0	Moisture Ratio (%)	102.5

Specimen Conditions After Soak

Soaked or Unsoaked	Soaked	Soaking Period (days)	4
Surcharges Applied (kg)	4.50	Measured Swell (%)	0.0
Dry Density (t/m ³)	1.85	Dry Density Ratio (%)	96.0
Moisture Content (%)	13.1	Moisture Ratio (%)	134.0

Specimen Conditions After Test

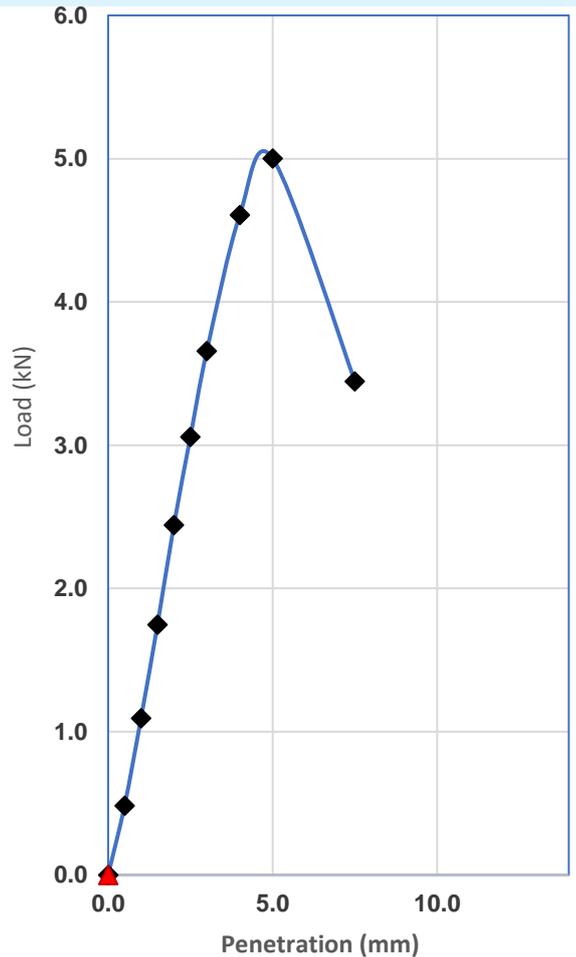
Top 30mm Moisture (%)	12.5	Remaining Depth (%)	11.7
-----------------------	------	---------------------	------

California Bearing Ratio (CBR)

Determined at a Penetration of

Correction applied to Penetration

25%
5.0mm
-



Comments:

Approved Signatory

Name: Matt van Herk
Function: Laboratory Manager
Issue Date: 26/11/2018

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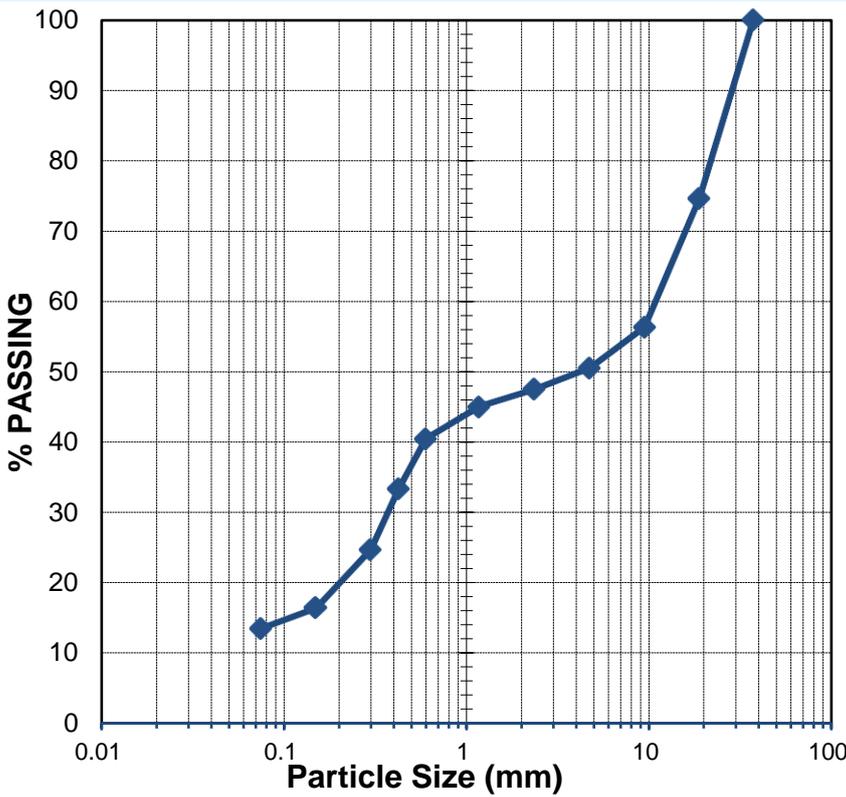


SOIL CLASSIFICATION TEST REPORT

Client	Brown Geotechnical	Ticket No.	S2587
Client Address	PO Box 278 Como, WA 6952	Report No.	LLS18/5448_1_PSDPI
Project	Keirnan Street	Sample No.	LLS18/5448
Sampling Location	Mundijong	Sampled By	Client
Sample Identification	TH7 1.2-1.6m		
Sampling Method	Sampled by Client, Tested as Received	Preparation Method	AS1289.1.1
Sample History	Air Dried	Wet or Dry Sieved	Dry Sieved

PARTICLE SIZE DISTRIBUTION - ANALYSIS BY SIEVING

AS 1289.3.6.1



Sieve Size (mm)	Percent Passing Sieve (%)
75.00	
53.00	
37.50	100
19.00	75
9.50	56
4.75	50
2.36	47
1.180	45
0.600	40
0.425	33
0.300	25
0.150	16
0.075	13

CONSISTENCY LIMITS

AS 1289.3.1.1	AS 1289.3.2.1	AS1289.3.3.1	AS 1289.3.4.1		
Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Mould Length (mm)	Condition of Dried Specimen
46	17	29	10.0	250	Curled,

Comments: _____



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Name: Brooke Elliott
Function: Quality Manager
Issue Date: 26-November-2018

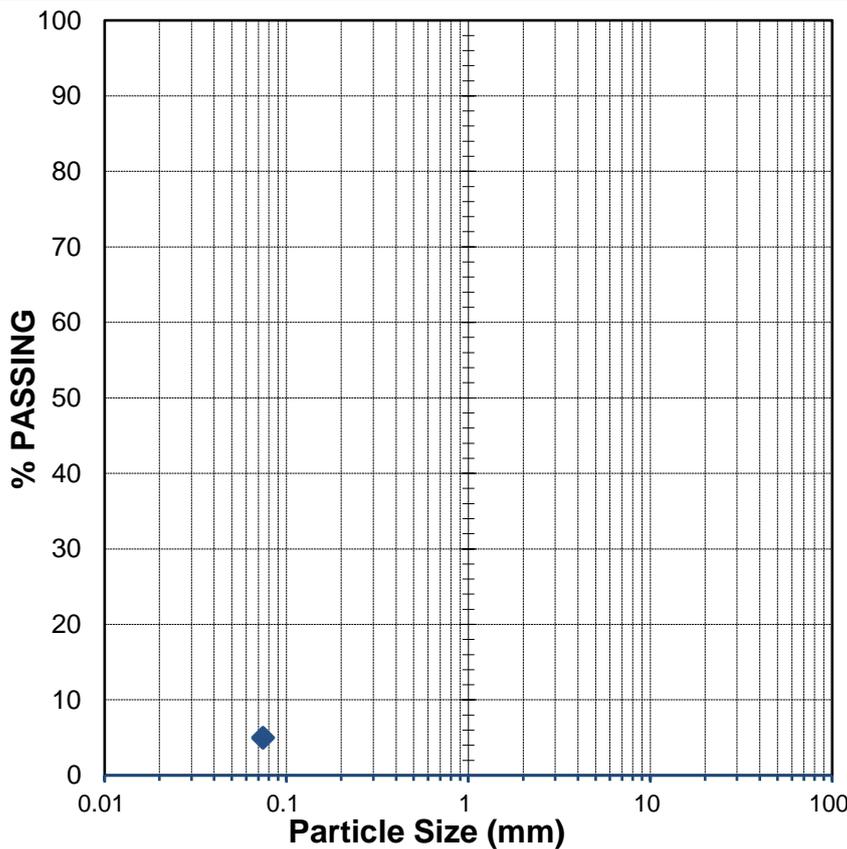


SOIL CLASSIFICATION TEST REPORT

Client	Brown Geotechnical	Ticket No.	S2587
Client Address	PO Box 278 Como WA	Report No.	LLS18/5443_1_%FINES
Project	Keirnan Street	Sample No.	LLS18/5443
Sampling Location	Mundijong	Sampled By	Client
Sample Identification	TH10 0.0-0.15m		
Sampling Method	Sampled by Client, Tested as Received	Preparation Method	AS1289.1.1
Sample History	Air Dried	Wet or Dry Sieved	Dry Sieved

PARTICLE SIZE DISTRIBUTION - ANALYSIS BY SIEVING

AS 1289.3.6.1



Sieve Size (mm)	Percent Passing Sieve (%)
75.00	
53.00	
37.50	
19.00	
9.50	
4.75	
2.36	
1.180	
0.600	
0.425	
0.300	
0.150	
0.075	5

Comments: *Client request of % fines only*



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Issue Date: 26-November-2018

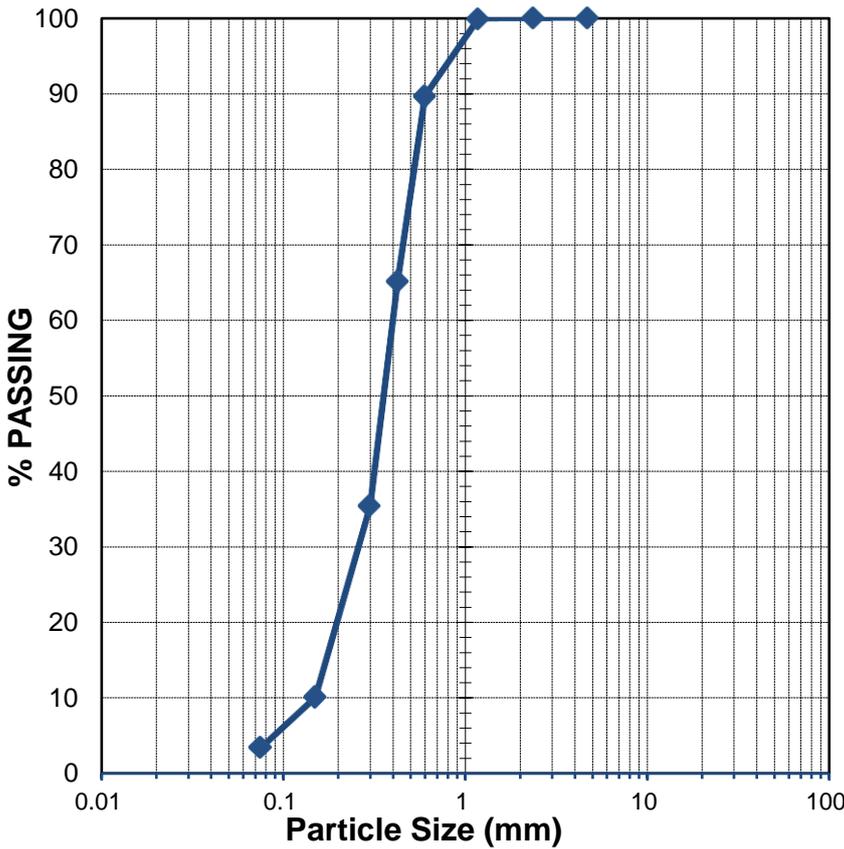


SOIL CLASSIFICATION TEST REPORT

Client	Brown Geotechnical	Ticket No.	S2587
Client Address	PO Box 278 Como WA	Report No.	LLS18/5444_1_PSD
Project	Keinan Street	Sample No.	LLS18/5444
Sampling Location	Mundijong	Sampled By	Client
Sample Identification	TH15 0.3-1.0m		
Sampling Method	Sampled by Client, Tested as Received	Preparation Method	AS1289.1.1
Sample History	Air Dried	Wet or Dry Sieved	Dry Sieved

PARTICLE SIZE DISTRIBUTION - ANALYSIS BY SIEVING

AS 1289.3.6.1



Sieve Size (mm)	Percent Passing Sieve (%)
75.00	
53.00	
37.50	
19.00	
9.50	
4.75	100
2.36	100
1.180	100
0.600	90
0.425	65
0.300	35
0.150	10
0.075	3

Comments: _____



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 Name: Matt van Herk
 Function: Laboratory Manager
 Issue Date: 26-November-2018



MODIFIED DRY DENSITY & MOISTURE CONTENT RELATION OF SOIL TEST REPORT

AS 1289.5.2.1

Client	Brown Geotechnical	Ticket No.	S2597
Client Address	PO Box 278 Como, WA 6952	Report No.	LLS18/5444_1_MMDD
Project	Keirnan Street	Sample No.	LLS18/5444
Sampling Location	Mundijong	Date Received	17/11/2018
Sample Identification	TH15 0.3-1.0m	Date Tested	19/11/2018
Sampling Method	Sampled by Client, Tested as Received	Preparation Method	AS1289.1.1
Liquid Limit Method	Visual/tactile assessment by competent technician	Sample Curing Time	2 Hours

Overflow Material

Retained 19.0mm (%)	0
Retained 37.5mm (%)	-

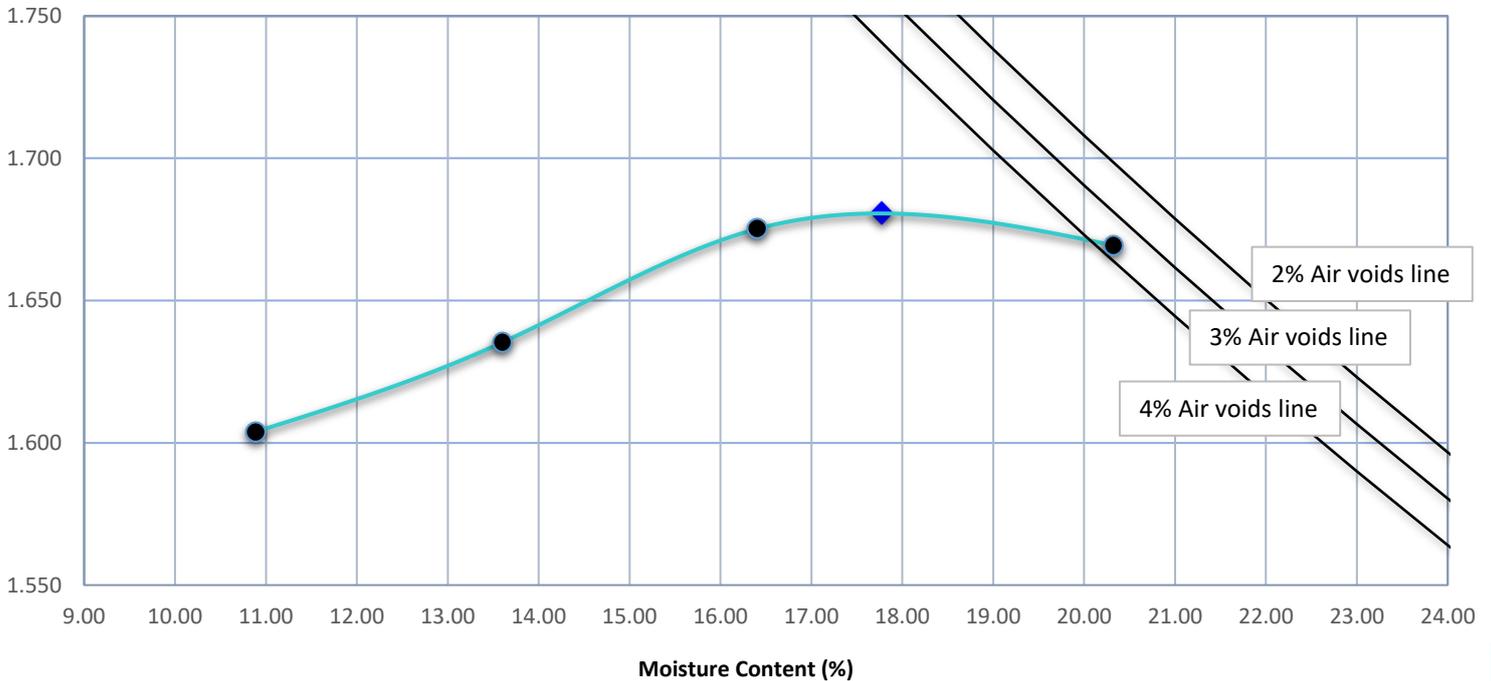
AS 1289.5.2.1, 2.1.1, 1.1

Laboratory Moisture & Density Results

Moisture Content (%)	10.9	13.6	16.4	20.3
Dry Density (t/m ³)	1.604	1.635	1.675	1.669

Plot: Dry Density vs. Moisture Content

Dry Density (t/m³)



Modified Maximum Dry Density (t/m³) **1.68**

Modified Optimum Moisture Content (%) **18.0**

Comments:

The above air void lines are derived from a calculated apparent particle density of 2.675 t/m³



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Date: 26-November-2018

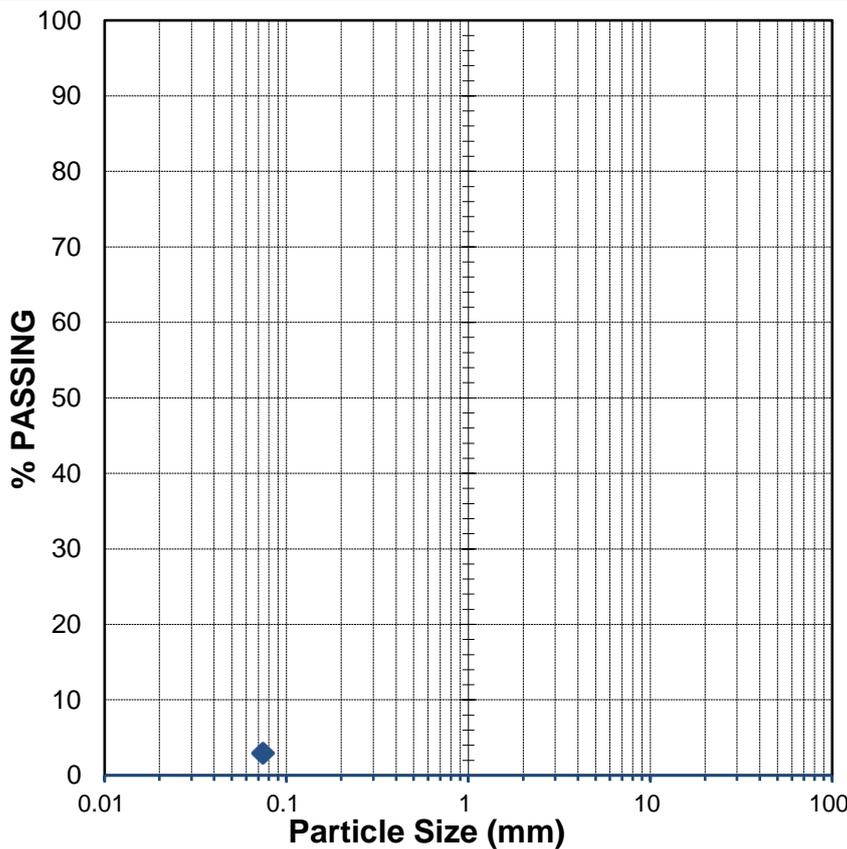


SOIL CLASSIFICATION TEST REPORT

Client	Brown Geotechnical	Ticket No.	S2587
Client Address	PO Box 278 Como WA	Report No.	LLS18/5445_1_%FINES
Project	Keirnan Street	Sample No.	LLS18/5445
Sampling Location	Mundijong	Sampled By	Client
Sample Identification	TH16 0.0-0.1m		
Sampling Method	Sampled by Client, Tested as Received	Preparation Method	AS1289.1.1
Sample History	Air Dried	Wet or Dry Sieved	Dry Sieved

PARTICLE SIZE DISTRIBUTION - ANALYSIS BY SIEVING

AS 1289.3.6.1



Sieve Size (mm)	Percent Passing Sieve (%)
75.00	
53.00	
37.50	
19.00	
9.50	
4.75	
2.36	
1.180	
0.600	
0.425	
0.300	
0.150	
0.075	3

Comments: *Client request of % fines only*



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Function: Laboratory Manager
Issue Date: 26-November-2018

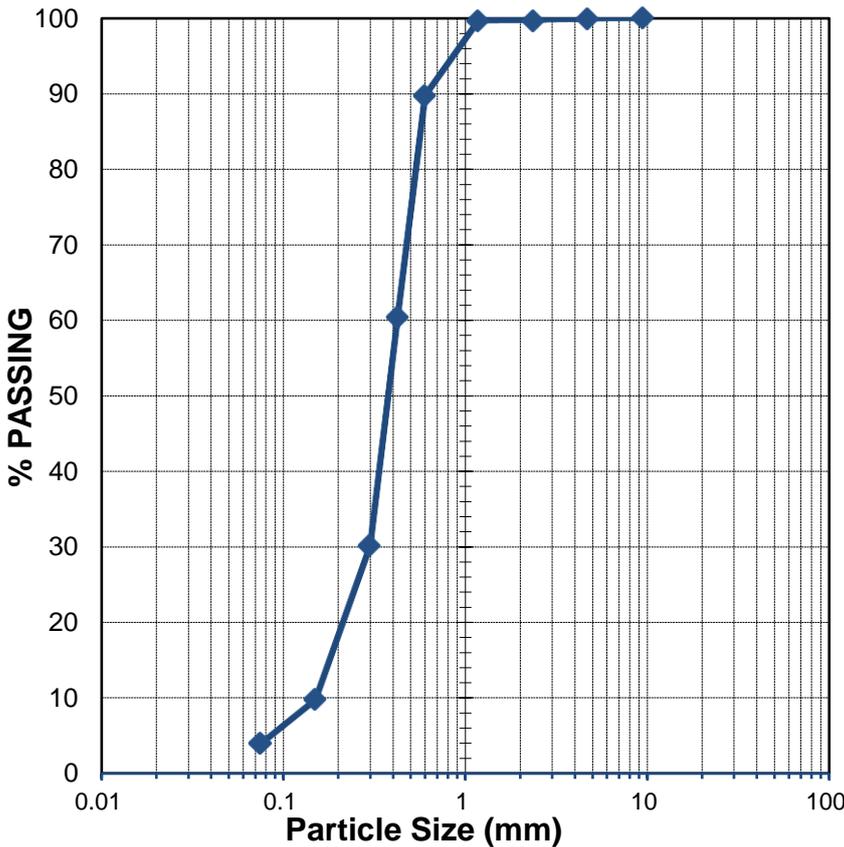


SOIL CLASSIFICATION TEST REPORT

Client	Brown Geotechnical	Ticket No.	S2587
Client Address	PO Box 278 Como, WA 6952	Report No.	LLS18/5446_1_PSD
Project	Keirnan Street	Sample No.	LLS18/5446
Sampling Location	Mundijong	Sampled By	Client
Sample Identification	TH19 0.5-1.5m		
Sampling Method	Sampled by Client, Tested as Received	Preparation Method	AS1289.1.1
Sample History	Air Dried	Wet or Dry Sieved	Dry Sieved

PARTICLE SIZE DISTRIBUTION - ANALYSIS BY SIEVING

AS 1289.3.6.1



Sieve Size (mm)	Percent Passing Sieve (%)
75.00	
53.00	
37.50	
19.00	
9.50	100
4.75	100
2.36	100
1.180	100
0.600	90
0.425	60
0.300	30
0.150	10
0.075	4

Comments:



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Approved Signatory

Name: Matt van Herk
Function: Laboratory Manager
Issue Date: 26-November-2018

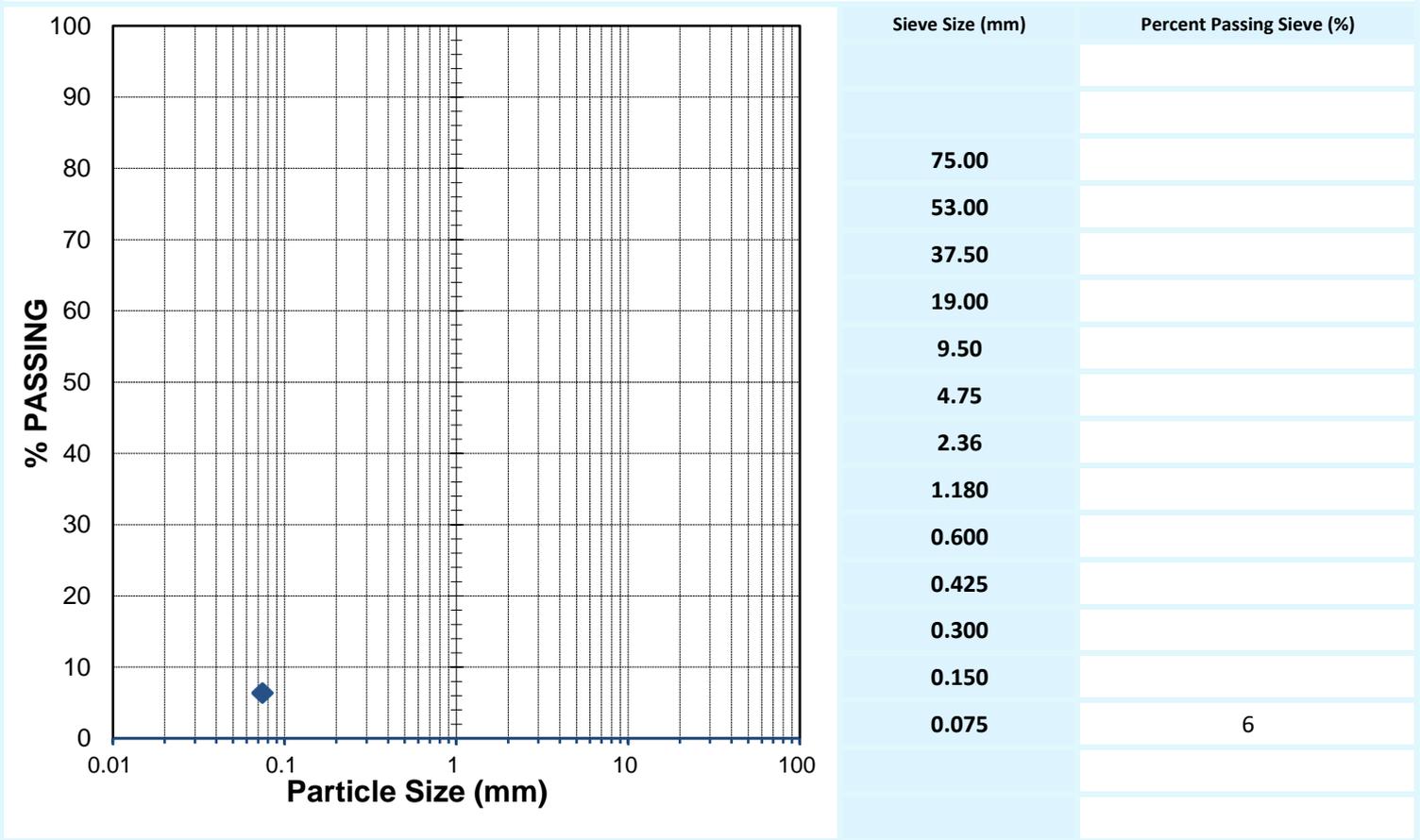


SOIL CLASSIFICATION TEST REPORT

Client	Brown Geotechnical	Ticket No.	S2587
Client Address	PO Box 278 Como WA	Report No.	LLS18/5447_1_%FINES
Project	Keirnan Street	Sample No.	LLS18/5447
Sampling Location	Mundijong	Sampled By	Client
Sample Identification	TH23 0.0-0.2m		
Sampling Method	Sampled by Client, Tested as Received	Preparation Method	AS1289.1.1
Sample History	Air Dried	Wet or Dry Sieved	Dry Sieved

PARTICLE SIZE DISTRIBUTION - ANALYSIS BY SIEVING

AS 1289.3.6.1



Comments: *Client request of % fines only*



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Matt van Herk
Approved Signatory

Name: Matt van Herk
Function: Laboratory Manager
Issue Date: 26-November-2018



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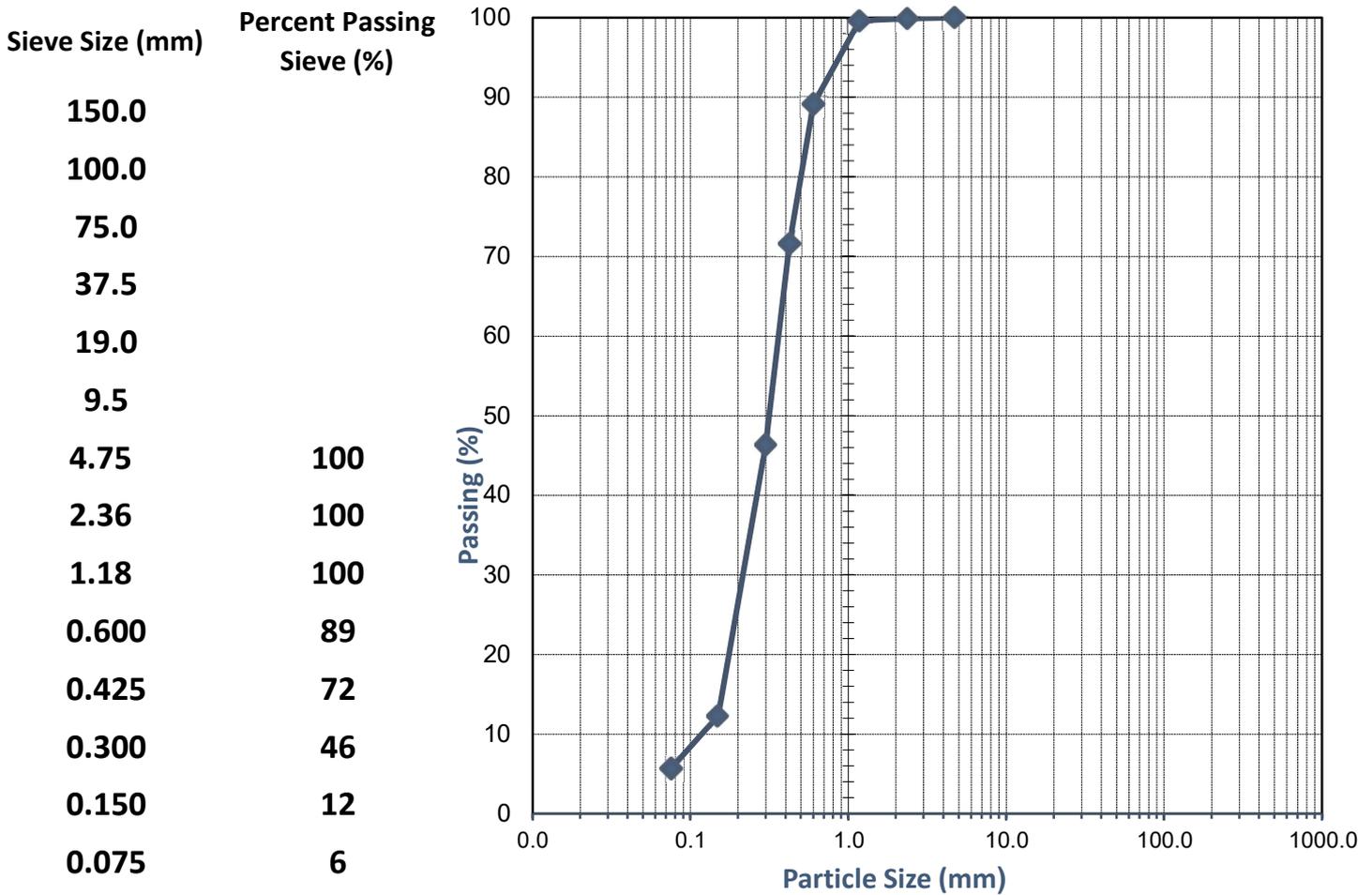
TEST REPORT - AS 1289.3.6.1

Client:	Brown Geotechnical	Ticket No.	S820
Client Address:	PO Box 278 Como, WA	Report No.	WG20/3379_1_PSD
Project:	Lot 50 Kiernan St	Sample No.	WG20/3379
Location:	Mundijong	Date Sampled:	23/01/2020
Sample Identification:	TH25 0.5-1.5m	Date Tested:	29/01/2020

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method:

Sampled by Client, Tested as Received



Comments:

Approved Signatory: *KMcConachy*

Name: Kirk McConachy

Function: Laboratory Manager

Date: 31/January/2020



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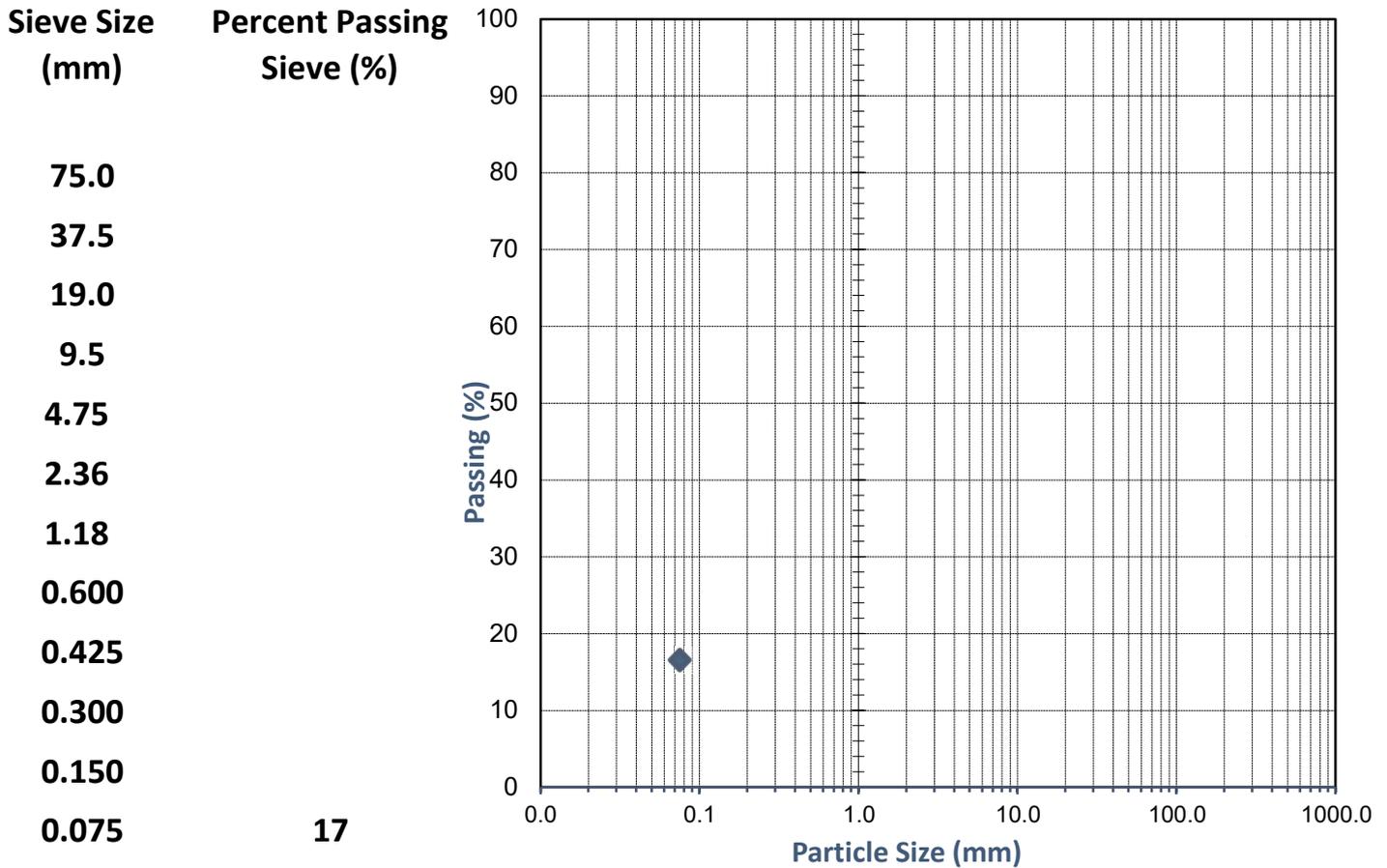
TEST REPORT - AS 1289.3.6.1 (% Fines)

Client:	Brown Geotechnical	Ticket No.	S820
Client Address:	PO Box 278 Como, WA	Report No.	WG20/3380_1_%FINES
Project:	Lot 50 Kiernan St	Sample No.	WG20/3380
Location:	Mundijong	Date Sampled:	23/01/2020
Sample Identification:	TH30 1.9-2.1m	Date Tested:	29/01/2020

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method:

Sampled by Client, Tested as Received



Comments: Clients request for the % Fines of Material passing 0.075mm only.

Approved Signatory: *KMcConachy*

Name: Kirk McConachy

Function: Laboratory Manager

Date: 31/January/2020



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TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Brown Geotechnical	Ticket No.	S820
Client Address:	PO Box 278 Como, WA	Report No.	WG20/3380_1_PI
Project:	Lot 50 Kiernan St	Sample No.	WG20/3380
Location:	Mundijong	Date Sampled:	23-01-2020
Sample Identification:	TH30 1.9-2.1m	Date Tested	30-01-2020

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:

Sampled by Client, Tested as Received

History of Sample:

Oven Dried <50°

Method of Preparation:

Dry Sieved

AS 1289.3.1.1	Liquid Limit (%)	24
AS 1289.3.2.1	Plastic Limit (%)	11
AS 1289.3.3.1	Plasticity Index (%)	13
AS 1289.3.4.1	Linear Shrinkage (%)	3.0
AS 1289.3.4.1	Length of Mould (mm)	250
AS 1289.3.4.1	Condition of Dry Specimen:	Cracked, Curled

Comments:

Approved Signatory:

Name: Brooke Elliott

Function: Quality Manager

Date: 04-February-2020



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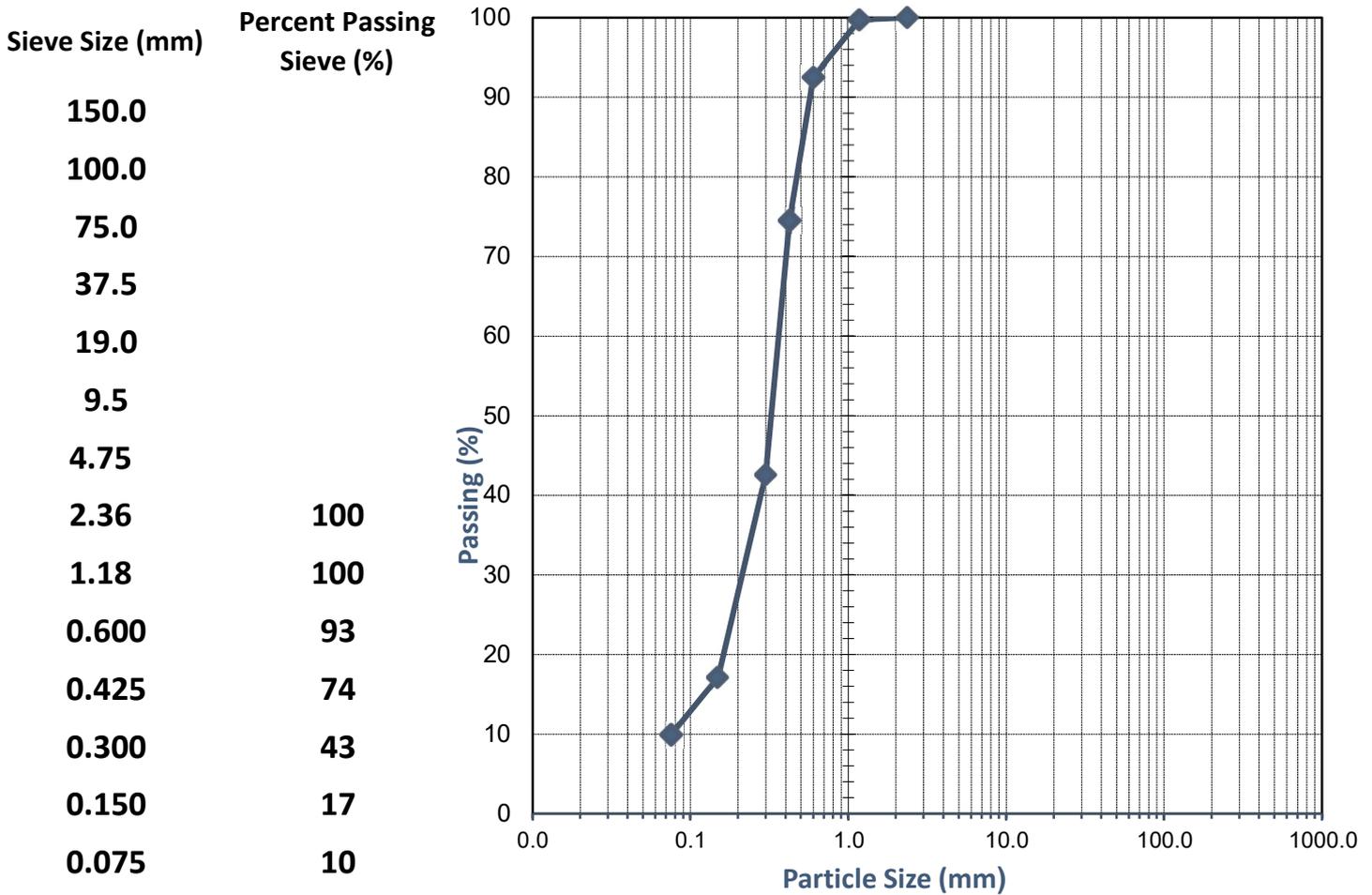
TEST REPORT - AS 1289.3.6.1

Client:	Brown Geotechnical	Ticket No.	S820
Client Address:	PO Box 278 Como, WA	Report No.	WG20/3381_1_PSD
Project:	Lot 50 Kiernan St	Sample No.	WG20/3381
Location:	Mundijong	Date Sampled:	23/01/2020
Sample Identification:	TH36 0.3-1.0m	Date Tested:	29/01/2020

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method:

Sampled by Client, Tested as Received



Comments:

Approved Signatory: *KMcConachy*

Name: Kirk McConachy

Function: Laboratory Manager

Date: 31/January/2020



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TEST REPORT - AS 1289.5.2.1

Client:	Brown Geotechnical	Ticket No.	S820
Client Address:	PO Box 278 Como, WA	Report No.	WG20/3381_1_MMDD
Project:	Lot 50 Kiernan St	Sample No.	WG20/3381
Location:	Mundijong	Date Sampled:	23/01/2020
Sample Identification:	TH36 0.3-1.0m	Date Tested:	28/01/2020

TEST RESULTS - Modified Maximum Dry Density

Sampling Method:

Sampled by Client, Tested as Received

Sample Curing Time:

2 Hours

Method used to Determine Liquid Limit:

Visual / Tactile Assessment by Competent Technician

Material + 19.0mm (%):

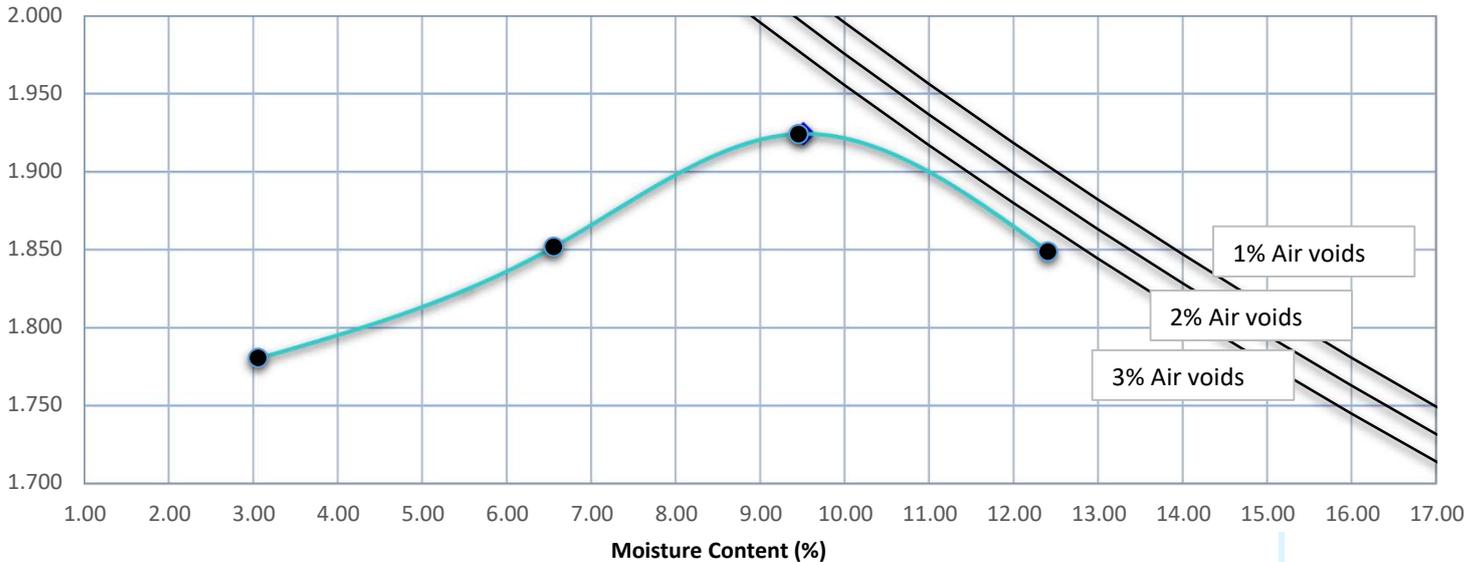
0

Material + 37.5mm (%)

-

Moisture Content (%)	3.1	6.6	9.5	12.4	
Dry Density (t/m³)	1.780	1.852	1.924	1.849	

Dry Density (t/m³)



Modified Maximum Dry Density (t/m³)

1.92

Optimum Moisture Content (%)

9.5

Comments: The above air void lines are derived from a calculated apparent particle density of 2.525 t/m³

Approved Signatory:

Name: Kirk McConachy

Function: Laboratory Manager

Date: 31/January/2020



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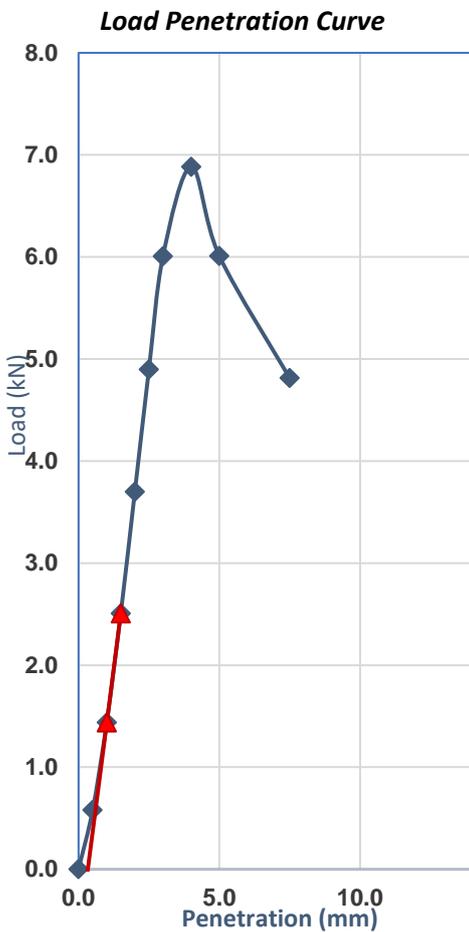
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TEST REPORT - AS 1289.6.1.1

Client:	Brown Geotechnical	Ticket No.	S820
Client Address:	PO Box 278 Como, WA	Report No.	WG20/3381_1_SCBR
Project:	Lot 50 Kiernan St	Sample No.	WG20/3381
Location:	Mundijong	Date Sampled:	23-01-2020
Sample Identification:	TH36 0.3-1.0m	Date Tested:	3-02-2020

TEST RESULTS - CALIFORNIA BEARING RATIO

Sample Description: Silty Sand, trace Gravel
Sampling Method: Sampled by Client, Tested as Received



Compaction Details			
Compaction Method	AS 1289.5.2.1	Hammer Type	Modified
Plasticity Determined by	Estimated	Curing Time (Hours)	2.0
% Retained 19.0mm	0	Excluded/Replaced	Excluded
Maximum Dry Density (t/m ³)	1.92	Optimum Moisture (%)	9.5
Target Dry Density Ratio (%)	96	Target Moisture Ratio (%)	100

Specimen Conditions At Compaction			
Dry Density (t/m ³)	1.85	Moisture Content (%)	9.3
Density Ratio (%)	96.0	Moisture Ratio (%)	98.0

Specimen Conditions After Soak			
Soaked or Unsoaked	Soaked	Soaking Period (days)	4
Surcharges Applied (kg)	4.50	Measured Swell (%)	0.0
Dry Density (t/m ³)	1.85	Dry Density Ratio (%)	96.0
Moisture Content (%)	12.5	Moisture Ratio (%)	131.5

Specimen Conditions After Test			
Top 30mm Moisture (%)	11.2	Remaining Depth (%)	11.4

Correction applied to Penetration: 0.3mm
Determined at a Penetration of: 2.5mm
California Bearing Ratio (CBR): 45%

Comments:

Approved Signatory:

Name: Brooke Elliott

Function: Quality Manager

Date: 04-February-2020



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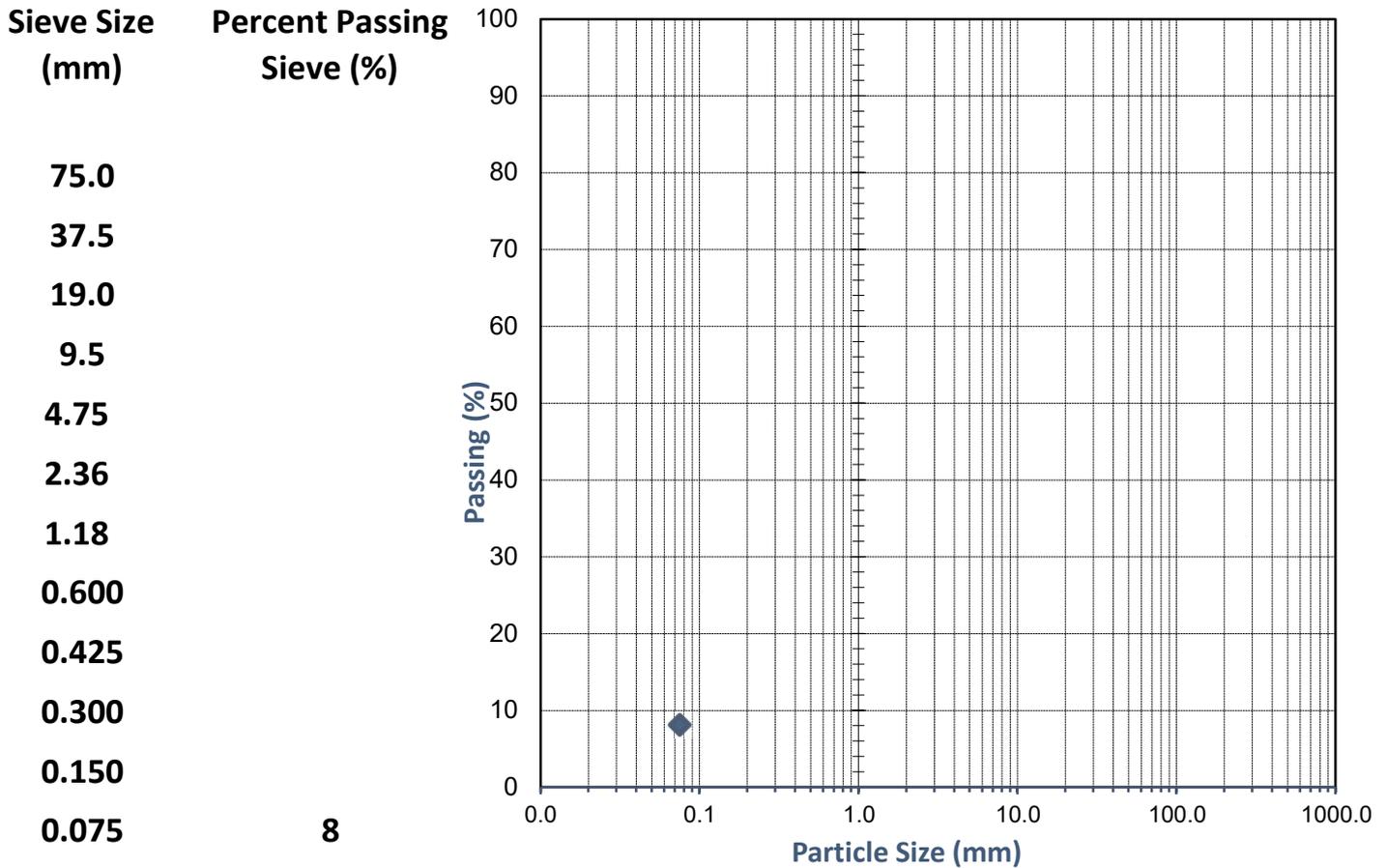
TEST REPORT - AS 1289.3.6.1 (% Fines)

Client:	Brown Geotechnical	Ticket No.	S820
Client Address:	PO Box 278 Como, WA	Report No.	WG20/3382_1_%FINES
Project:	Lot 50 Kiernan St	Sample No.	WG20/3382
Location:	Mundijong	Date Sampled:	23/01/2020
Sample Identification:	TH37 0-0.15m	Date Tested:	29/01/2020

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method:

Sampled by Client, Tested as Received



Comments: Clients request for the % Fines of Material passing 0.075mm only.

Approved Signatory: *K McConachy*

Name: Kirk McConachy

Function: Laboratory Manager

Date: 31/January/2020



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& Laboratory Services

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TEST REPORT - ASTM D2974-14 (Test Method C)

Client:	Brown Geotechnical	Ticket No.	S820
Client Address:	PO Box 278 Como, WA	Report No.	WG20/3382_1_ORG
Project:	Lot 50 Kiernan St	Sample No.	WG20/3382
Location:	Mundijong	Date Sampled:	23/01/2020
Sample Identification:	TH37 0-0.15m	Date Tested:	28/01/2020

TEST RESULTS - Organic Content

Sampling Method:

Sampled by Client, Tested as Received

Testing Completed By:

CO - WGLS

Furnace Temperature (°):

441

Sample Number	Sample Identification	Ash Content (%)	Organic Content (%)
WG20/3382	TH37 0-0.15m	91.8	8.2

Comments:

Approved Signatory:

Name: Kirk McConachy

Function: Laboratory Manager

Date: 31/January/2020



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ANNEXURE 7
Stormwater Modelling Report
Calibre



LOTS 11 TO 14 KIERNAN ST, MUNDIJONG
STORMWATER MODELLING REPORT

PREPARED FOR DJ MACCORMICK PROPERTY GROUP

COMMERCIAL IN CONFIDENCE

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PO BOX Z5426, ST GEORGES TERRACE, PERTH 6831

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www.calibregroup.com

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[18-001031]

ISSUE	DATE	ISSUE DETAILS	AUTHOR	CHECKED	APPROVED
REV-A	7.12.2018	For Client Review	Sarah Main	Brendan Oversby	Brendan Oversby

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1. Executive Summary

Calibre have been commissioned by DJ Maccormick Property Group ('the client') to complete a drainage analysis of the eastern culvert entering the subject land (Culvert A1) and the affects (if any) blocking the culvert has on the downstream Manjedal Brook, shown on Figure 1.

Consisting of approximately 15.80 ha of degraded pasture, the subject land is located on the corner of Soldiers Rd and Keirnan St within Mundijong. The topography of the site generally falls east to west, discharging into the neighbouring property abutting the western boundary. Discharge from the Subject Land eventually enters Manjedal Brook and ultimately Folly River further downstream.

Several stormwater models have been completed over the area since 2007, in support of various stormwater management documents. These include the Mundijong Floodplain Management Strategy (SKM, 2007), Mundijong-Whitby DWMS (GHD, 2010) and the Whitby LWMS (Cardno, 2011), none of which included Culverts A1, B1, B2 and C1. However, whilst the recent Birrega and Oaklands flood modelling and drainage study (DWER, 2015) did not include the culverts, it did show stormwater overflowing Soldiers Rd into the subject land in line with the existing degraded surface water feature which currently traverses the subject land.

The proposed strategy will utilise results of the 2015 Birrega and Oaklands flood study, in conjunction with the Whitby LWMS.



Figure 1 - Location Plan

2. Existing Site Conditions

2.1 Landform and Existing Drainage

The subject land generally slopes from east to west with a high point in the south-eastern corner of 41.30mAHD, falling to 34.80mAHD in the north-eastern corner at an approximate 1:80 (v:h) gradient. A degraded surface channel runs through the site in line with topography with the upstream end lying adjacent to the 450mm Culvert A1.

Manjedal Brook is located adjacent to the northern boundary of the site, discharging west under Soldiers Rd (Figure 2). Surface runoff generated within the subject land will ultimately discharge into the Manjedal Brook.

2.2 Surface Geology

Perth Metropolitan Region 1:50k environmental geology series (GSWA, 1980) shows the site consists of shallow sands (S10) overlying sandy clays of the Guildford Formation (Cs). Some alluvial sandy silts are found in the north-eastern portion of the site (Msc1), associated with surface water flows in the Manjedal Brook (Figure 2).

Infiltration potential across the site is expected to be minimal due to the presence of clay sands and a shallow groundwater table. For this reason infiltration has not been included in the stormwater model.

2.3 Wetland Mapping

Geomorphic wetland mapping of the swan coastal plain (DWER, 2015) shows a conservation category wetland over a portion of the Soldiers Rd reserve and Manjedal Brook. The wetland (UFI 15446) is classified as a flat seasonally water-logged palusplain, which discharges directly into the Manjedal Brook.

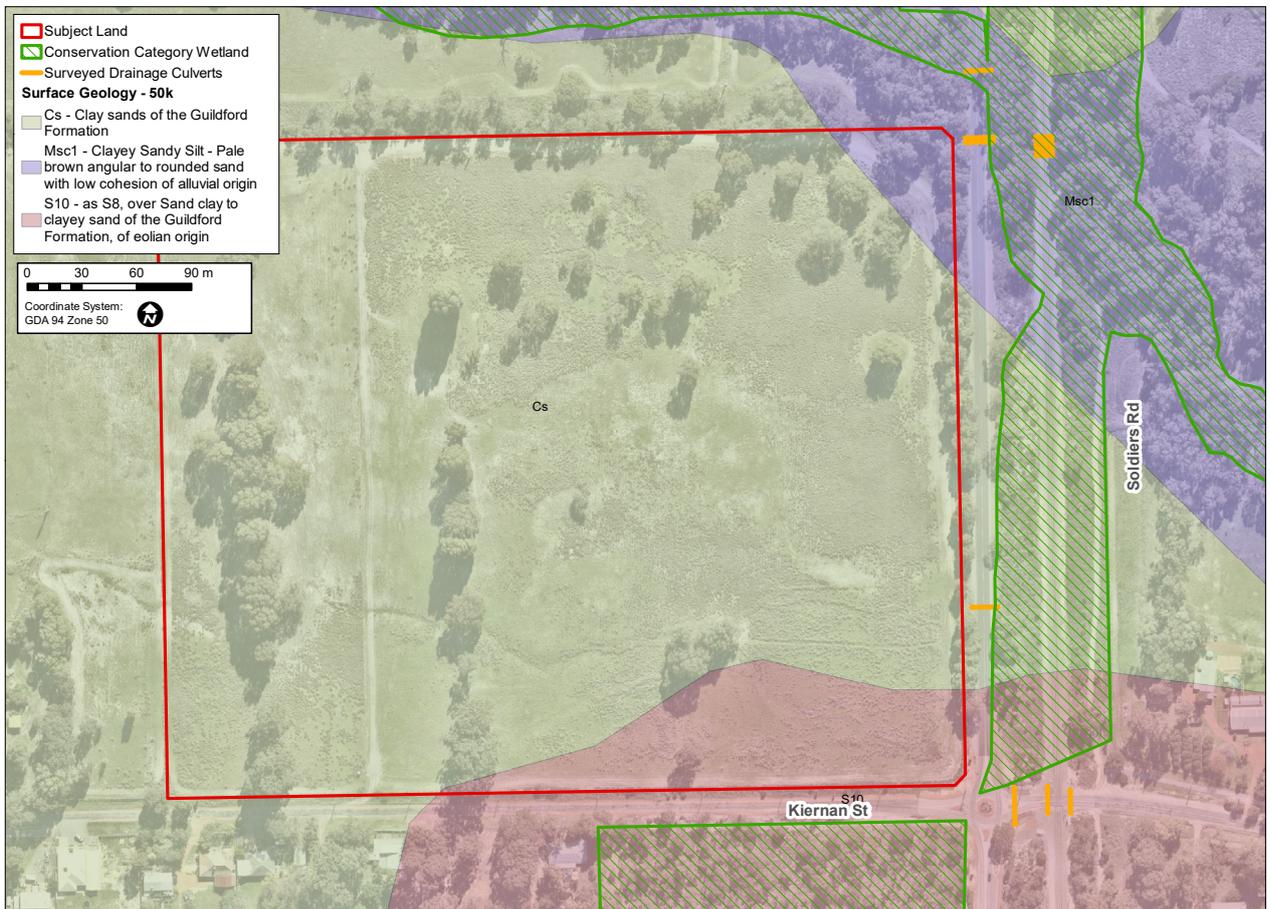
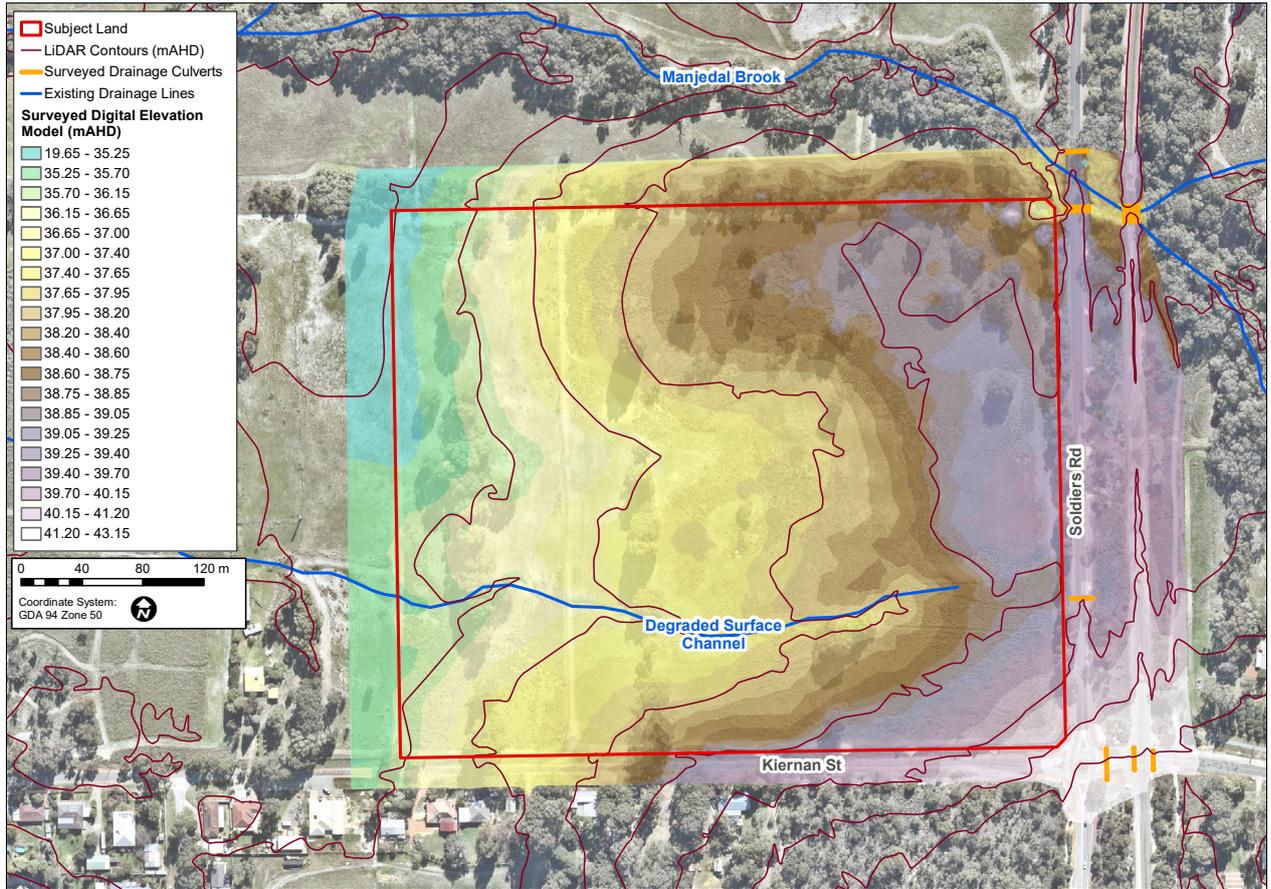


Figure 2 - Existing Environment

3. Stormwater Modelling

3.1 Regional Modelling

3.1.1 Mundijong Floodplain Management Strategy (SKM, 2007)

A Floodplain Management Study including 2-dimensional flood modelling (MIKE Flood) was completed by SKM in 2007 on behalf of the Department of Water and Environmental Regulation (DWER). This study simulated a number of design storms of varying intensity, frequency, and duration. The study found that the 6-hour duration storm was the critical storm for most of the study area. However, it is noted that the establishment of at least one flow gauging site to enable calibration of the flood model is needed in future.

Results from the model indicates the peak 1% AEP flood level within Manjedal Brook upstream of Soldiers Rd is approximately 39.20mAHD. However, the model did not include Culverts A1, B1, B2 or C1 (Figure 3).

3.1.2 Mundijong-Whitby District Structure Plan - District Water Management Strategy (GHD, 2010)

The Mundijong-Whitby District Water Management Strategy (DWMS) was prepared by GHD in 2010, on behalf of the Shire. The DWMS provides guidance on the overall approach for water management within the District Structure Planning area.

Hydrologic and Hydraulic modelling of the DSP area was completed in support of the DWMS using the 1-Dimensional modelling software InfoWorks CS. Modelling utilised broad assumptions and catchment inflows identified in the 2007 SKM stormwater model. Modelling results provided subcatchment scale peak discharge flows and volumes, detention volumes required to manage surface water flows from major events, and hydraulic grade lines within the main waterways. However, the model did not include Culverts A1, B1, B2 or C1 (Figure 3).

Results from the model indicate the Peak 1% AEP flow within the Manjedal Brook, downstream of Soldiers Rd, is estimated to be 40.21 m³/s. The Peak 1% AEP flood level at the same location is estimated to be 40.65 mAHD.

3.1.3 Whitby Local Water Management Strategy (Cardno, 2011)

In support of the the Whitby Local Water Management Strategy, a 2-dimensional model was completed over the Whitby LSP area, which included Manjedal Brook as a downstream condition. The modelling indicates that the majority of flow that is conveyed under the South Western highway in Manjedal Brook actually breaks the banks of the Brook and is conveyed across the landscape to the south west, eventually crossing Kiernan Street at discharge location five. This is not entirely consistent with the initial modelling undertaken by GHD for the DWMS which assumes the majority of flow is contained within Manjedal Brook and conveyed to the west and discharged via culverts under Soldiers Road. The 2-dimensional modelling is considered to be more accurate than the 1D modelling undertaken by GHD given a DTM created by LiDAR was used and modelling output is consistent with anecdotal evidence from residents within the region.

Modelling results show the peak 1% AEP flow within Manjedal Brook, at Soldiers Rd, is 17.13m³/s. However, in the post-development scenario, this decreases to 14.66m³/s. Peak 1% AEP flood depths at the same location seem to be between 0.1 and 0.2m deep based on the colour gradient shown within the report. This translates to a peak flood height of between 37.90 to 38.00 mAHD, which is much lower than previously modelled.

3.1.4 Birrega and Oaklands Flood Modelling and Drainage Study (DWER, 2015)

Modelling of the Birrega and Oaklands area was completed in support of the Birrega and Oaklands Drainage and Water Management Plan (DWMP). The DWMP was initiated by the DWER based on advice from the Western Australian Planning Commission (WAPC) with the aim of identifying planning constraints relating to water issues within the project area.

Results from the model within and adjacent to the subject land indicates the peak 1% AEP flood level within the Manjedal Brook at Soldiers Rd is between 38 and 39 mAHD. Whilst Culvert A1 has not been hydraulically modelled, there does seem to be some overflow from the Brook into the site at this location. It should be noted that the peak 1% AEP flood elevation at the overflow point is marked as 39.00mAHD, however the road elevation is 40.41mAHD, which would suggest the 20m² modelled grid cell interpolated a lower elevation at the overflow point based on the elevations either side of Soldiers Road. Therefore the primary entry point into the subject land is via inflow Culvert A1. The peak 1% AEP flood depth through the subject land is quite shallow and is constrained to the degraded channel that discharges east to west through the subject land (Figure 3).

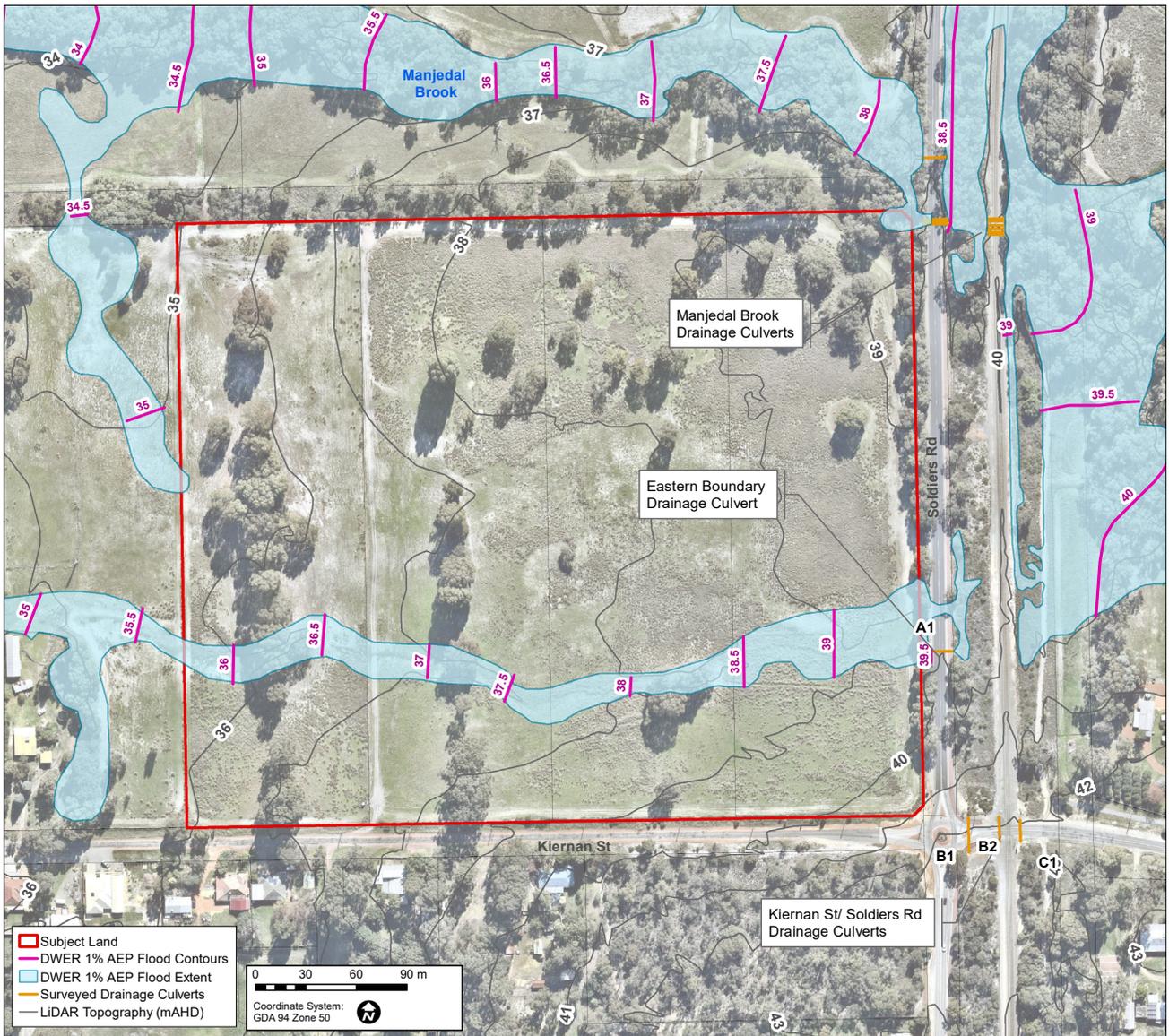


Figure 3 - Regional Modelling

3.2 Local Modelling

Stormwater analysis has been completed using XP-SWMM 1D/2D integrated modelling software. The software provides an accurate tool to predict the extent, depth, velocity and duration of flooding and for evaluating flood mitigation works.

3.2.1 Hydrology

Routing

Runoff routing has been undertaken using the Laursen method within XP-SWMM. The Laursen method involves the delineation of impervious percentages and makes use of sub-catchment pervious area roughness parameters to calculate a storage delay parameter. Routing is then determined using the Muskingum procedure, with sub-catchment storage calculated as a function of site discharge (XP Solutions, 2015).

Catchment Delineation

Possible contributing catchments for the eastern culvert have been delineated using the ESRI Watershed Analysis tool. This has resulted in 3 possible contributing catchments ranging in size from 1.58 ha (A) to 21.62 ha (C). The catchments broadly slope towards the Manjedal Brook with Culvert A1 capturing bypass flows from the contributing catchments.

Catchment Runoff Parameters

The current land use was mapped based on aerial photography for the area and local planning data. Runoff coefficients specified for each pre-development land use are based on the following assumptions:

- Hardstand areas are assumed to have a 100% runoff coefficient. This includes roofed areas, garages and storage sheds etc.
- Road reserves, including adjacent bicycle paths are assumed to have 90% runoff coefficient with a Manning’s n’ roughness of 0.02.
- The rail reserve is assumed to have an 80% runoff coefficient with a Manning’s n’ roughness of 0.03, based on compacted gravel material.
- Vegetated areas are assumed to have a runoff coefficient of 50% and a 10mm Initial Loss. This is based on sandy topsoil overlying sandy clays of the Guildford Formation.
- Cleared areas are assumed to have a runoff coefficient of 60% and a 10mm Initial Loss, based on the soil lithology described above.
- Manning’s n’ roughness coefficients were assigned to each land use based on the breakdown of surface material (vegetation, soil, bitumen etc) digitally identified from aerial imagery.
- Catchment slope is based on surveyed and lidar surface elevations.

Catchment and land use mapping is shown on Figure 4 and outlined in Table 1. Catchment runoff parameters are conservative due to the degree of impervious to pervious area associated with rural and undeveloped land.

		Land Use (ha)					TOTAL (ha)
		Vegetated	Cleared	Hardstand	Road	Rail	
Runoff Assumptions	Initial Loss (mm)	10	10	-	-	-	
	Runoff Percentage (%)	50	60	100	90	80	
Catchment	A	0.09	0.99	-	0.22	0.28	1.58
	B	1.40	-	-	0.36	0.26	2.02
	C	10.54	10.03	0.39	0.43	0.23	21.62
TOTAL (ha)		12.03	11.02	0.39	1.01	0.77	25.22

Table 1 - Catchment Runoff Parameters

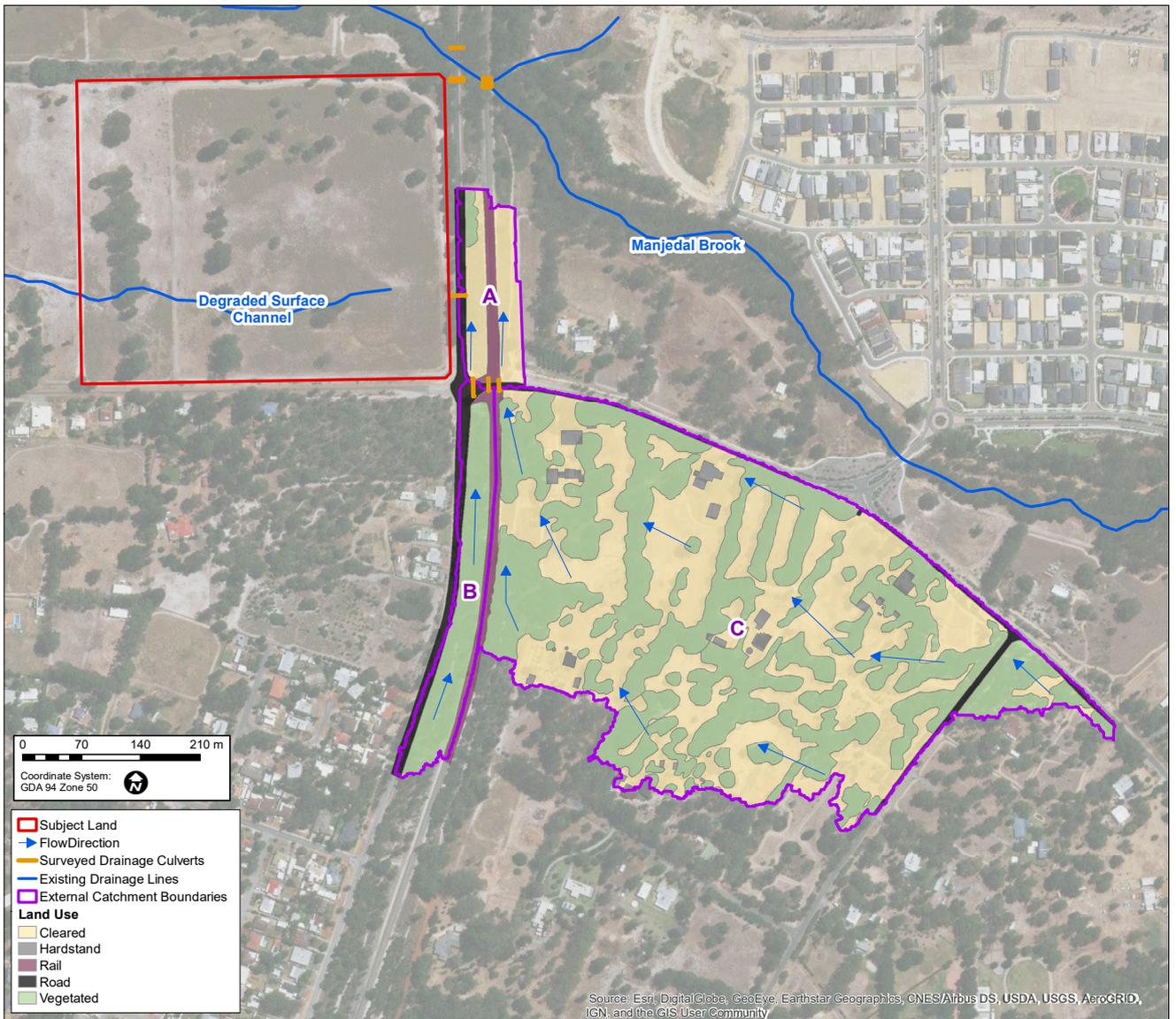


Figure 4 - Catchment and Land Use Mapping

3.2.2 Hydraulics

Key hydraulic inputs include:

- Culvert dimensions and inverts taken from the site survey.
- Inflow and outflow losses of 0.50 were applied to drainage culverts.
- A Mannings n' roughness coefficient of 0.014 was applied to all drainage culverts.
- A free outfall was assumed for culverts C1, B1 and 2 and A1.
- A 2-dimensional grid has been included within Catchment A. The intent of including a 2-dimensional surface was to determine cross-catchment flow adjacent to Culvert A1 and the interaction of this area with the Manjedal Brook flood extent. The 2-dimensional grid is linked to the 1-dimensional hydraulic components by either connection to the culvert invert at an individual grid node or through the use of an interface and connection line (shown on Figure xx). Runoff generated within Catchment A is captured through a 'rain on grid' approach.
- A range of storm durations were analysed for the 20% AEP (5yr ARI) and 1% AEP (100yr ARI), ranging from 10mins to 72 hours.

Hydraulic components are shown on Figure 5 with culvert dimensions and inverts detailed in Table 2. Calibration of Manjedal Brook is discussed further in Section 3.2.3.

		Dimensions				
		Size (mm)	Type	Number	U/S Invert (mAHD)	D/S Invert (mAHD)
Culvert	A1	430	Pipe	1	39.26	39.10
	B1	300	Pipe	1	41.78	41.43
	B2	300	Pipe	1	41.92	41.74
	C1	300	Pipe	1	41.64	41.48
	MB1	2 x 1200 1 x 1400	Pipe	3	37.18	37.08
	MB2	600	Pipe	1	37.66	37.72
	MB3	1200	Pipe	2	37.79	37.78

Table 2 - Culvert Details

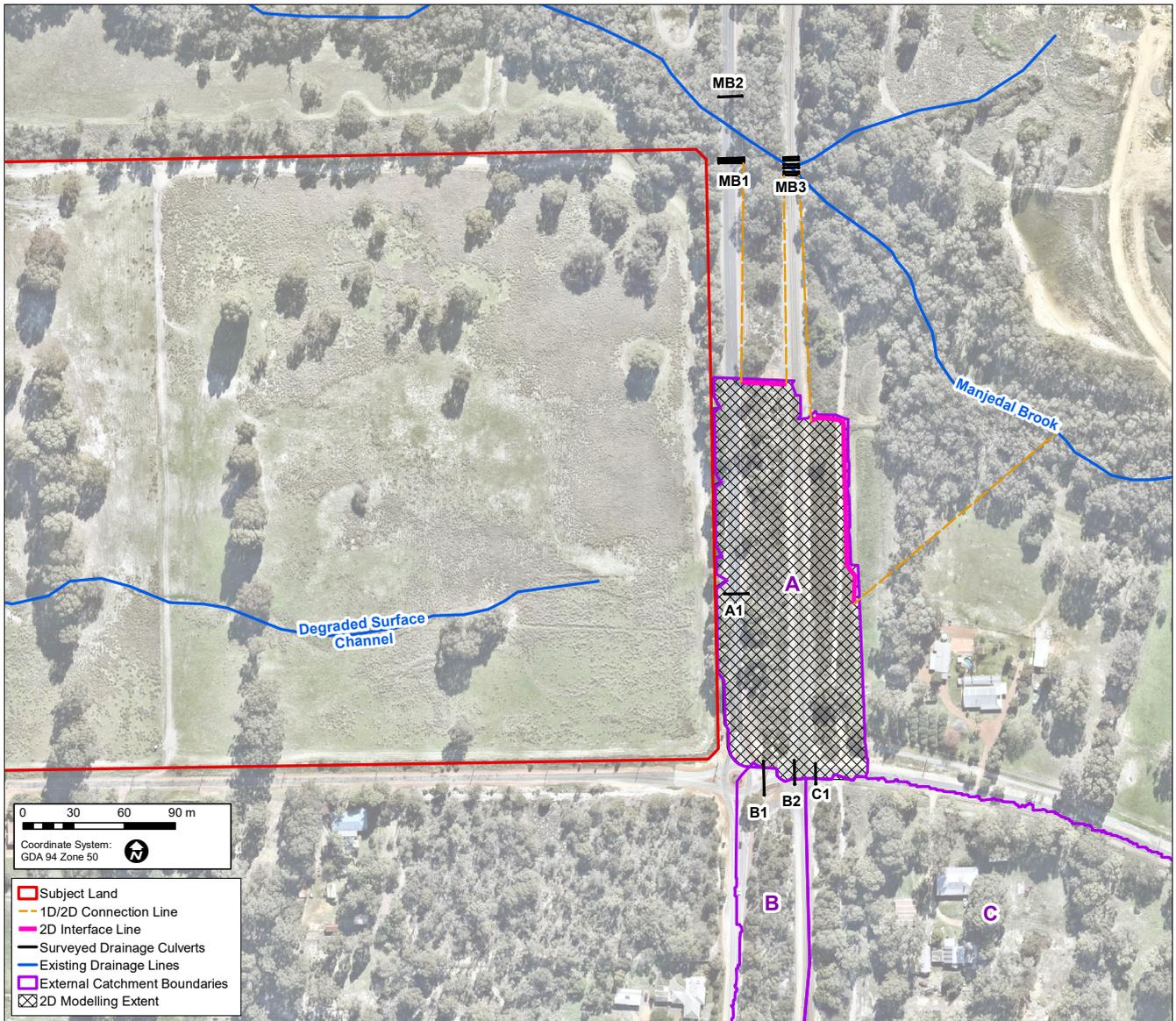


Figure 5- Modelling Hydraulics

3.2.3 Manjedal Brook Calibration

Topographically Catchment A and thus Catchments B and C slope towards the Manjedal Brook with stormwater runoff discharging into the Brook itself. For this reason the Brook needs to be modelled as a downstream condition, in line with the overarching regional models. To complete this, the Brook has been included as a 1-dimensional element in the model extending from Tinspar Avenue to the east and Taylor Rd to the west.

Key modelling criteria for the calibration of the Brook includes:

- Mannings n' roughness for the Brook is between 0.05 to 0.08 depending on the density of vegetation identified from aerial photography.
- Inverts, gradients and cross-sectional data has been taken from LiDAR and surveyed elevation data.
- The peak 1% AEP flood elevation adjacent to Taylor Rd was utilised as a constant backwater condition.
- A peak 1% AEP storm duration of 6 hours was assumed for the Manjedal Brook, based on modelling output from the Mundijong Whitby LWMS.
- A dummy inflow catchment is included at the upstream boundary at Tinspar Avenue. The inflow catchment was sized to meet DWER's pre-development peak 1% AEP flood elevations within the modelled section of the Brook and the peak 1% AEP pre-development flow identified in the Whitby LWMS of 17.13m³/s.

The modelling extent for Manjedal Brook and cross-section locations are shown on Figure 6. Peak 1% AEP outflow hydrographs are shown on Figure 8.

Results of the calibration show the peak 1% AEP flood elevations between Sections B and G and flow at Soldiers Rd are within +/- 5% of the pre-development models. This indicates the model is appropriately calibrated to pre-development conditions.

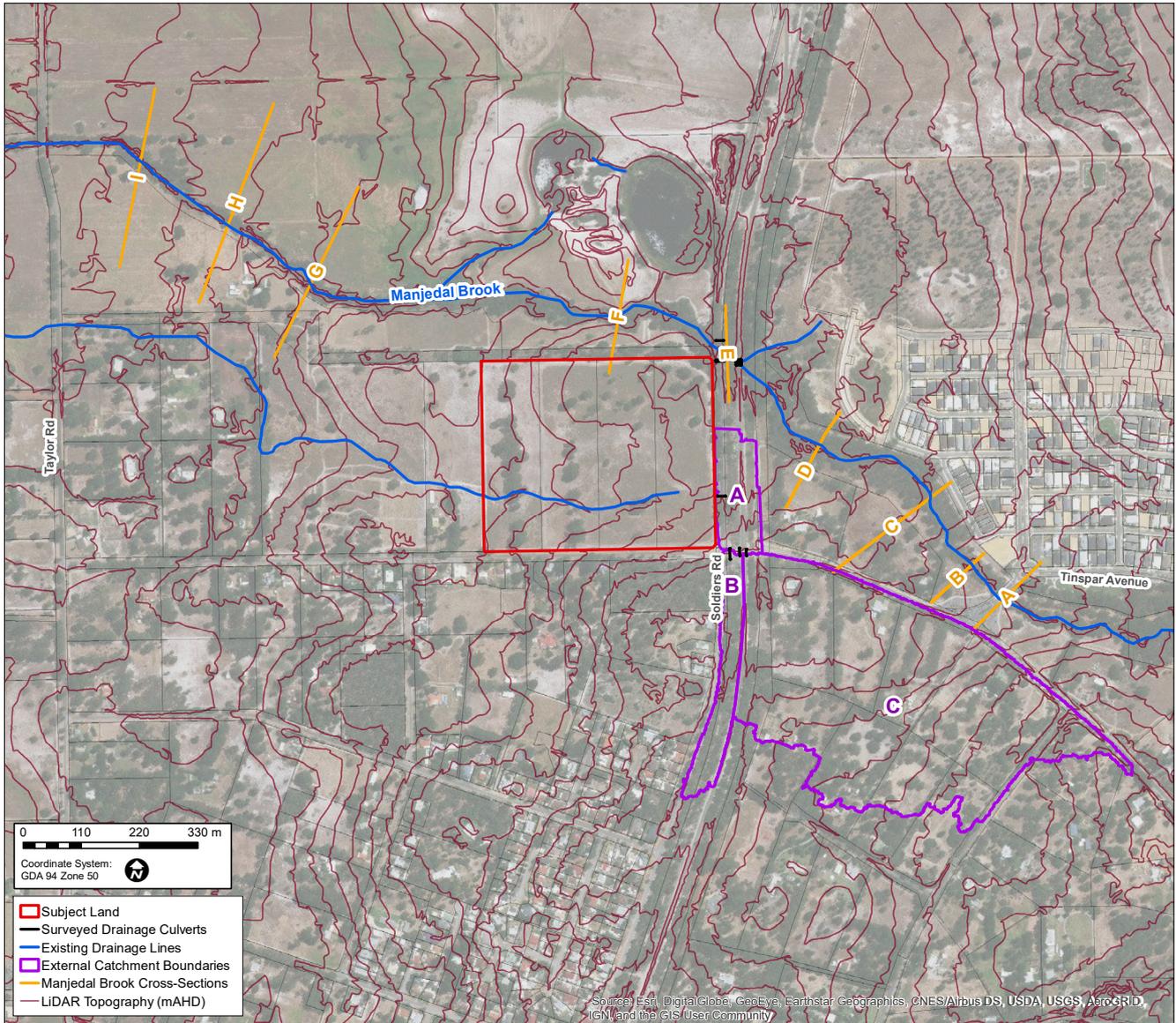


Figure 6- Manjedal Brook Cross-Section Locations

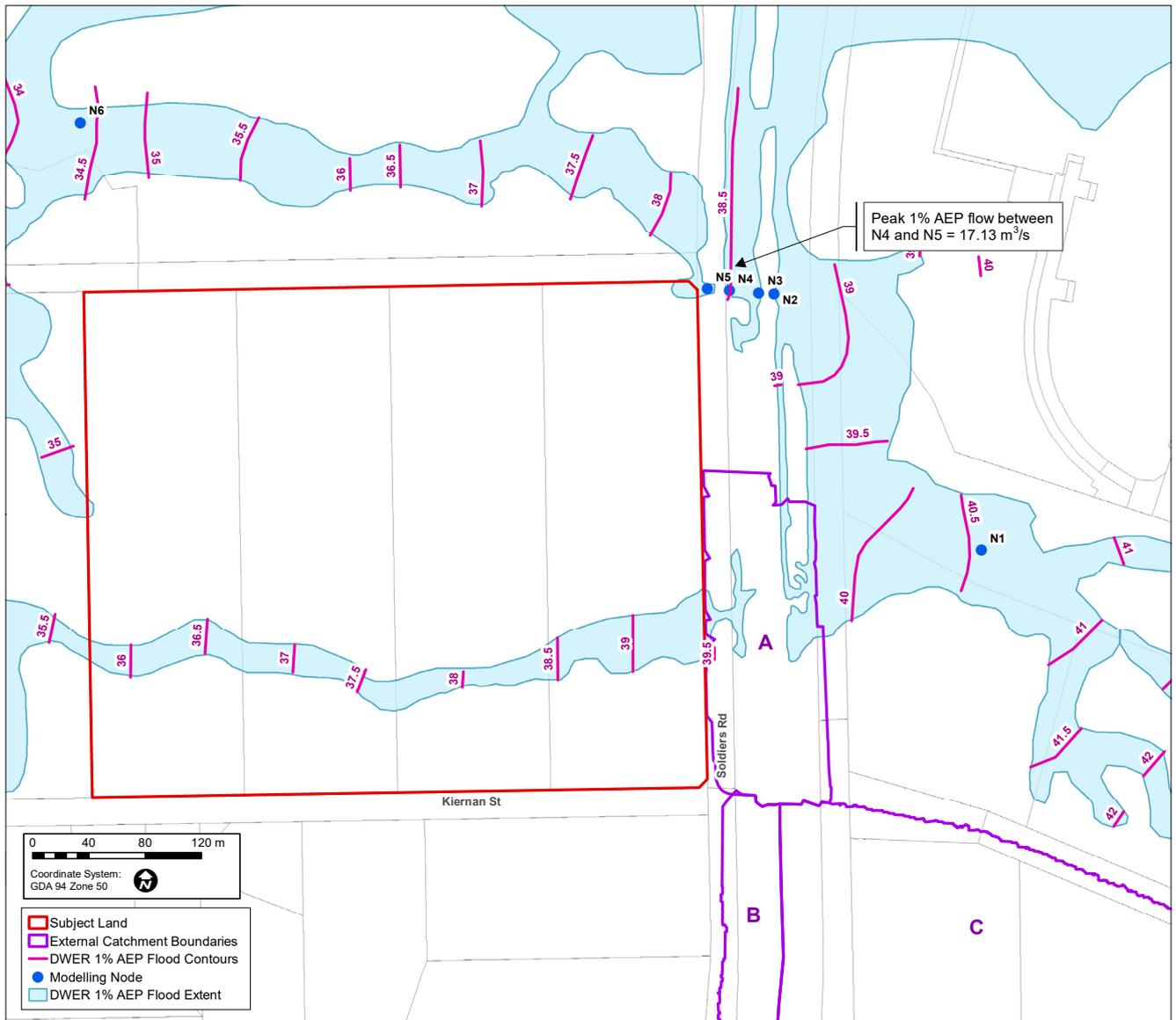


Figure 7- Manjedal Brook Modelling nodes and DWER Flood Mapping

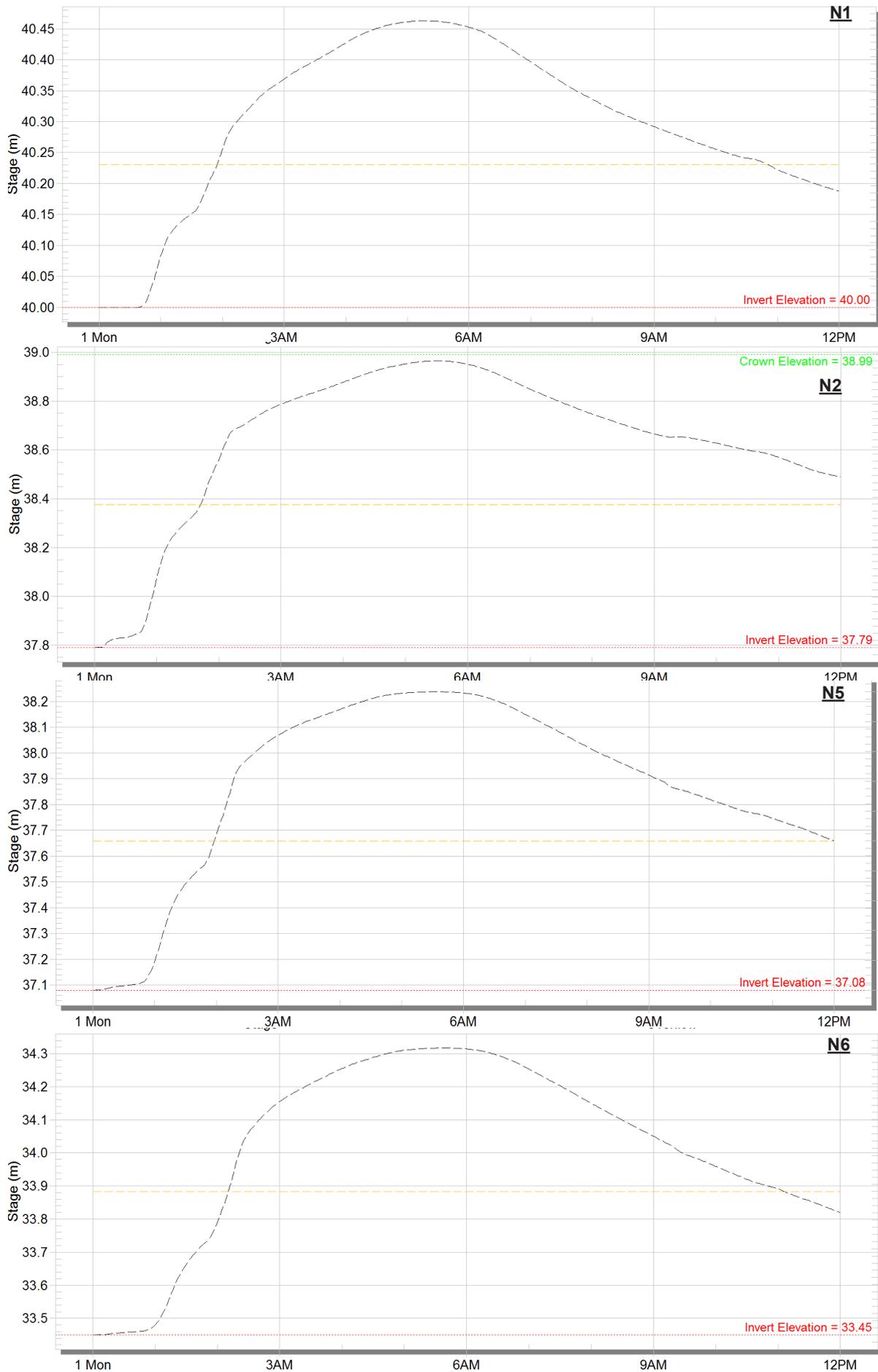


Figure 8- Manjedal Brook 1% AEP Flood Hydrographs

3.3 Results

Key outputs from the model are:

- Calibration of the Manjedal Brook is within +/- 5% of existing overarching models (See Section 3.2.3)
- The maximum ponding depth adjacent to Culvert A1 is 0.54m, approximately 0.66m below the Soldiers Rd pavement level of 40.41m AHD (Figure 10).
- Stormwater within the Manjedal Brook and discharge from Culvert C1 does spill over the railway line towards Culvert A1. However flow depths are quite shallow <0.05m with the corresponding flow rates minimal
- The 1% AEP flow entering the subject land through Culvert A1 is 0.154m³/s, which peaks at 2hrs into the storm event (Figure 9)
- A peak flow of 0.033 m³/s bypasses Culvert A1 discharging into the Manjedal Brook. The bypass flow peaks at 2.5hrs into the storm event and is expected to discharge into the Brook prior to the Brook peaking at 6hrs.
- The 1% AEP flow from Culverts B1, B2 and C1 is 0.047, 0.037 and 0.353 m³/s, respectively.

A plan view of the stormwater modelling results are shown on Figure 10.

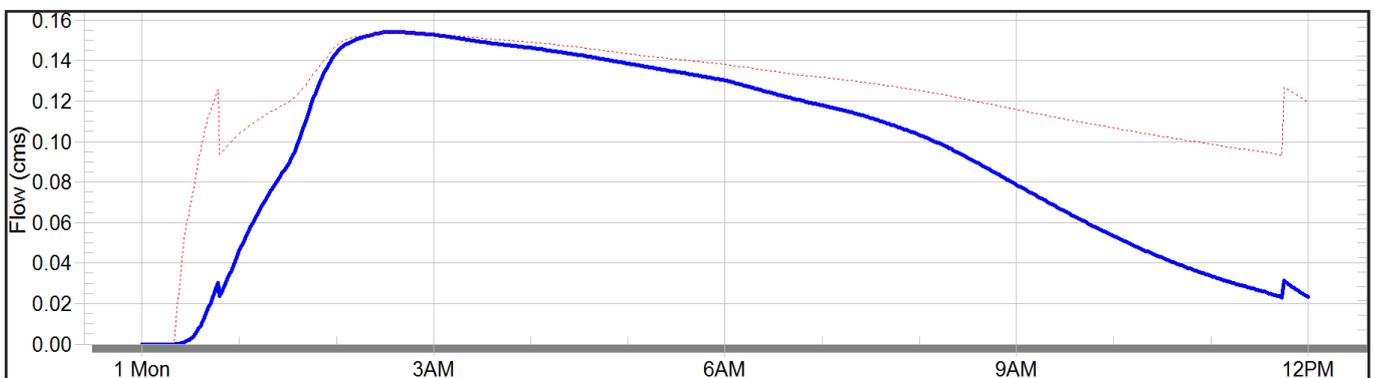


Figure 9 - Culvert A1 Existing 1% AEP Flow

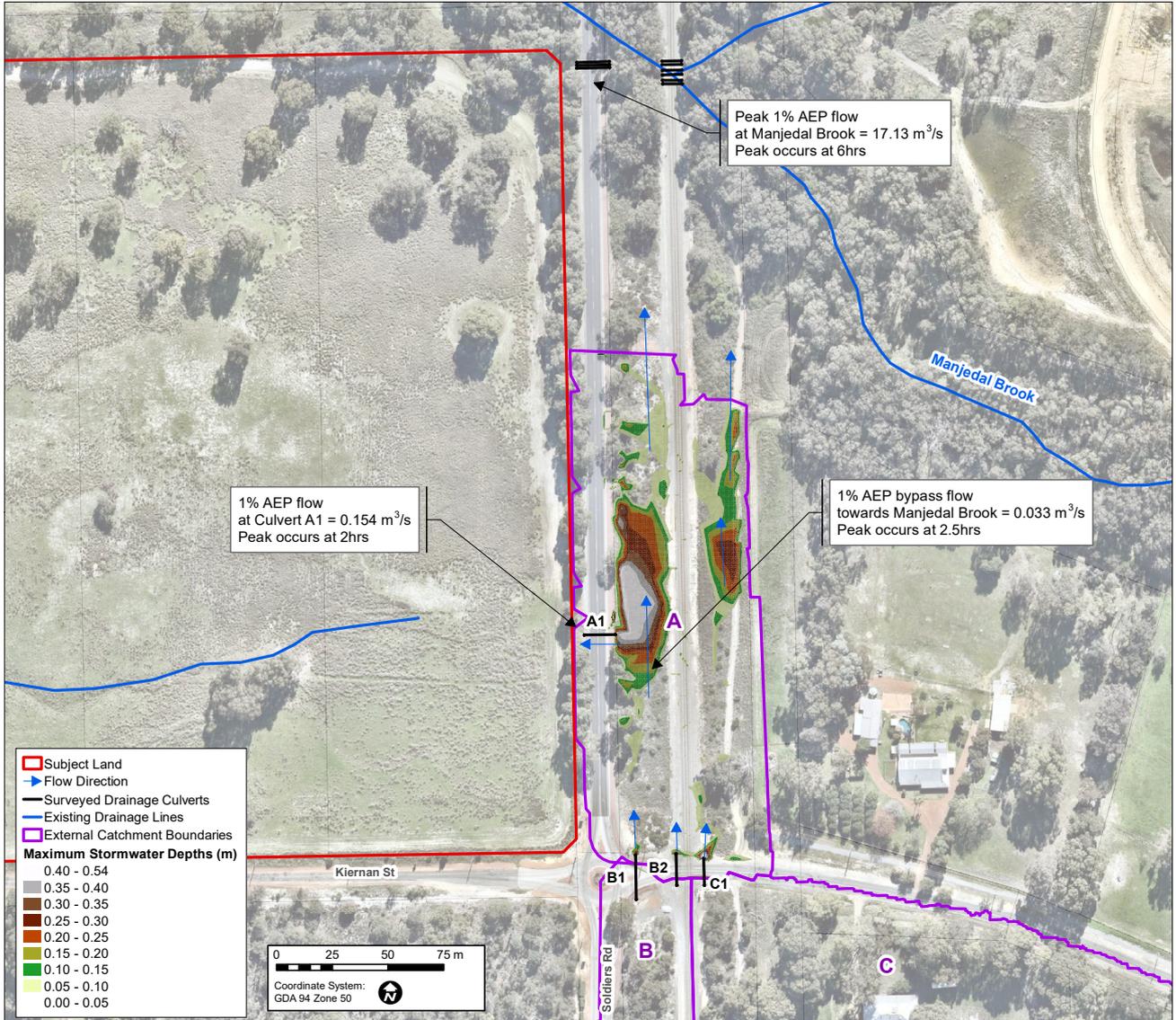


Figure 10 - Existing Flood Extent

3.4 Blocked Culvert and Road Upgrade Scenario

As part of the Shire's road construction works program, Soldiers Rd will be widened to allow for increased traffic flow. At this stage the width of the road widening and the extent is not yet known. However, given there is a conservation category wetland mapped within Catchment A (Figure 10), it is expected road works will be constrained to Catchment B. For modelling purposes an additional 4m width has been assumed, based on the provision of 1 additional road lane. This has resulted in an additional 0.184ha of road reserve within Catchment B.

Blocking of Culvert A1 has also been assumed as part of this Scenario. This takes into account possible affects of planning and subdivisional works within the subject land. Stormwater will be directed towards the Manjedal Brook via the 2-dimensional grid surface.

All other modelling parameters will be as per Section 3.2.

Key outputs from the model are:

- The peak stormwater depth adjacent to Culvert A1 is now 0.57, with 0.63m clearance still retained to the crest elevation of Soldiers Rd.
- Outflow from Culvert B1 has increased to 0.058m³/s from 0.037m³/s with the peak flow occurring 1.5hrs into the storm event, prior to the peak within the Manjedal Brook.
- The peak flow within Manjedal Brook has increased from 17.131 m³/s to 17.257 m³/s, which is less than the combined flow from existing Culvert A1 and the increase from Culvert B1. This is due to the discharge from Catchment A entering the Brook at 2.5hrs into the storm event, prior to the Brook peaking at 6hrs.

A plan view of the stormwater modelling results are shown on Figure 11 with modelling output presented in Table 3.

Node	Peak Elevation	
	Existing Scenario	Blocked Culvert and Road Upgrade Scenario
N1	40.466	40.466
N2	38.974	38.977
N5	38.244	38.247
N6	34.322	34.322

Table 3 - Stormwater Modelling Output

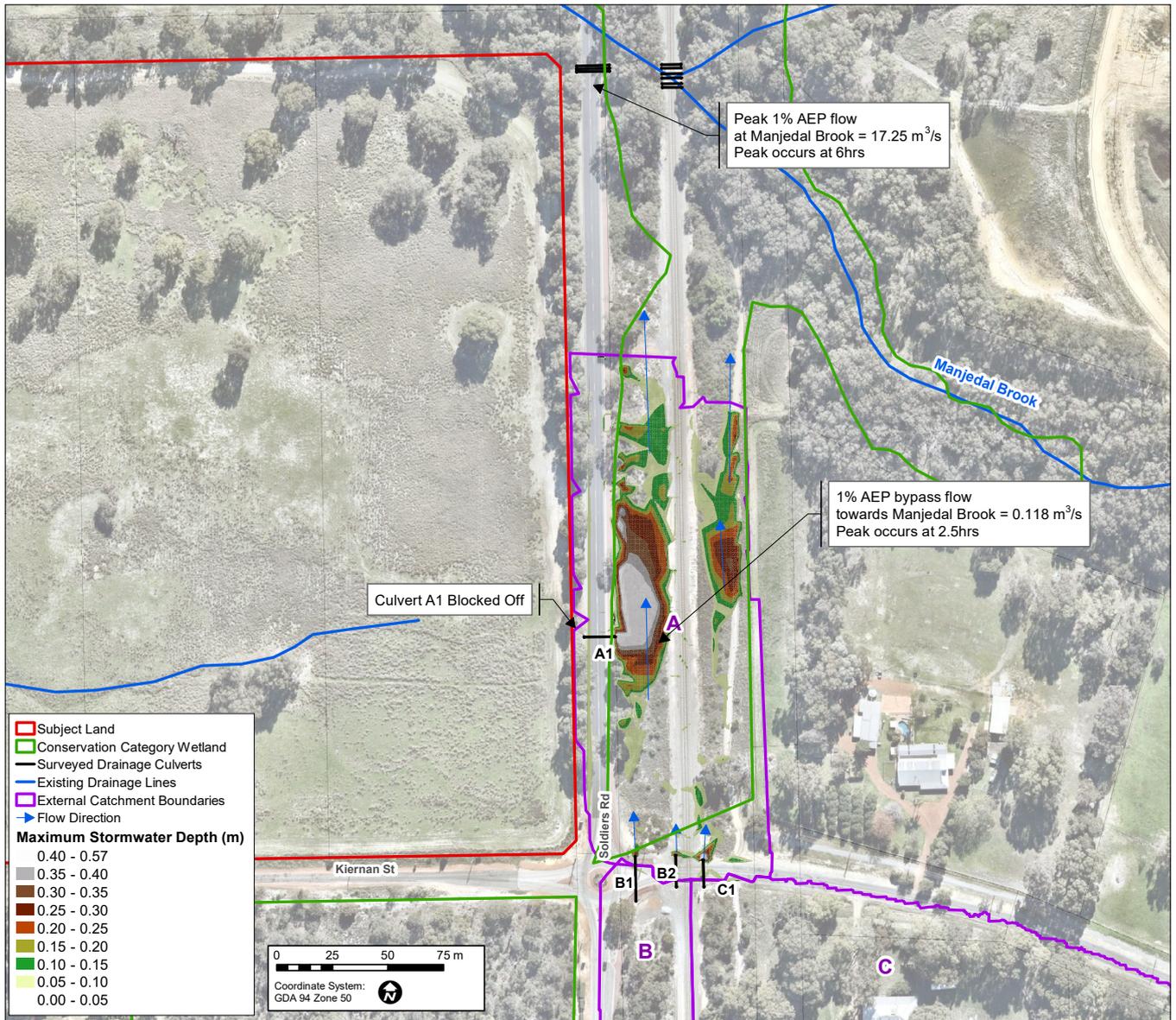


Figure 11 - Proposed Flood Extent

4. Conclusion

This report has assessed the existing drainage system surrounding the subject land with the aim of determining the peak flow rate entering the site and the affects to the downstream Manjedal Brook from blocking the culvert.

Outcomes are as follows:

- Blocking of the culvert and increasing the width of Soldiers Rd increases the downstream Manjedal Brook flood elevation by 0.003m adjacent to the Soldiers Rd culvert, dissipating at Node 1 and 6. This is considered a minimal to negligible affect to the Brook.
- Flows within the Brook have increased by 0.002m³/s, less than the increased flow generated by the widening of Soldiers Rd within Catchment B and the blocking of Culvert A1. This minimal flow increase is due to the discharge from Catchment A entering the Brook at 2hrs into the storm event, prior to the Brook peaking at 3.5hrs. It should be noted that the Whitby LWMS indicates flows within the Brook will reduce by approximately 3m³/s due to the detention of post-development flows within the Whitby development. This more than counters the affect of increased flows from Catchments A and B.
- Stormwater ponding adjacent to Culvert A1 has increased by 0.03m, with 0.63m of freeboard still provided to the crest elevation of Soldiers Rd.

Based on the above, the affects of blocking Culvert A1 and widening of the Soldiers Rd reserve is negligible and localised within a small range adjacent to the Soldiers Rd culvert crossings, with no affect to the upstream town centre. It is therefore recommended the Shire endorses the proposal to block Culvert A1, should it be required during the development of Lots 11 to 14 Kiernan St, Mundijong.

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ANNEXURE 8
Local Water Management Strategy
Calibre

**LOCAL STRUCTURE PLAN: SUB-PRECINCT G2
KEIRNAN STREET, MUNDIJONG
Local Water Management Strategy**



PREPARED FOR DJ MACCORMICK PROPERTY GROUP



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1 Executive Summary

The Local Water Management Strategy (LWMS) has been prepared to support the Local Structure Plan (LSP), with detailed investigations and strategies undertaken for:

- the subdivision of the DJMM landholdings at Lots 11 to 14 Keirnan Street;
- land external to the DJMM landholdings being Lot 50 Keirnan Street (future co-located High School and District Playing Field site); and
- the eastern part of Lot 101 Lang Road (retained as open space for the protection of the aboriginal heritage site).

Further water management strategies in the form of Urban Water Management Plans are to be undertaken to support each respective subdivision application. The above lots are referred throughout this document as the Subject land.

The subject land is approximately 36.26 hectares (ha) in area and is located west of Soldiers Rd and north of Kiernan St. A location plan for the site is provided in **Figure 1**.

The majority of the subject land is cleared with minimal to sparse tree and understorey species. The landform of the site generally slopes east to west with an overland flow route running the length of the southern portion of the subject land. The northern portion of the site discharges north to the Manjedal Brook and forms part of the brooks floodplain. Winter groundwater levels at the site are approximately 1m from the surface in an average year fluctuating to the surface in high rainfall years.

The objective of this LWMS is to detail the best management practices approach to water management that will be undertaken for this development, in accordance with Better Urban Water Management (WAPC, 2008). This will include managing, protecting and conserving the total water cycle of the local environment and the greater catchment. The practices will involve:

- Stormwater management that incorporates the latest water sensitive urban design practices;
- Groundwater resource management;
- Protection and enhancement of ecosystems dependent on water resources from the subject land;
- Sustainable water servicing.

The effectiveness, efficiency and benefits provided by the best management practices require a collaborative effort between local governments, developers and relevant regulatory authorities. Further summary of the practices to be undertaken for the subject land can be found in the Key Elements section.

1.1 Planning Summary

This Local Structure Plan (LSP) has been prepared to facilitate the urban subdivision and development of the LSP Area situated on the northern side of Kiernan Street, Mundijong.

The LSP Area is bound by Keirnan Street to the south; Taylor Road to the west; Manjedal Brook and the land contained within the Shire adopted LSP for Sub-Precinct G1 to the north; and Soldiers Road to the east.

The LSP incorporates Lots 11 to 14 Keirnan Street Mundijong, being the landholdings owned by DJM Mundijong Pty Ltd (DJMM), together with the future co-located High School and District Playing Field Reserve (to be developed by others), the Aboriginal Heritage site on the eastern part of Lot 101 Lang Road (to be retained as open space) and the respective section of unconstructed Lang Road road reserve. (Refer **Figure 2**).

The LSP incorporates the subject site, being the landholdings owned by DJM Mundijong Pty Ltd (DJMM), together with the wider area (to be developed by others) described as 'Sub-Precinct G2' in the Mundijong-Whitby District Structure Plan, as required by the Shire of Serpentine-Jarrahdale (SJ).

The LSP has been prepared in accordance with the requirements of Schedule 2, Part 4 of the Planning and Development (Local Planning Scheme) Regulations 2015.

The design of the LSP encompasses the fundamental principles and objectives of the Mundijong-Whitby District Structure Plan and the recently proposed revised Mundijong District Structure Plan, which documents provide the high-level strategic framework to guide the future urban land use and urban development for this location.

The design of the LSP ensures a strong sense of place and belonging is provided for the future residents of this urban community. This is to be achieved through design by creating a highly connected walkable neighbourhood and ensuring maximum connection to the natural environment.

This LWMS is prepared in support of the LSP with specific details for the Subject Land, in accordance with overarching planning requirements.

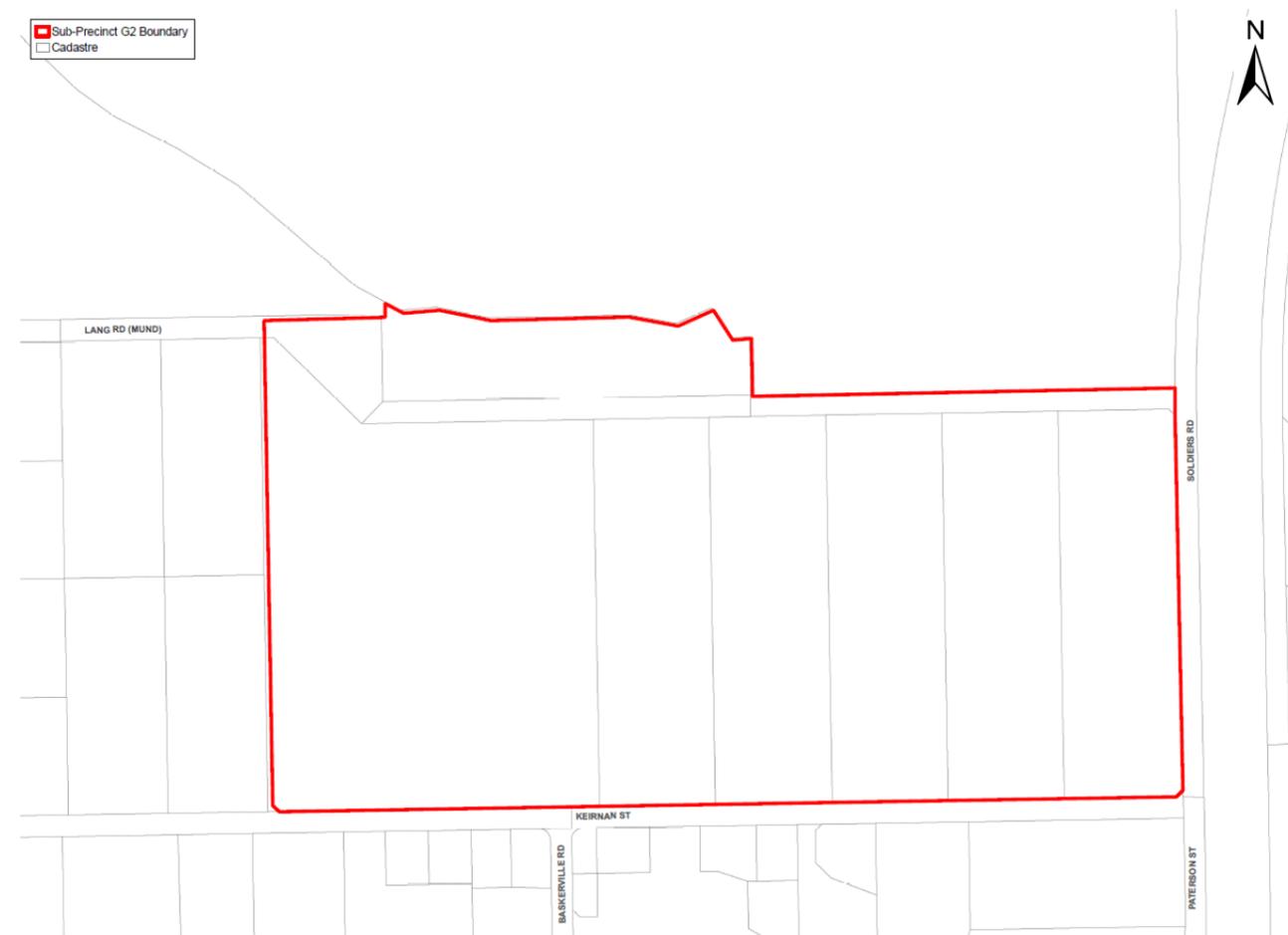
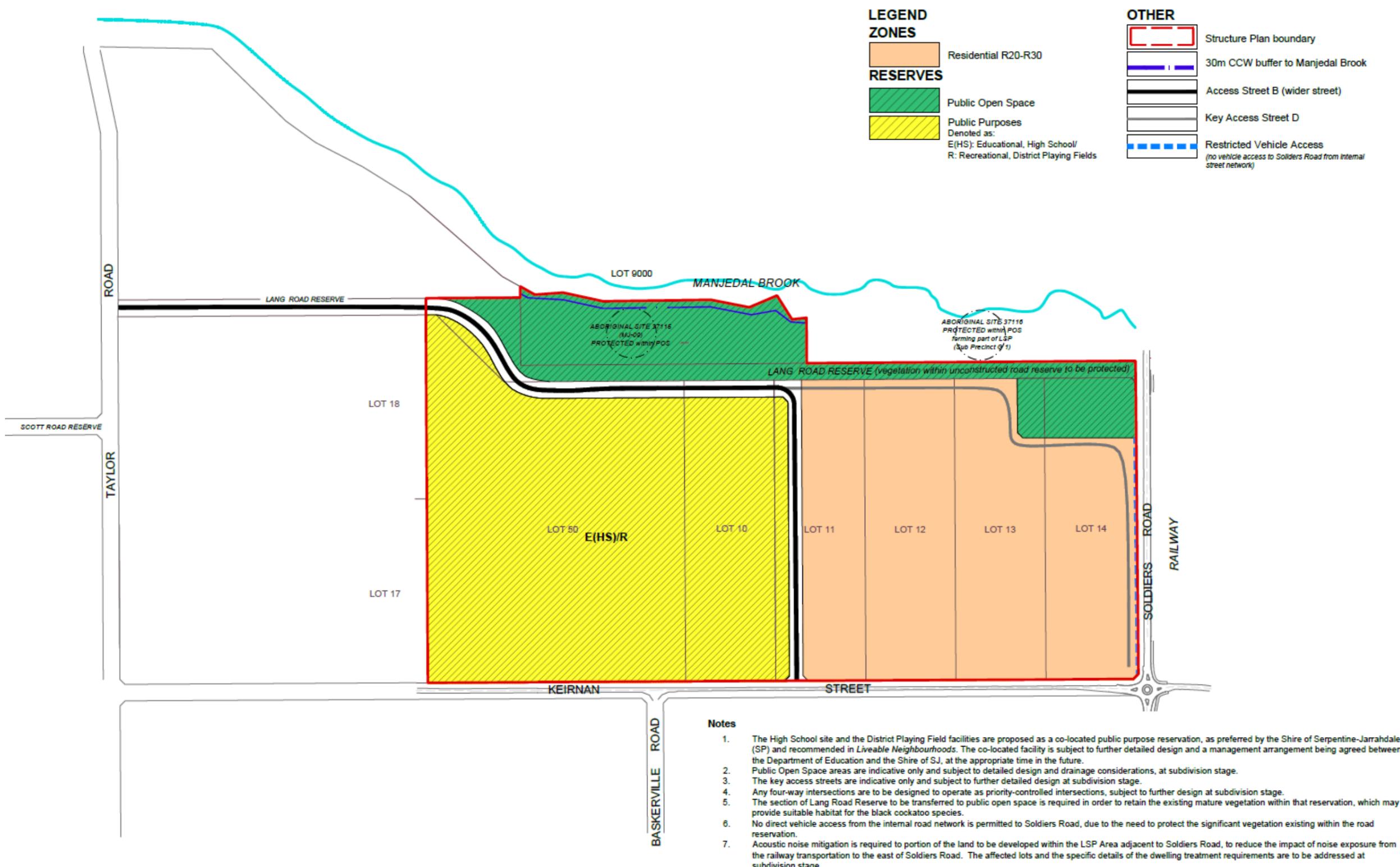


Figure 1: Location Plan



LOCAL STRUCTURE PLAN

Keirnan Street, Mundijong (LSP Area G2)
DJM MUNDIJONG PTY LTD

1:2000 @ A3/P2284-22/19.02.2020



PETER WEBB AND ASSOCIATES
CONSULTANTS IN TOWN PLANNING & URBAN DESIGN

Figure 2: Local Structure Plan

2 Key Elements

Water management strategies for the subject land are based on best-practice Water Sensitive Urban Designs (WSUD) that integrate sustainability and the provision of attractive communities. The strategies will be achieved through the synthesis of planning and designs to manage, protect and conserve the total water cycle. The plans and designs for the development are appropriate for the subject land's development constraints, surrounding environment and providing a sustainable liveable neighbourhood. These strategies will also be applied across the greater Local Structure Plan area. Final details for the rest of the LSP will be provided in separate plans as these areas are developed.

A summary of the WSUD elements that will be implemented within the development to achieve best management practices are outlined below and shown in **Figure 3**.

2.1 Water Conservation and Servicing

- All houses are to be provided with a mains potable water (through Water Corporation);
- Rainwater tanks are to be encouraged to provide a non-potable water source;
- Provision of awareness raising material on water saving measures is to be provided to the lot purchasers; and
- Each lot is to be connected to a gravity sewer system, managed by the Water Corporation.

2.2 Drainage and Flood Management Strategy

- Stormwater detention systems, combined with treatment systems such as bioretention gardens will capture and treat stormwater flows. All flows leaving the site up to the 20% AEP event are generally to match the pre development rate. Modelling of the 1% AEP event has assumed flows will be detained to the pre-development rate as a conservative measure, this may be updated at a later date;
- All lots are to detain the first 15mm on site in soakwells to Shire standards;
- All finished floor levels will be designed to maintain a clear separation of 300mm between the habitable floor level and the 1% Annual Exceedance Probability (AEP) event flood level, generated on site; and
- All finished floor levels will be designed to maintain a clear separation of 500mm between the habitable floor levels and the 1% AEP event flood level, of the regional flood.

2.3 Water Dependent Ecosystem Management

- New habitat will be created within the bioretention systems that mimic ephemeral wetlands;
- The WSUD elements used on site will treat stormwater and groundwater, improving the water quality prior to it entering downstream ecosystem of Manjedal Brook; and
- Flows to the Brook will be managed to predevelopment rates.

2.4 Groundwater Management and Acid Sulfate Soil Management Strategy

- Filling of building pads and roads will be used to manage groundwater so that adequate clearance is maintained between maximum estimated groundwater level and finished surface level;
- A subsoil drainage system is to be used in areas where clearance to groundwater is minimal;
- Inflows to the groundwater system will be treated through the on lot soakwells and basins; and
- A change in land use from livestock grazing to sewerred residential with small gardens is likely to reduce nutrient loading to groundwater.

2.5 Monitoring and Maintenance

- Appropriate monitoring is to be undertaken through the construction phase of each stage for surface water and potentially groundwater in relation to possible contamination; and
- Post development monitoring is to consider surface and groundwater quality, ecosystem enhancement and WSUD structural performance.

2.6 Implementation and Governance

- Developers are to undertake detailed Urban Water Management Plans (UWMP) to provide the necessary information for management of water across the site; and
- The Local Government and Department of Water and Environmental Regulation are to continue to provide guidance, direction and assistance so that the targets outlined in this report are able to be realised.

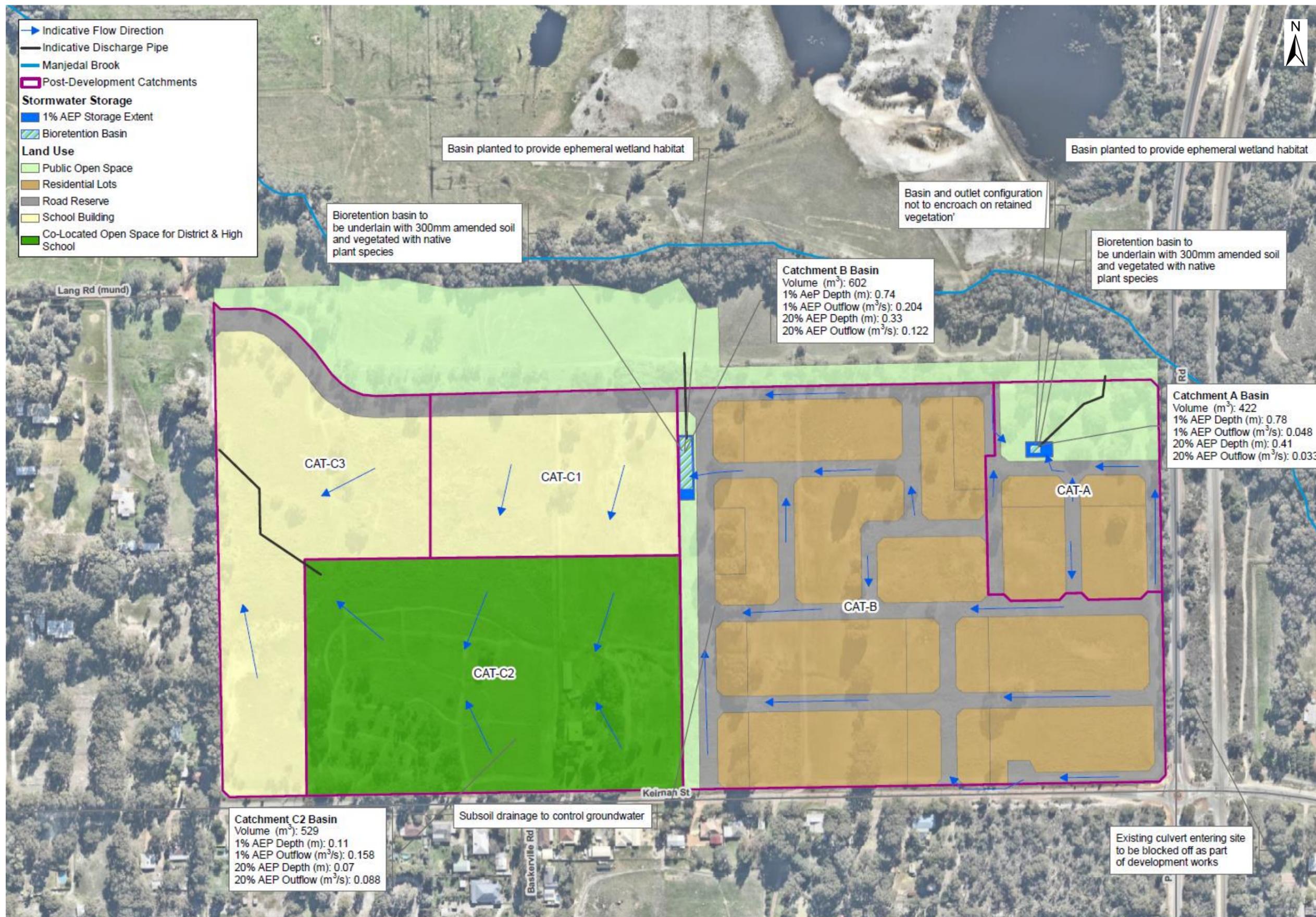


Figure 3: WSUD Elements

3 Site Environmental Characteristics

The site is predominately an area of open pasture with minimal tree and understorey vegetation, sloping west and north towards the Manjedal Brook. A small section of native vegetation in the north-eastern section of the Site will be retained within Public Open Space (POS), which also contributes towards the Manjedal Brook conservation buffer.

Figure 4 and Figure 5 show the topography, wetland areas and site features of the subject land.

3.1 Landform

The subject land slopes east to west towards the neighbouring rural lot at an average gradient of 1:130 (V:H). A degraded surface channel existing within the southern portion of the subject land discharges east to west. Within the northern portion of the subject land, the topography elevates within an apparent sand deposit before falling again towards the Manjedal Brook. Surface elevations range from 39 mAHd in the east to 31.3 mAHd along the western boundary.

3.2 Wetlands & Vegetation

The majority of the subject land has been classified as Multiple Use wetland, which does not preclude urban development. Two Conservation Category wetlands (CCW) exist in close proximity to the site boundary, one to the south (UFI 14969) and one within the Soldiers Rd reserve which merges with the Manjedal Brook (UFI 15446). A 50m buffer has been applied to the CCW areas with all development, associated with the subject land, located outside the buffer area.

GHD completed a flora survey of the subject land on 3 July 2018 as part of an Environmental Constraints Assessment. The survey was completed to characterise the dominant vegetation units and their condition and identify and record the vascular flora taxa present at the time of the survey. As a result the subject land was found to be predominantly cleared with scattered remnant trees remaining in the northern half of the project area.

The existing vegetation across the subject land consists of mixed Eucalypt species (both native and planted/introduced) over introduced grasses and herbs. Two rows of introduced Eucalypts (including *Eucalyptus caldulensis* and *E. cladocalyx*) have been planted on Lots 11 and 12. The remnant tree species remaining within the northern half of the project area consist of Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) trees. There is no native understorey remaining.

The vegetation condition within the entire subject land is considered to be completely degraded. The vegetation structure is no long intact and is completely dominated by an understorey/ ground cover of common herbaceous and grassy weeds. Vegetation within the subject land has predominately been cleared and seeded with grass for pasture.

Significant trees are mapped in Figure 4. A copy of the Environmental Constraints Assessment is included in the CD of Attachments.

3.3 Fauna

The fauna habitat on site is minimal and likely to be linked to the small areas of native vegetation in the northern portion of the subject land. As part of GHD's Environmental Constraints Assessment, several significant trees have been identified as potential roosting habitat for Black Cockatoos, within the northern portion of the subject land (Figure 4). However due to the degraded nature of the vegetation over the balance of the subject land, the value of these areas as fauna habitat would be poor.

There may be some movement of wetland/waterway dependant fauna across the site to access the adjoining Manjedal Brook.

3.4 Waterways

The subject land is presently serviced by the Manjedal Brook to the north of the subject land and a degraded surface channel that runs east to west through the site before discharging via sheet flow to the Manjedal Brook further downstream (Figure 4). This minor depression only conveys water during extreme events. This depression is not mapped as significant wetland system and in effect is a paddock depression covered in pasture species.

3.5 Contaminated Sites

A review of the Department of Water and Environmental Regulation's (DWER) Contaminated Sites Database (DWER, 2018) was undertaken with no known sites found within or in the vicinity of the subject land.

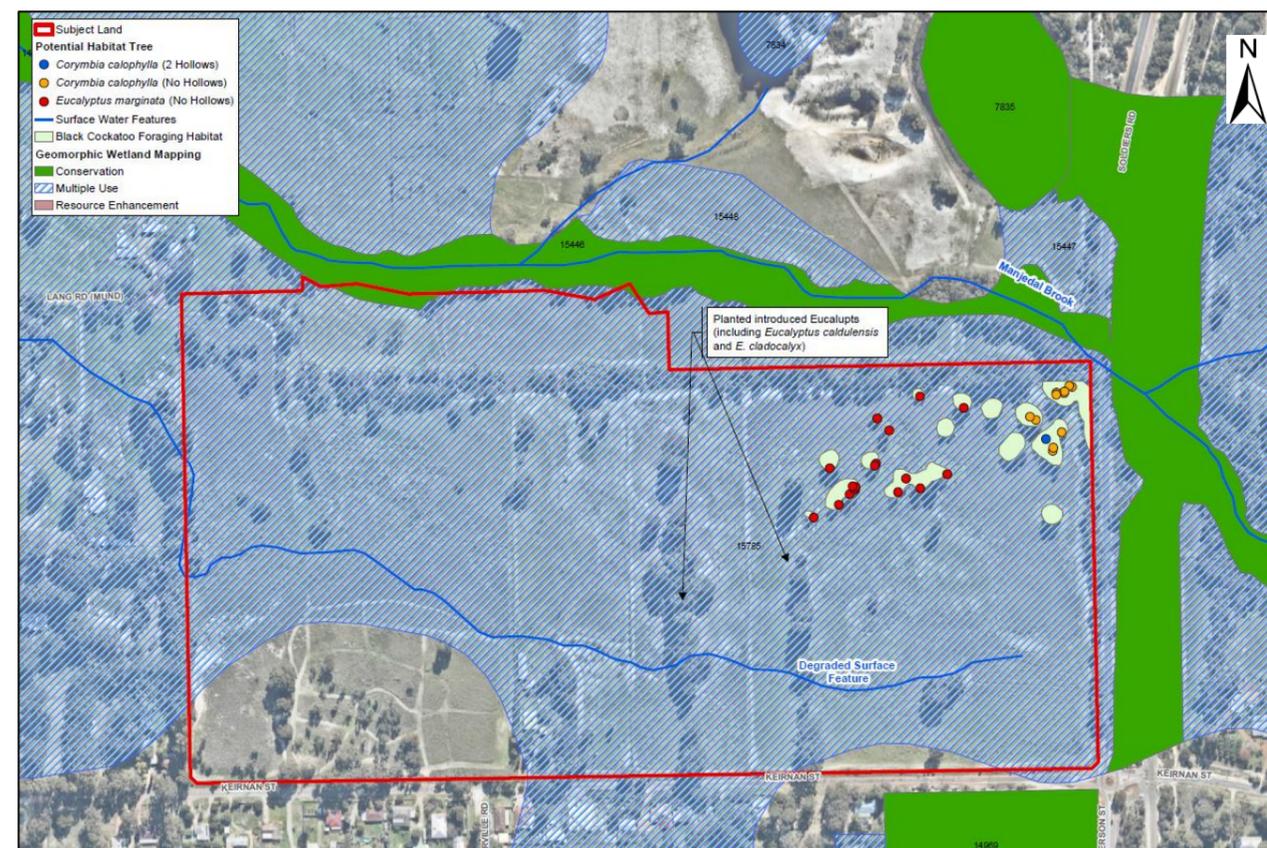


Figure 4: Wetland Mapping and Significant Trees

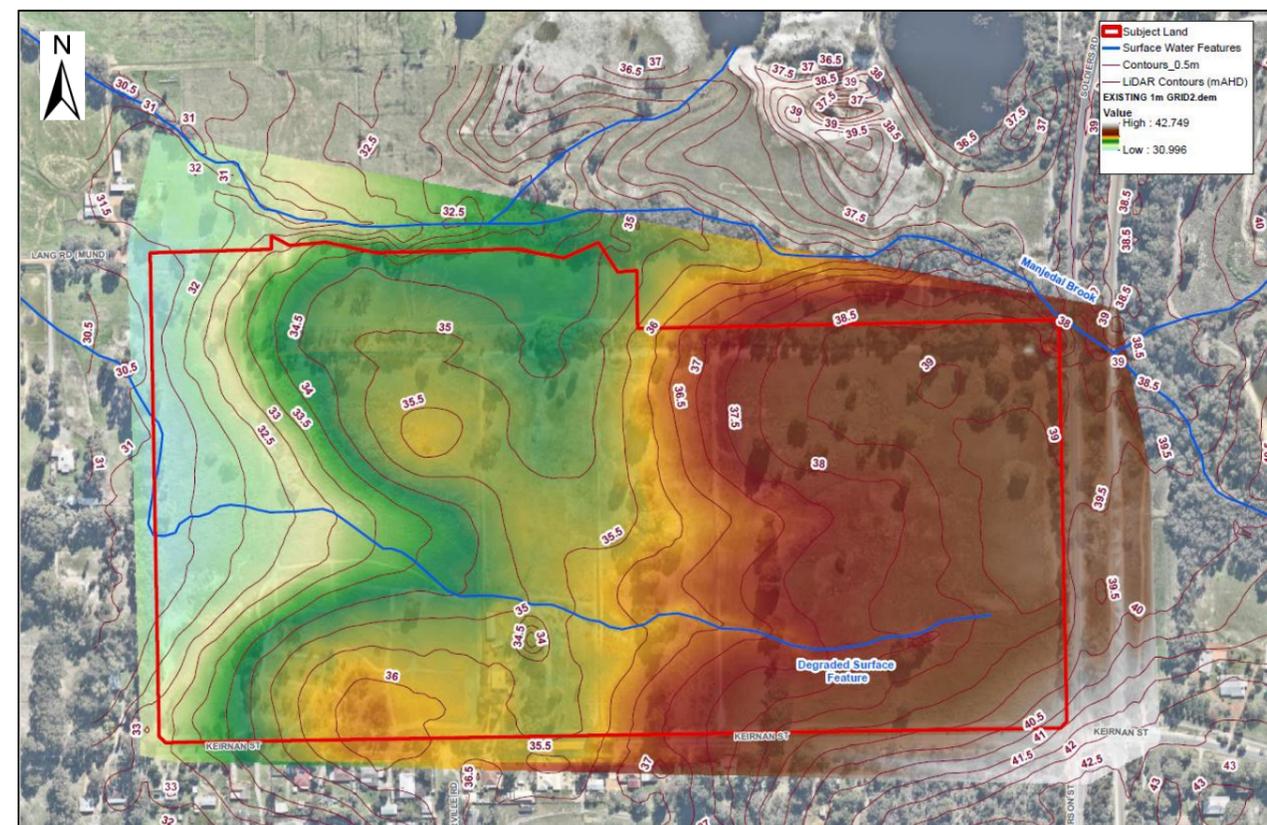


Figure 5: Landform Contours

4 Subsurface Conditions

4.1 Regional Geology Mapping

The geological map for the area [2] shows the majority of the site to be underlain by the Guildford Formation consisting of clay, sand, silt and gravels, with the Bassendean Sands Formation concentrated towards the centre. (Brown Geotechnical, 2020).

4.2 Geotechnical Investigation

Brown Geotechnical completed a preliminary geotechnical investigation of the subject land in February 2020. The investigation included the installation of 32 boreholes to a depth of 3m.

Test locations are shown on **Figure 6** with both geotechnical reports included in the CD of Attachments.

Site Specific Soils

The topsoil has an average thickness of 0.1m. Once the grass and roots are removed the topsoil is relatively low in organic content. It should be suitable for use as engineering fill when screened and blended with clean sand fill at a ratio of approximately 1:2 (screened topsoil : clean sand). Further testing following screening could bring the ratio down to 1:1 for some portions of the site.

Below the topsoil, the site is covered by at least 0.6m of medium grained sand with silt. The silt content is about 8-12%. The sand is cohesionless and drainage characteristics are good. The silt content decreases to less than 5% in the central and north-west.

The sand is underlain by a clayey subgrade across the southern third and in the north east corner, consisting of dense clayey sand and / or sandy gravel with clay to at least 2.0m. The soils have a moderate to low plastic fines content, an intermediate to low plasticity and a low expansive nature. The drainage in the clayey soils are poor. The sandy gravel with clay often becomes hard with iron cementation below about 1.2m which caused refusal of the 5 tonne excavator in some holes at around 1.6m to 2m.

No uncontrolled fill was encountered in test holes.

With respect to the desk study and geological information obtained prior to the fieldwork, it appears that the Bassendean Sand Formation is not only present in the centre of the site, but also extends across to the north western corner to at least 2m depth.

Site Specific Soil Permeability

Permeability testing was undertaken at seven locations (P1 to P7). Results indicated the in-situ sands contain moderate to low fines, zero plasticity and are free draining. The drainage condition within the sands prior to proof rolling is good. Permeability between 7×10^{-4} m/s and 1×10^{-3} m/s was recorded.

Groundwater levels over much of the site are quite high and this may impact on suitability of some areas of the site to allow for the use of soakwells. Additional sand fill may be required in some areas, especially where the clayey subgrade approaches the existing surface. A suitably designed drainage system would allow for the use of soakwells if sufficient height, say at least 1.2m, is obtained above the clayey subgrade and the groundwater. Further permeability testing and groundwater monitoring is recommended as part of the detailed geotechnical investigation to refine these observations.

It is suggested that soakage devices not be used in areas containing clay rich soils.

4.3 Acid Sulphate Soils

Acid Sulphate Soil (ASS) risk mapping of the Swan Coastal Plain shows the full extent of the site having moderate to low risk of ASS occurring within 3m of soil surface. ASS risk mapping for the site has been presented in **Figure 7**.

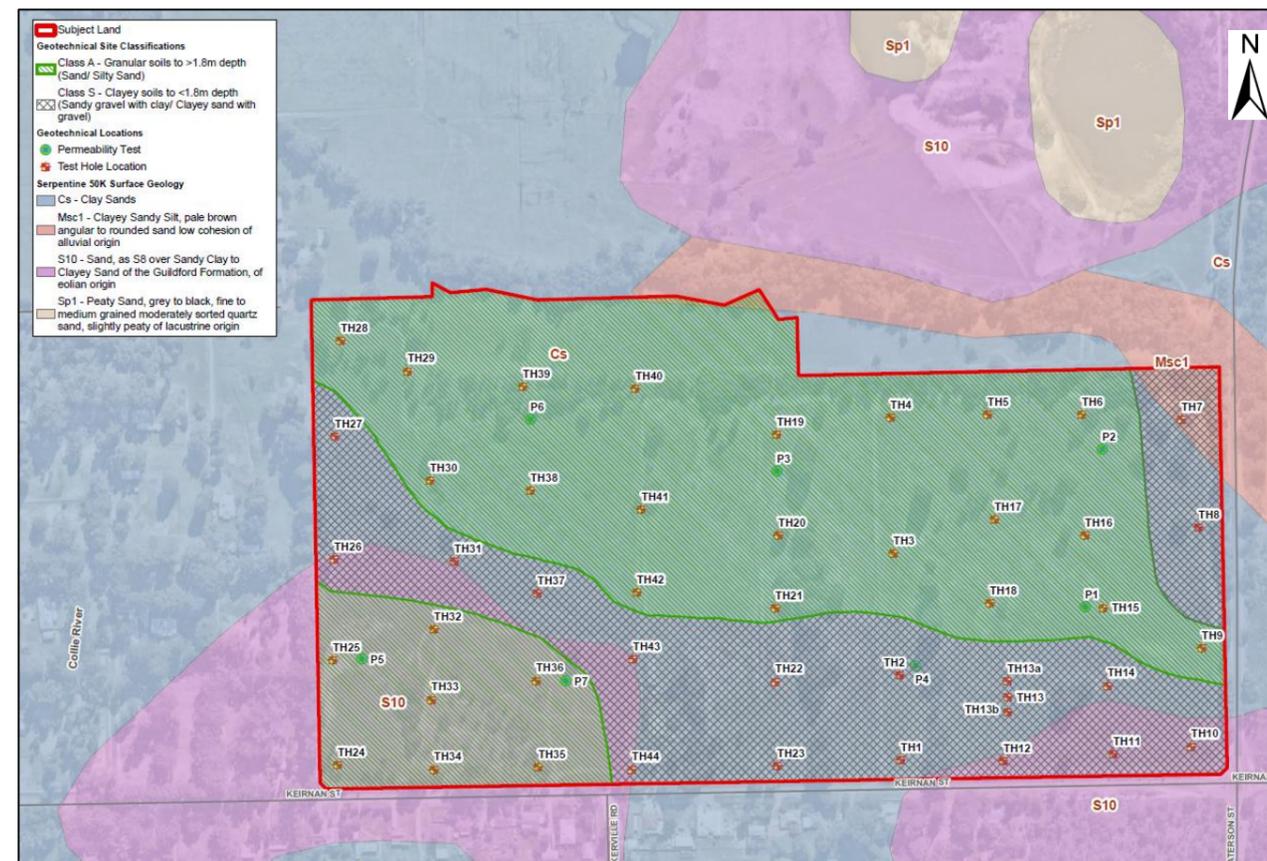


Figure 6: Surface Geology and Borehole Locations

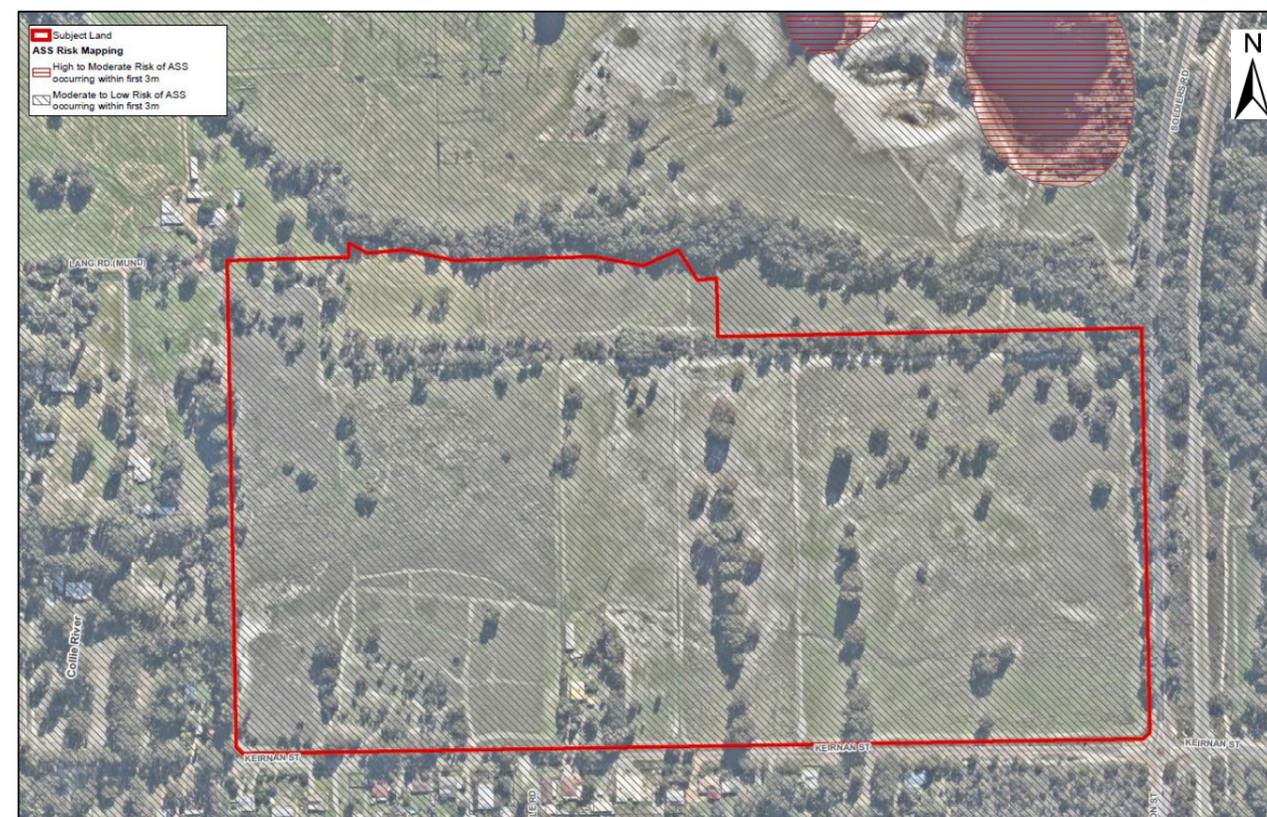


Figure 7: Acid Sulphate Soils Mapping

5 Surface Water Pre-Development

5.1 Manjedal Brook Flood Summary

Stormwater modelling of the Manjedal Brook was completed in 2015 as part of the Birreka and Oaklands Flood Modelling and Drainage Study. Results of the model indicates peak flood elevations within the Brook range between 38.5 mAHD in the east to 32.0 mAHD in the west. Some overflow into the site occurs along the eastern boundary (see **Figure 8**) with flood levels quite shallow and constrained to the existing degraded channel that traverses the southern portion of the subject land.

An existing 430mm diameter inflow culvert has been located along the eastern boundary, roughly aligning within the existing degraded channel. This suggests the majority of inflow from the Brook occurs at this point. To determine the degree and frequency of inflow, Calibre undertook an external modelling exercise. This involved the delineation of all connected external catchments, land use mapping, calibration of the Manjedal Brook and an integrated 2D model to determine bypass flows. Results indicated a peak 1% AEP inflow of 0.118 m³/s, peaking at 2.5 hrs into the storm event (See **Figure 9**)

An additional modelling scenario was also included, which involved blocking of the culvert and widening of Soldiers Rd to determine the effects to the downstream Manjedal Brook. Results indicate the peak 1% AEP flood elevation within the Brook has increased by only 0.002m. However the peak 1% AEP flow has also increased by 0.126 m³/s which is less than the flow currently discharging through the eastern culvert. Based on the external modelling exercise it is recommended that blocking of the eastern culvert is acceptable.

Modelling methodology and results have been summarised in a separate modelling report, included in the CD of attachments.

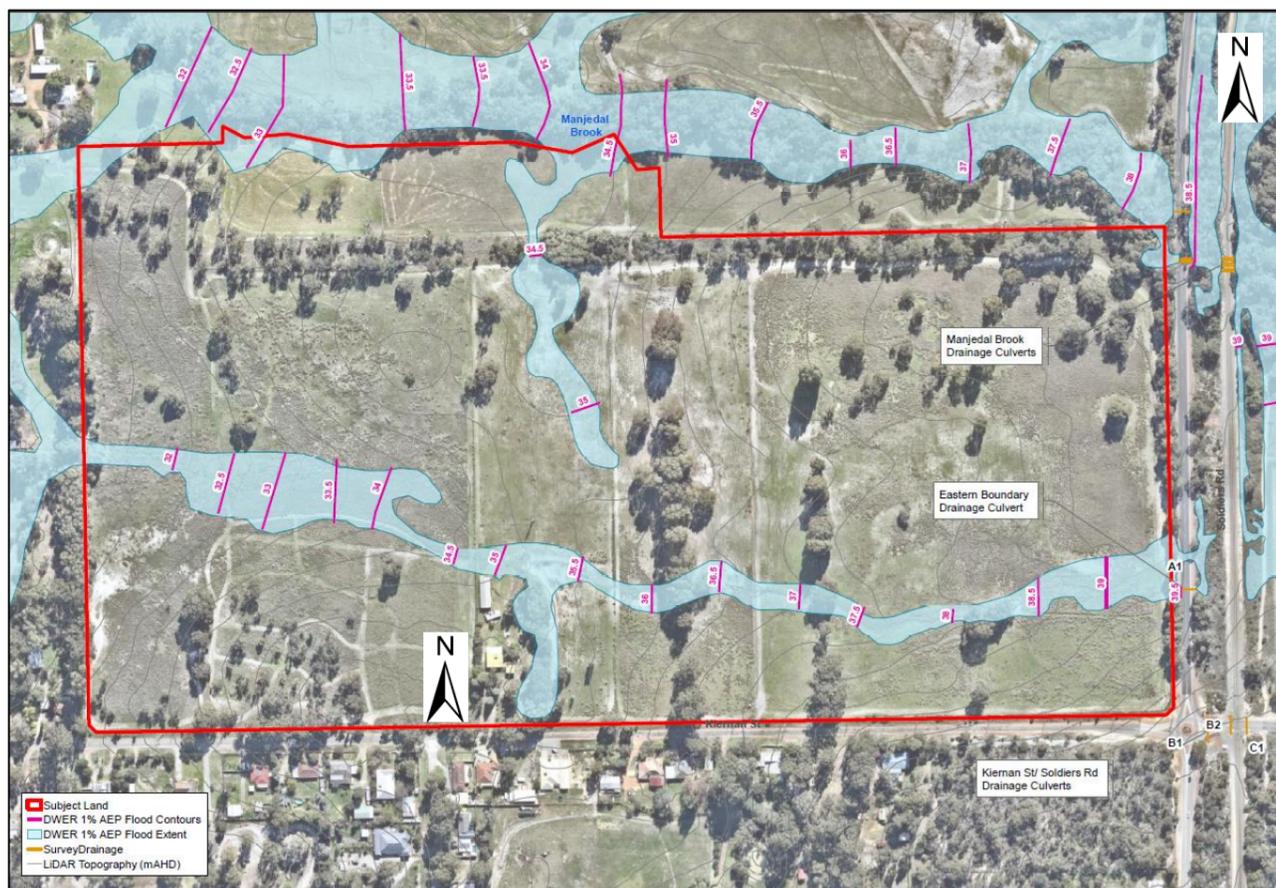


Figure 8: Regional Flood Mapping



Figure 9: Localised Flooding Associated with Soldiers Road

5.2 Pre-Development Flood Analysis

An XP-SWMM model has been developed to assess the flows within the site. The model has been used to simulate both pre and post-development scenarios to determine the detention storage volumes and outlet structures required to ensure no increases in peak flows from the site.

The design storms modelled were according to the methodology in Australian Rainfall & Runoff (AR&R) 2016 and in line with the Stormwater Management Manual of WA. The rainfall temporal pattern was assumed to be spatially uniform across the catchment with storm durations from 10 minutes to 720 hours analysed.

No external flows have been included in the model as external flows from the east will no longer occur with the blocking of the eastern culvert (see Section 5.1) and it is considered unlikely any flows from the south will cross Kiernan Street into the site.

Lang Road Reserve, in the north of the site, is to be maintained as POS and as such will not be included in the modelling. In the pre-development scenario the reserve is considered as vegetated land and both of these land uses have a proportional loss of 0.5, and as such it is not considered necessary to include this area in the modelling assessment.

The pre-development catchments have been determined using a digital terrain model (DTM) for the site. The site has been split into four catchments. Catchment A is a relatively small section of the site in the north east that drains to the north and into Manjedal Brook. Catchment B includes the northern portion of the site that drains to the central north and also into Manjedal Brook. Catchment C1 and C2 include the southern and western portions of the site and drain to the west through a relatively undefined watercourse, which eventually reconnects with Manjedal Brook further downstream. The catchments are shown below in **Figure 10**.



Figure 10: Pre-Developed Catchments

Roughness coefficients and corresponding runoff coefficients were then assigned to the catchments based on the breakdown of land uses (digitally identified from aerial imagery), surface geology and surface slope. A critical storm duration of 6 hours was determined for the site.

Table 1 provides a summary of the land use areas for each of the catchments,

Table 1: Catchment and Land Use Areas

Land Use	Catchment Area (ha)				
	A	B	C1	C2	Total
Cleared	1.11	9.22	5.47	12.30	
Vegetated	0.36	0.89	0.86	1.38	
Total	1.47	10.11	6.33	13.68	31.59

Table 2 provides a summary of the catchment parameters applied to each of the land uses and

Table 2: Land Use Parameters

Land Use	Initial loss (mm)	Proportional Loss	Pervious Roughness (n)	Impervious Roughness (n)
Cleared	0	0.4	.03	.014
Vegetated	0	0.5	.035	.014

Table 3 provides a summary of the peak flows for the site.

Table 3: Pre-Development Peak Flows

Storm Event	Peak Flows (m3/s)		
	Catchment A	Catchment B	Catchment C
63.3% AEP Storm	0.02	0.071	0.14
20% AEP Storm	0.034	0.0122	0.24
1% AEP Storm	0.052	0.205	0.401

5.3 Surface Water Quality

Due to there being no significant waterways or wetlands within the subject land, no surface water quality monitoring has been undertaken.

6 Groundwater Pre-Development

6.1 Groundwater Levels

To determine likely seasonal maximum groundwater levels across the subject land, onsite groundwater level monitoring was undertaken by Emerge Associates between July 2016 and December 2017. The investigation included the installation of 6 monitoring bores across the site, to a depth of approximately 8m Below Natural Surface (BNS).

As required by DWER groundwater levels were measured across two winter periods, with a total of 10 monitoring events for each bore. The maximum recorded groundwater level occurred in 2017, which coincides with an above average rainfall year (1975 to 2017, Rainfall Station No. 009023). Maximum groundwater levels, estimated maximum groundwater contours and depth to groundwater is shown in **Figure 11**. Groundwater levels generally fall east to west with depth to groundwater ranging from above surface to 3.45m BNS. Groundwater level data is included in **Table 4**.

Groundwater was also found in all of the test pits as part of the Geotechnical Investigation (Brown Geotechnical, 2020). Groundwater depth ranged between 0.6 and >2.4 m BNS, although this did not represent the seasonal maximum as the investigation occurred in November. A copy of the geotechnical report is included in the CD of Attachments.

Table 4: Groundwater Level Summary

	MB01		MB02		MB03		MB04		MB05		MB06	
	mAHD	mBGL										
27/07/2016	37.0	2.9	36.1	2.3	32.4	2.5	32.5	2.1	34.4	3.5	35.2	2.7
22/08/2016	37.6	2.3	36.4	2.0	32.6	2.3	32.8	1.8	34.9	3.0	35.5	2.4
16/09/2016	38.2	1.7	36.7	1.7	32.8	2.1	33.1	1.5	35.5	2.4	35.8	2.1
14/10/2016	38.4	1.5	36.7	1.7	32.9	2.0	33.2	1.4	35.6	2.3	35.9	2.0
9/11/2016	38.1	1.8	36.5	1.9	32.8	2.1	33.0	1.6	35.3	2.6	35.8	2.1
22/08/2017	38.9	1.0	37.1	1.3	33.5	1.4	33.8	0.8	36.2	1.7	36.4	1.5
13/09/2017	38.7	1.2	36.9	1.5	32.9	2.0	33.6	1.0	36.0	1.9	36.3	1.6
6/10/2017	38.9	1.0	37.0	1.4	33.4	1.5	33.7	0.9	36.1	1.8	36.4	1.5
13/11/2017	38.3	1.6	36.6	1.8	33.1	1.8	33.4	1.2	35.6	2.3	36.1	1.8
7/12/2017	37.9	2.0	36.3	2.1	33.0	1.9	33.2	1.4	35.2	2.7	36.0	1.9

6.2 Groundwater Allocation

There is currently allocation available below the subject land in the Perth Superficial Swan Aquifer, Leederville Aquifer and the Cattamarra Coal Measures Aquifer.

A review of DWER's online water register indicates allocation is available in the Superficial Aquifer, Leederville Aquifer and the Perth- Cattamarra Coal Measures within the Lower Serpentine groundwater subarea. To support irrigation of the proposed POS area, a groundwater licence will be obtained prior to detailed design.

6.3 Groundwater Quality

As part of the groundwater monitoring programme undertaken by Emerge Associates, groundwater quality was also sampled on two occasions, 22 August 2017 and 13 November 2017. The groundwater samples were analysed for nutrient concentrations and in-situ measurements of physical parameters. Nutrient concentrations peaked in November 2017, with results shown in **Table 5**. Results indicated that Total Nitrogen (TN) was above the Peel Harvey Water Quality Improvement Plan's target TN value of 1.0 mg/L and Total Phosphorus was generally measured below the target value of 0.10 mg/L.

Table 5: Groundwater Quality Summary

	Units	MB01	MB02	MB03	MB04	MB05	MB06
Physical Parameters (measured in situ)							
Temperature	°C	17.3	17.8	17.9	18.5	19.5	17.4
Electrical Conductivity	mS/cm	0.477	1.609	0.206	0.096	0.164	0.204
Dissolved Oxygen	mg/L	3.88	2.51	7.76	6.84	5.61	5.44
Dissolved Oxygen	%sat	40.7	26.4	81.8	72.7	61.1	56.9
pH	pH units	4.8	5.15	5.48	5.65	5.31	5.18
Redox	mV	61	45.9	51	35.9	52.4	53.5
Nutrients & Nutrient Species (laboratory analysis)							
Ammonia as N	mg/L	<0.01	0.01	0.02	<0.01	0.01	0.01
Nitrites as N	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrates as N	mg/L	<0.01	0.02	9.94	2.29	0.86	3.63
Total Kjeldahl Nitrogen as N	mg/L	0.5	<0.1	1.2	0.7	0.2	0.5
Total Nitrogen as N	mg/L	0.5	<0.1	11.1	3.0	1.1	4.1
Total Phosphorous as P	mg/L	0.03	0.04	0.08	0.10	0.05	0.06
Reactive Phosphorous as P	mg/L	<0.01	<0.01	<0.01	0.02	<0.01	<0.01

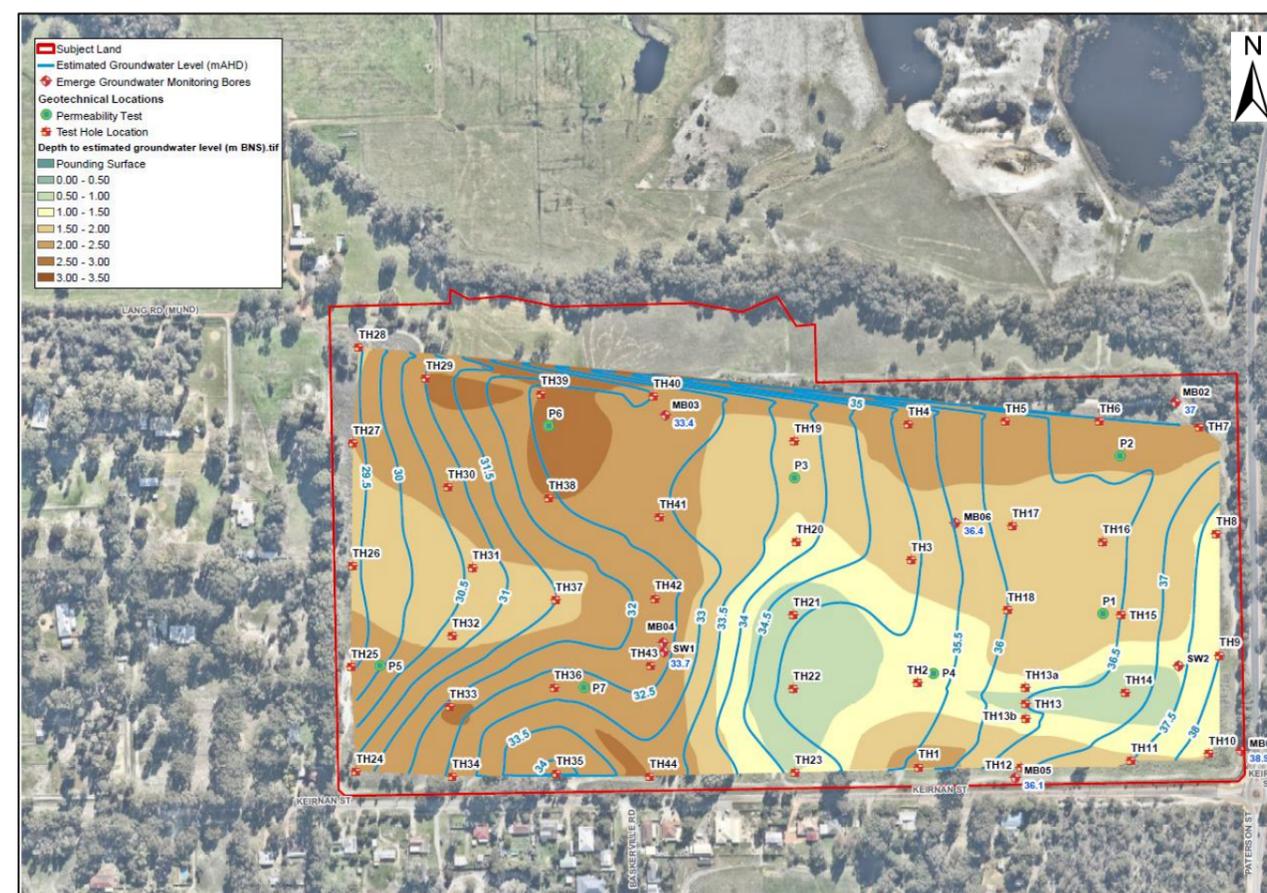


Figure 11: Monitoring Bore Locations and Groundwater Isoleths

7 Post-Development Stormwater Management

The drainage management strategy will utilise a minor and major approach, covering a range of storm events up to the critical 1% AEP storm.

The major drainage system is designed for rainfall events greater than the 20% AEP, up to the 1% AEP. The major system includes detention storages located within the Public Open Space, discharging into neighbouring property and Manjedal Brook. The sites road network will be utilised to convey the major drainage to the various detention storages.

The minor drainage system has capacity for frequent rainfall events up to the 20% AEP and includes water quality treatment for the first 15mm of rainfall. Minor drainage structures include on-lot soakwells, a pipe drainage system, GPT's and bioretention gardens within the POS.

7.1 Minor Drainage System

Key points for the design of the minor drainage system are as follows:

- Lots and roads graded to direct overland flow to the low point of each catchment.
- Lots will retain and infiltrate the first 15mm of rainfall on site within soakwells, installed as per Shire standards.
- Peak outflow discharging into Manjedal Brook will be equal to or less than pre-development flows for respective AEP storm events.
- Water flowing off impervious surfaces not associated with lots, including roads, pathways and driveways and excess runoff from pervious areas will be directed to bioretention basins. The bioretention basins will be located at the base of the detention storages, sized to retain the first 15mm of rainfall or 2% of the effective impervious area. The bioretention basins will have vertical side slopes and a depth of 0.30m.
- Bioretention basins will be underlain with 0.3m of amended soil media, stormwater will infiltrate through the media before entering a subsoil drainage pipe, laid at the base of the amended soil media. Subsoil inverts will be at or above the estimated pre-development groundwater level. Amended soil media will be in accordance with the Facility for Advancing Water Biofiltration (FAWB) Adoption Guidelines for Filter Media in Biofiltration Systems and the Stormwater Management Manual of WA guidelines.
- Local native plants will be used throughout the POS and bio-retention basins. Non-local species used in the landscaping design will be chosen for drought tolerance.
- A GPT to be installed upstream of the detention basins, sized to treat the first 15mm of rainfall with capacity to bypass larger flows.
- It is anticipated that surface water quality will be improved through the introduction of the stormwater management system associated with the swales, basins and wetland systems.

7.2 Major Drainage System

Key points for the design of the major drainage system are as follows:

- The finished floor levels are to be a minimum of 500 mm above the regional peak 1% AEP flood level. This varies across the site, with a floor level of 40 m AHD being relevant for the south eastern edge and 39 m for the north eastern edge. This drops to 32 m AHD on the south western edge and 33.5 m AHD in the north-west. The exact heights are to be refined as part of detailed design.
- The road drainage network to be sized to convey the peak 1% AEP storm event towards catchment detention storages at the low point of each catchment, in the POS.
- Finished floor levels will also be a minimum 300mm above the gutter line or the peak flood level of the internal stormwater system
- On-lot soakwells will overflow towards the road drainage network in events above 15mm.
- The eastern boundary culvert will be blocked as part of development works. As detailed in Section 5.1, this will not impact flood levels within Manjedal Brook.
- Peak outflow discharging into the Manjedal Brook will equal or be less than pre-development flows for respective AEP storm events.
- Outflow pipes from the detention basins will be set 150 mm above the top of the bioretention basins, with rock pitching installed at the downstream invert to prevent erosion.
- Detention basins to have a maximum side slope of 1:6 (V:H) and a maximum depth of 1.2m

- Low kerbing to be provided at the low-point adjacent to catchment detention storage to allow overland flow to enter the storage from the road pavement.

7.3 Post-development Flood Analysis

The aim of the drainage management for the proposed development is to maintain or reduce the pre-development flow regime leaving the subject land, provide at-source infiltration for pervious areas and protect houses from flooding during extreme rainfall events.

Post-development catchments have been determined based on development layouts and preliminary estimation of development contours. The catchments for the post-development analysis are presented in **Figure 12**. The following changes have occurred relative to the pre-development catchments:

- Catchment A has increased in size due to the regarding required for development lots.
- Catchment B has increased in size as all of Lots 11-14 are now directed to the northern point of discharge, where previously the southern portion of this area drained to the west.
- Catchment C1 is directed into the sports ovals (C2) and combined with catchment C3 to provide the total flow at the western point of discharge. The area of catchment C for the post-development scenario has reduced considerably, resulting in reduced flows at the western point of discharge.

Roughness coefficients and corresponding runoff coefficients were assigned based on the development layouts provided.

Table 6 provides a summary of the land use areas for each of the catchments and **Table 7** provides a summary of the catchment parameters applied to each of the land uses.

Table 6: Catchment and Land Use Areas

Land Use	Catchment Area (ha)					Total
	A	B	C1	C2	C3	
POS	1.03	0.57	0.00	6.58	0.00	
Lots	1.20	8.80	2.66	0.00	3.64	
Road	0.86	3.41	1.17	0.00	1.67	
Total	3.09	12.78	3.83	6.58	5.31	31.59

Table 7: Land Use Parameters

Land Use	Initial loss (mm)	Proportional Loss	Pervious Roughness (n)	Impervious Roughness (n)
POS	0	0.5	.03	.014
Lots/school	15	0.5	.04	.014
Road	0	0.2	.03	.014

Post-development analysis was used to determine the changes in flows at each of the points of discharge and to determine the detention storage required to ensure that peak flows from the site are not increased for any of the assessed AEP events.

Post-development detention storage has been located in the POS in the north of the site. The storage inverts were modelled based on the peak 1% AEP flood level within Manjedal Brook (see section 5.1) and assumed to be 0.5m above the controlled groundwater levels.

The resultant post-development flows and required site detention storage for the various catchments is presented in **Table 8** and the overall Stormwater Management Plan solution is provided in **Figure 13**.

Table 8: Post-development Peak Flows and Site Storage Requirements

Scenario	Peak Flows (m3/s)		
	Catchment A	Catchment B	Catchment C
	Storage		
Volume (m3)	422	602	529
Area (m2)	778	1125	9,131
	63.3% AEP Storm		
Pre-development	0.020	0.071	0.140
Post-development	0.033	0.069	0.107
Post-development with storage	0.019	0.055	0.042
Depth of water in storage	0.19 m	0.23 m	0.04 m
	20% AEP Storm		
Pre-development	0.034	0.122	0.240
Post-development	0.063	0.137	0.204
Post-development with storage	0.033	0.122	0.088
Depth of water in storage	0.41 m	0.33 m	0.07 m
	1% AEP Storm		
Pre-development	0.052	0.205	0.401
Post-development	0.104	0.246	0.338
Post-development with storage	0.048	0.204	0.158
Depth of water in storage	0.78 m	0.74 m	0.11 m

The storage associated with Catchments C2 is resultant of the sports ovals and has been modelled for consistency, but is not required for attenuation of flows.

Outlet configurations for the detention storages associated with catchments A and B have included the following:

- Subsoil drainage at the base of the 300mm deep bioretention media.
- Detention drainage, which has been placed 150mm above the top of the bioretention media, to allow for adequate ponding and infiltration into the media.
- Weir outlet at the top of the required detention storage to allow the 1% AEP, and larger events, to overtop the storages.

The outlet for the storage associated with catchment C2 (the sports oval) has been placed at the base of the ovals storage. A larger pipe has been adopted for the oval to minimize the potential for blockage. The adopted outlet configurations for the storages are presented in **Table 9** below. A further overland flow outlet for the sports oval will be included in the case of a blockage in the outlet pipe.

Table 9: Storage Outlet Configurations

Outlet Configuration	Catchment A	Catchment B	Catchment C2
Subsoil drainage invert (m AHD)	38.0	35.4	34.0
Subsoil drainage outlet configuration	2 x 120 mm dia pipe	1 x 170 mm dia pipe	1 x 375 mm dia pipe
Detention drainage invert (m AHD)	38.45	35.85	n/a
Detention drainage outlet configuration	1 x 140 mm dia pipe	2 x 220 mm dia pipe	n/a
Weir invert	39.0	36.1	n/a
Weir configuration	V weir, 1:1 side slopes	V weir, 1:1 side slopes	n/a

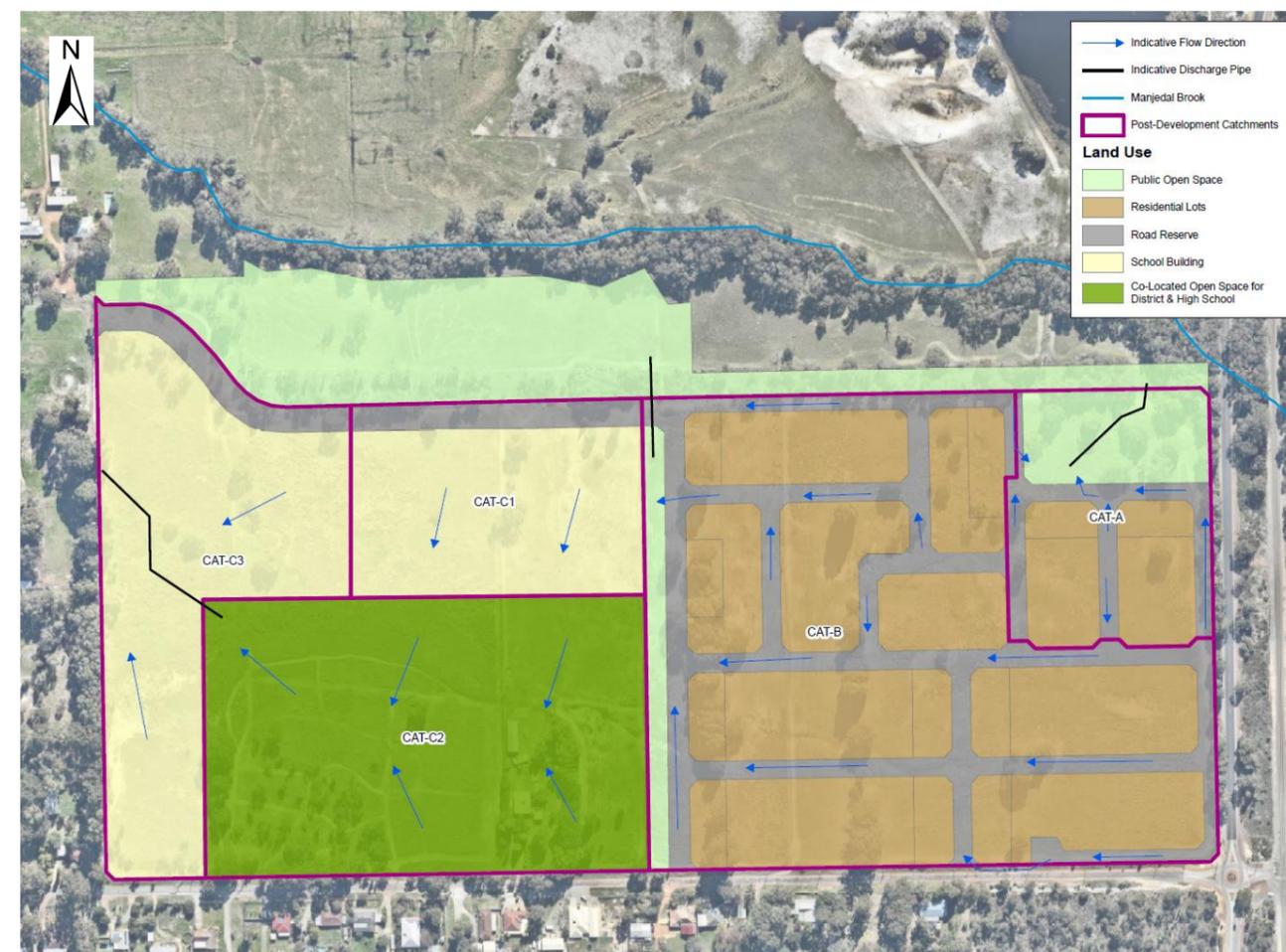


Figure 12: Post-development Catchments

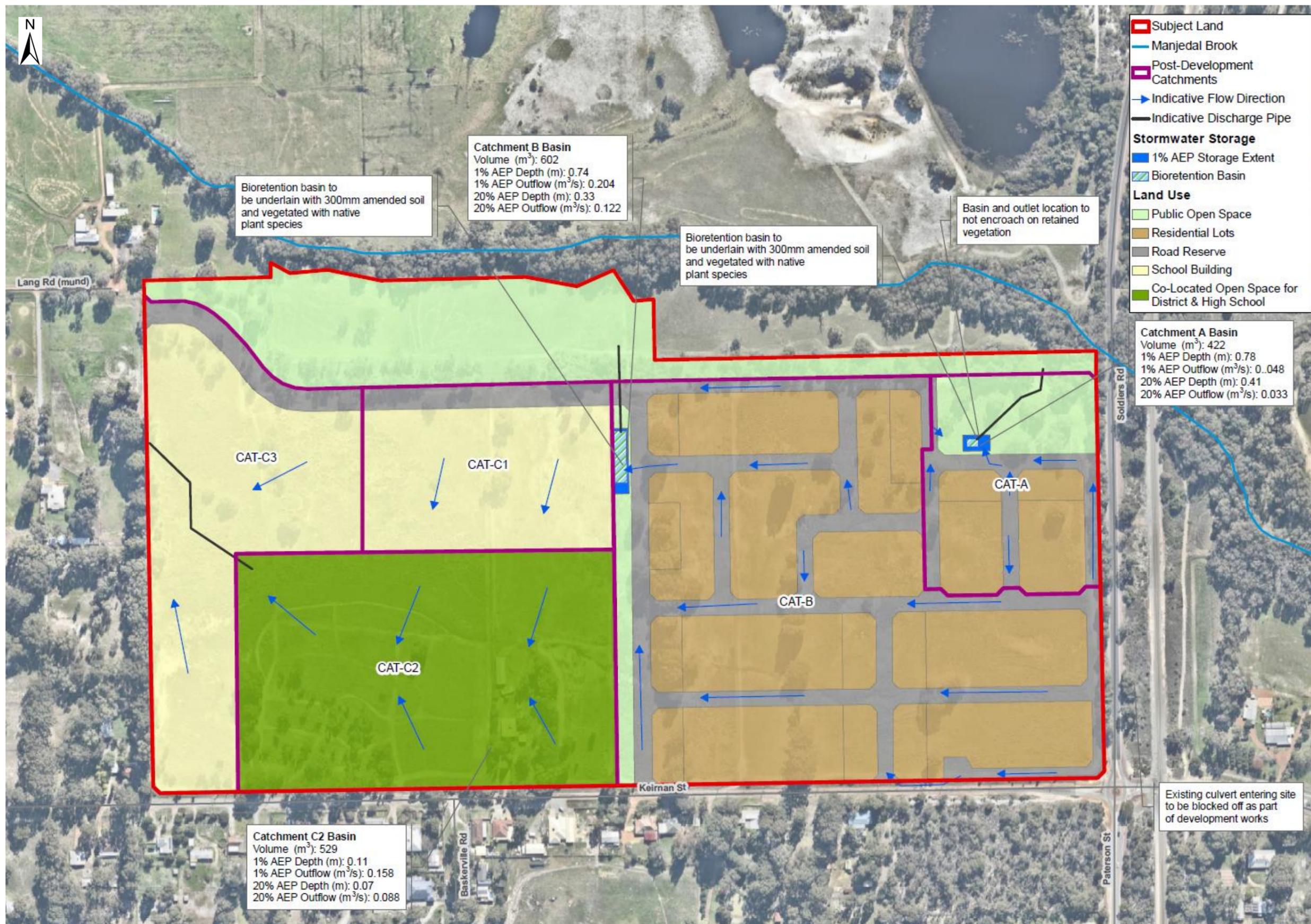


Figure 13: Stormwater Management Plan

8 Groundwater Management Strategy

Groundwater management for the subject land has been prepared in line with the Stormwater Management Manual for Western Australia (DWER, 2007).

Groundwater management objectives are to:

- Where subsoils are installed, subsoils will discharge directly into the internal drainage network to be treated prior to discharging into the Manjedal Brook.
- Manage groundwater levels to protect infrastructure and assets.
- Maintain groundwater regimes for the protection of groundwater dependant ecosystems.
- Protect the value of groundwater resources.
- Adopt nutrient load reduction design objectives for discharges to groundwater.

8.1 Groundwater Level Management

Key points for the management of groundwater levels are as follows:

- A minimum separation of 1.5m to the estimated pre-development groundwater levels or impermeable clay layer will be maintained post-development. Where this separation does not already exist, imported fill and a subsoil pipe network will be utilised.
- Subsoils will be set predominately at the estimated pre-development groundwater level. Subsoil pipes will be laid at a minimum 1:400 grade, will be a minimum pipe diameter of 225mm and will be located within the road reserve.
- Mounding will occur between the subsoil pipes, with a maximum of 500mm below houses after a 20% AEP event in the wettest month of the year. Mounded groundwater will rapidly drain to the subsoil system, reducing the mounding elevation below residential lots. The use of free draining fill and the distance between subsoil pipes throughout the development will assist in reducing mounding of groundwater. The permeability of all sand fill is to be a minimum of 5m/day.
- Road levels and building floor levels are to be set so that they are not negatively impacted by the recorded maximum groundwater elevation within the area in which they are located.
- All lot soak wells are to be shallow in nature (e.g. 900mm), so that their infiltration rate is not influenced by high groundwater levels.
- Where possible water will be infiltrated on site to maintain similar overall infiltration volumes to the pre-development scenario. This is to be achieved through the use of pervious surfaces, bioretention basins and soakwells, which are designed to infiltrate water.

An indicative Groundwater Management Plan has been included in **Figure 14**. It is expected that the discharge of subsoil flow at the downstream extent of the development will be similar to existing conditions. This is to be confirmed as part of future investigations.

8.2 Groundwater Quality

Key points for the management of groundwater quality are as follows:

- Due to the removal of stock and the use of a main sewer system and smaller lots, nutrients and other potential pollutants will mainly be restricted to uses associated with house gardens. Information on nutrient wise gardening is to be provided to lot purchasers to assist with minimising nutrient inputs. This will include information currently available through the Shire.
- POS areas will be vegetated using mainly native vegetation with limited nutrient application used.
- All stormwater up to the first 15mm of rainfall will be treated in bioretention basins. This means that water entering the subsoil system from the filtered stormwater should be treated to DWER guidelines. The bioretention basins will be designed and constructed according to the latest FAWB Adoption Guidelines for Filter Media in Biofiltration Systems and the Stormwater Management Manual for WA design guidelines.
- Roof runoff directed to soakwells is another major source of groundwater. This water is relatively clean, which will assist with keeping groundwater pollutant concentrations within acceptable limits.
- Suitable soil amelioration products will be laid within gardens and turf areas in POS, to assist with binding nutrients in the soil profile. This will reduce potential movement of nutrients to the groundwater.

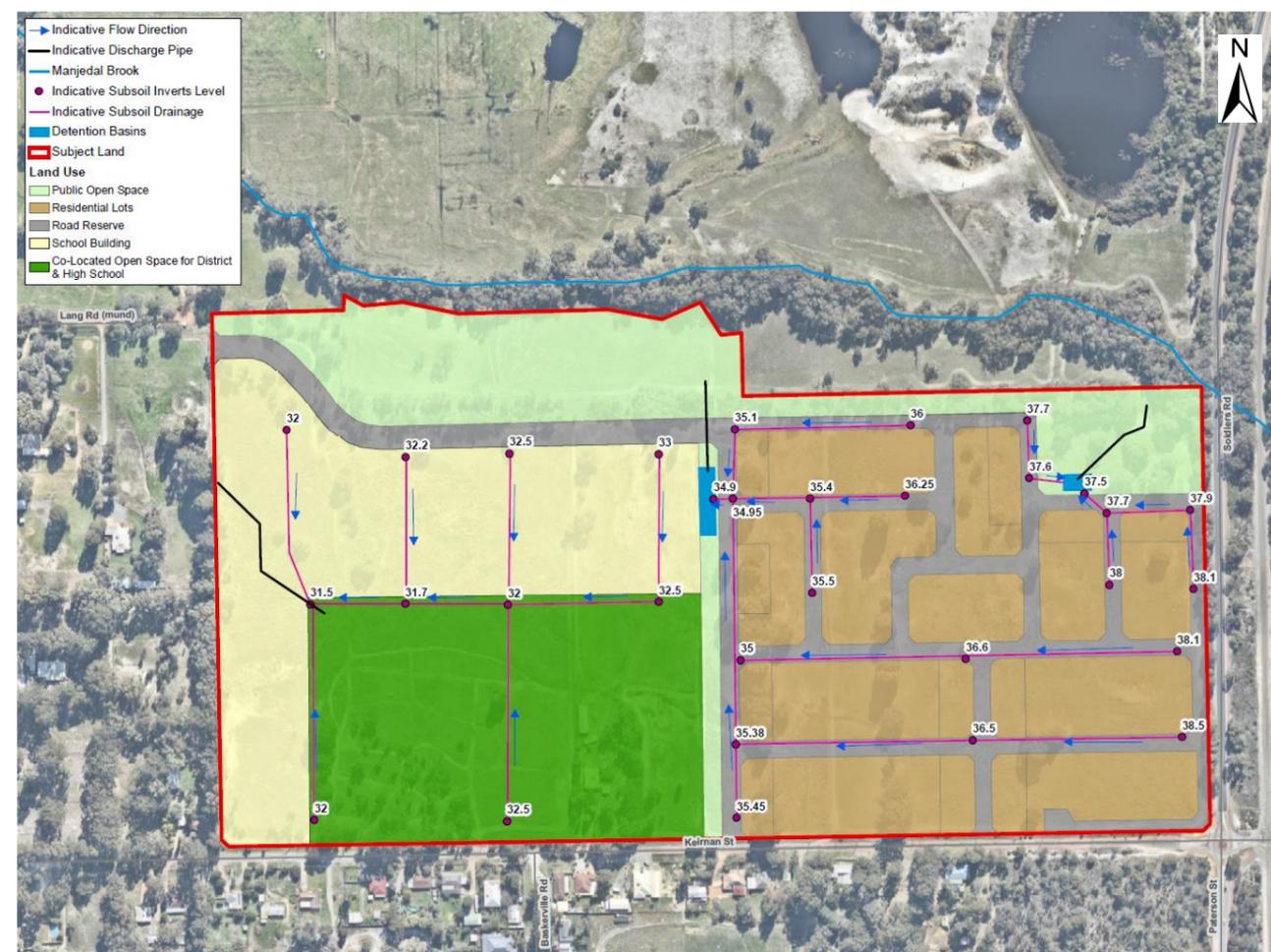


Figure 14: Groundwater Management Plan

9 Water Servicing

9.1 Potable Water Supply

The Water Corporation's Esinet website shows that there is potable water supply available via the existing 315PE water main on Soldiers Road and the existing 150PE water main on the south side of Keirnan Street. The water reticulation through the site will be via a reticulated 150PE network.

9.2 Fire Fighting

Fire fighting water supply will be provided by way of hydrants designed and installed to Australian Standard AS 2419.1-2005.

9.3 Non Potable Water Supply

There is the potential for individual Non-potable water supplies including outdoor taps and garden irrigation which could be supplied from onsite groundwater bores, with an appropriate licence. This is the responsibility of lot owners.

As part of the development, 6.01 ha of POS will be constructed which will consist of some retained trees, open grass areas, landscaped gardens and approximately 880m² of vegetated stormwater basin. Approximately 3ha of the POS will require full irrigation, utilising an irrigation rate of 6,750 kL/yr/ha. The garden beds and potentially the edge of the basins (at a total area of 2.7ha) and the sports ovals (7.74 ha) require a further 4000kL/ha /yr. An initial allocation of water for POS irrigation has therefore been set at 58,410 kL per year.

Given there is allocation in all 3 aquifers below the subject land, the water source of choice for POS irrigation is to be groundwater, acquired through an approved groundwater licence as part of the subdivision process.

A concept Landscaping Masterplan can be presented in **Figure 15**.

Efficiency

In an effort to reduce irrigation requirements within POS areas, the following water efficiency initiatives should be explored as part of the detailed landscape plan:

- Water efficient appliances to be installed where required.
- Utilise an irrigation rate of 6,750 kL/ha/yr consistent with DWER's irrigation targets.
- Use of native species and xeriscaping.
- Sprinkler types chosen based on landscaping and hydro-zoned with valves designed to reduce overspray.
- Installation of subsurface irrigation lines where possible.
- Watering to occur predominately during the night.

9.4 Sewer

A reticulated network of DN150 gravity sewer mains will provide every lot with a single connection. The fall of the gravity sewer will be from the south-east to the north-west and will be designed in accordance with Water Corporation standard DS50. The subdivision's sewer will connect to the designated connection point within the Lang Road reserve at proposed invert level 33.0m AHD. This connection point in the north west is external to the subject land.

It is possible that this access chamber may need to be a designated tankering point for the development until the WWPS and gravity sewer mains to the pump station are constructed. The ultimate scheme is for the development's wastewater to be conveyed to the future Mundijong wastewater pump station (WWPS), located west of the LSP area on Scott Road, east of Tonkin Highway.

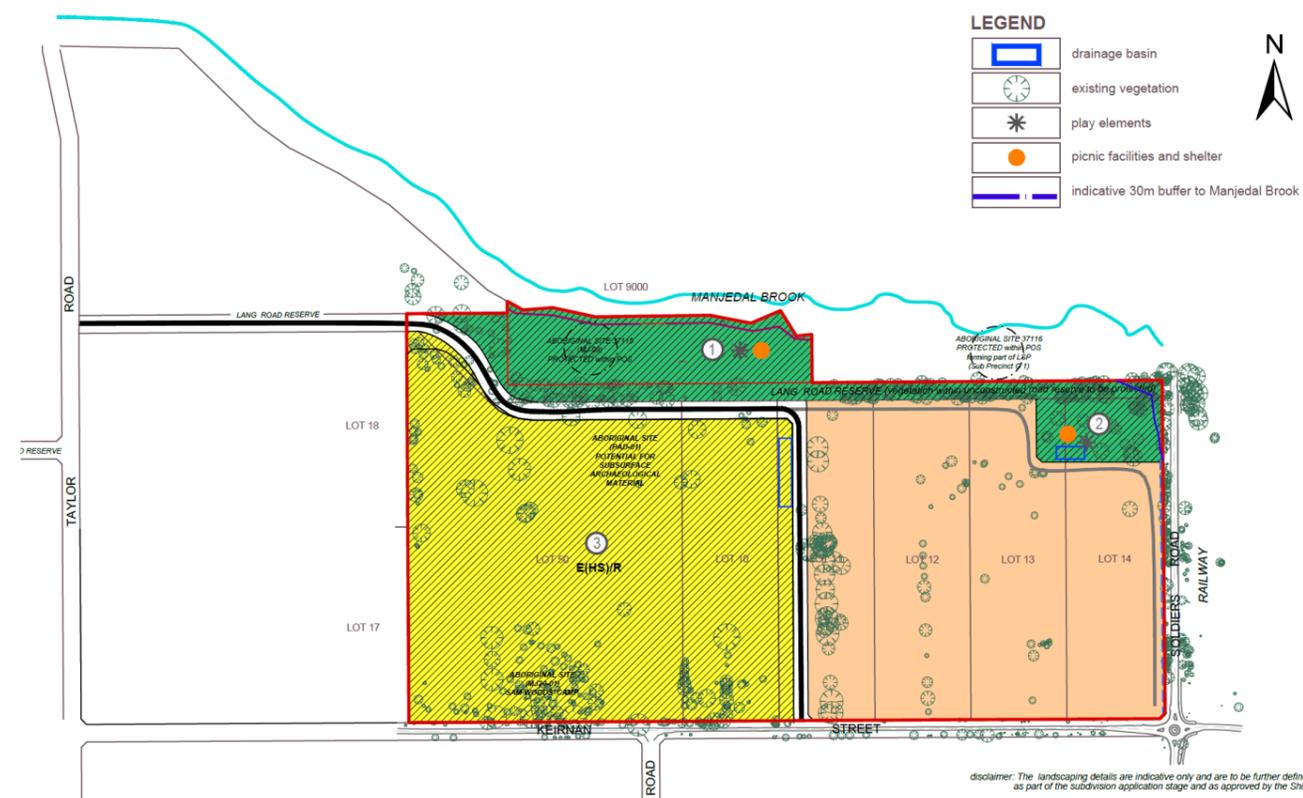


Figure 15: Landscaping Concept

10 Water Dependent Ecosystems Management

There are two main focuses for the management of water dependent ecosystem (WDE) as part of the subject land's future development. Firstly, protection of the nearby Conservation Category Wetland system and Manjedal Brook by treating water prior to discharge from the subject land and keeping groundwater levels as close as possible to predevelopment levels. Secondly, there will also be the creation of new WDE habitat across the site. This includes basins within the POS areas.

10.1 On Site Ecosystems

Detention and Infiltration Systems

The bioretention basins constructed as part of this development will provide some ephemeral wetland type habitat to generalist wetland species. The construction and planting of these basins, can maximise this effect through shaping to create various zones and the use of locally native plants. This can be complemented by utilising native plantings in surrounding streetscape areas.

As such, these areas can act as areas for future colonisation by a variety of small fauna and assist with fauna movement between larger nearby natural systems. The bioretention basin areas are to include both an understorey of sedges and rushes as well as an overstorey of wetland shrubs, with trees on the banks. Species should be chosen from the Vegetation guidelines for stormwater biofilters in the south west of Western Australia (Monash University, 2015), or similar publications.

Manjedal Brook Ecosystem Protection

The Brook and its foreshore buffer is outside of the subject land. The main focus for protection of this system is therefore to manage water that leaves the subject land, prior to it entering the Brook.

The stormwater management system has been designed to detain flows to pre development levels for all events up to and including the 1%AEP. The basins are also designed to treat and infiltrate the majority of the 1EY storm. Through this combination of measures, water leaving the site is both detained to the predevelopment flow that the Brook has evolved to and potential pollutants are reduced.

11 Monitoring & Maintenance

Monitoring within the subject land and the contingency actions to address any related problems are shown in **Table 10**. The following is a summary of the monitoring that has been and will be undertaken in relation to water management.

11.1 Pre-Development

Groundwater

Pre-development monitoring of groundwater levels and quality was undertaken between 2016 and 2017 by Emerge. The full details can be seen in the previous groundwater sections (Section 6).

Surface Water

Surface water monitoring for water quality is not considered necessary, given there are no natural flowing water systems or exposed groundwater, associated with wetlands, found within the site.

Construction Phase

Installation of drainage control structures ahead of the construction phase of the development will be utilised. These will include the use of Water Sensitive Urban Design techniques such as sediment curtains, hydro mulching and temporary detention basins to maintain the quality of the water leaving the development area during construction. The bioretention basins will be monitored for any damage, including compaction, sediment build up, oils, and litter during and at the completion of construction to ensure the structure's effectiveness is not diminished. Sediment and litter on roads will be monitored, with removal completed as necessary with street sweeping.

To minimise issues with degradation of vegetated treatment systems, it is recommended that planting should be delayed until the risk of high sediment loads has passed. The systems should be stabilised with geofabric or similar in the interim. Once the sediment risk has passed, the accumulated sediment and geofabric should be removed and the system vegetated.

Construction monitoring and maintenance regimes are to be developed and finalised within the UWMP.

11.2 Post-Development

Groundwater

Post-development groundwater monitoring may be undertaken for a further 2 years after 80% completion of subdivisional works. Monitoring is to be monthly for levels and quarterly for quality.

Trigger values set at 10% above the pre-development rates will be set in place. Should these trigger values be reached, contingency actions will be undertaken to rectify the issue.

Indicative monitoring locations are shown on **Figure 16**. A final bore field and monitoring regime is to be decided as part of the subdivisional process and reported in the UWMP.

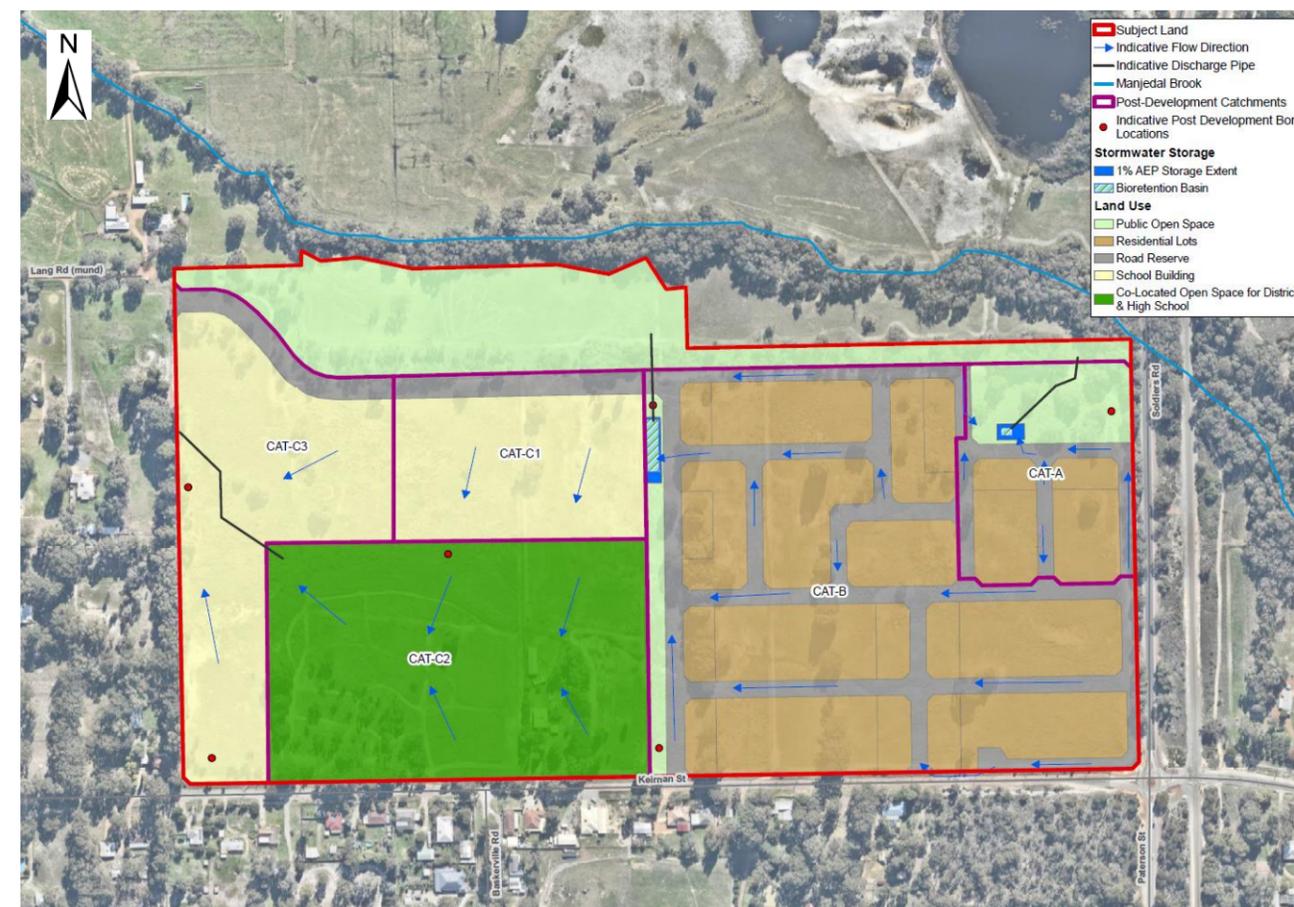


Figure 16: Groundwater Monitoring Locations

WSUD and Other Infrastructure

Performance monitoring of WSUD elements will be completed to ensure the system is working effectively. Indicators will be used as a cost effective method to evaluate the adequacies of WSUD performance. It can be assumed that if the WSUD elements operate in accordance to their intended design then the desired management objectives are being met.

The key WSUD elements to be monitored will include:

- Ensuring the inlet and outlet structures are free of debris through regular removal of material and control of catchment generated debris e.g. street sweeping, leaf removal and appropriate locating of rubbish bins to reduce rubbish;
- Vegetative cover of the systems is maintained;
- Sediment build up is not impeding the functionality (note, design vegetated systems so that excessive short term sediment in early stages is not an issue e.g. do not plant until high risk sediment movement has passed);
- Erosion is not present;
- Soils are not compacted;
- Litter is removed;
- Excessive hydrocarbons are not present in the system;
- Weeds controlled;
- Infiltration of stormwater is maintained to reduce standing water (in non-wetland systems);
- Flows are not excessively detained;
- Stormwater pipes are flowing freely;
- Gross Pollutant Traps are functioning and are not blocked; and
- Subsoil pipes are flowing freely (should they be required in localised areas).

Compared to traditional engineered structures for stormwater runoff management, the WSUD elements require different routine maintenance and these are generally of a landscape maintenance nature. The most common maintenance is the removal of weeds, debris and siltation. The most time intensive period of maintenance for a vegetated WSUD system is during plant establishment (which typically includes two growing seasons), when supplementary watering, plant replacement and weeding may be required. The WSUD elements will be constructed and utilised in different stages so that the functions of the WSUD elements are protected from elevated pollutant loads generated from a developing catchment.

It is recommended that vegetated WSUD elements are monitored by personnel with floristic knowledge and/ or qualifications and be capable of identifying evasive species within the natively vegetated WSUD systems. Furthermore, personnel in charge of monitoring should have a good understanding of principles and the functional design of the WSUD elements and the treatment system. The maintenance activities prompted through monitoring activities will generally require coordination between landscape and civil services.

The pit and piped network will also require maintenance to ensure they continue to function as designed. This will include rodding, removal of sediments and other debris, as well as the replacement of broken components due to general long term corrosion and wear.

Maintenance inspections should be conducted after significant storm events (mobilised sediments and coarse material). Inspections should focus on ponding time for the different systems, unequal surface flow distribution and scouring.

A key focus should also be on the control of litter and sediment that is often generated during the house/building construction phase. This is the most common time when systems are degraded or fail, due to large volumes of pollutants such as non-biodegradable litter, cement fines, direct vehicle compaction, sand movement and other sedimentation issues. Compliance aspects will need to be discussed with the Local Authority, so that rectification of the source problems can be achieved.

11.3 Reporting

All information collected from the monitoring programs should be recorded and provided in a report, prepared by the developer, to the Department of Water and Environmental Regulation and Local Government. The report will compare monitoring results with target design and performance criteria to ascertain what, if any, actions may be required, and will provide ongoing assessment of the suitability of monitoring and reporting strategies. If a trigger value for a contingency action is reached, a more detailed report on the occurrence, its impact and proposed action to prevent recurrence is to be compiled by the developer and submitted to the Local Authority and Department of Water and Environmental Regulation. After 2 years of monitoring for the relevant Stage by the developer, the local authority will become responsible for any further monitoring they wish to undertake.

Table 10: Monitoring and Maintenance Table

Function	Item to Monitor	Purpose of Monitoring	Trigger for Immediate Action	Maintenance Action Required	Monitoring Frequency	Responsibility
Drainage Management Systems	Structural Effectiveness (inlets, traps and outlets)	Inspection for debris, litter and sediments surrounding structural components.	Debris, litter or sediments causing blockages or impairing functions.	Remove any debris or blockages. Inspect system for any erosion related issues.	Every 3 months	Developer until handover to Council
	Erosion	Inspection for erosion.	Presence of severe erosion or erosion impairing functions.	Investigate, identify and rectify the cause of the erosion. Replace filter media as required.	Every 3 months	Developer until handover to Council
	Sediment Build Up	Inspection for sediment accumulation within pits, on the surface of swale systems and within soakwells. B) Inspection of sediment build up on roadways.	A) Accumulation of large volumes of sediments in swale or on the surface or greater than 50% of the swale/basin's depth. B) Accumulation of sediment on roadway	A) Investigate, identify and stabilise cause of sediment source. Remove accumulated sediments and replace filter media or plants removed. B) Street sweeping to remove sediment	Every 3 months	Developer until handover to Council
	Weeds	Inspection for the presence of weeds.	Weeds are noxious or highly invasive or if weeds cover more than 25% of area.	Manual removal or targeting herbicide application, with waterway approved products.	Monthly	Developer until handover to Council
	Plant Condition	Inspection of vegetation health and cover, and presence of dead plants.	Plants dying or a pattern of plant deaths.	Investigate cause of plant deaths and rectify. Infill plantings may be required.	Monthly	Developer until handover to Council
	Organic Litter	Inspection for the presence of organic litter (e.g. leaves) on surface.	Litter coverage is thick or extensive, or detracting from the visual appearance of the system.	Investigate source of litter and undertake appropriate response, e.g. alter landscaping maintenance practices, community education). Remove litter.	Monthly	Developer until handover to Council
	Rubbish/Litter	Inspection for the presence of litter.	Litter is blocking structures or detracting from the visual appearance of the system.	Identify source of litter and undertake appropriate responses. Remove litter.	Monthly	Developer until handover to Council
Groundwater	Pre development levels(Pre development)	To acquire baseline for wetland protection and to allow for effective post development management strategies. E.g. fill levels	NA	NA as pre development base line.	Monitoring has been completed to DWER requirements already.	Developer (has already undertaken monitoring)).
	Wetland revegetation work	Determine if revegetation has been successful.	A) Death of plants above 20%. B) Weed invasion at a level where it hinders native regeneration, species composition maintained.	Removal of weeds,	Every 3 months (for 2 years after practical completion)	Developer until handover to Council
Surface Water/Wetlands	Levels pre development	Provides baseline for wetland and drain water levels	Extreme levels of flooding	Investigate and identify source of flooding. Undertake appropriate responses to rectify the flooding if not due to extreme rainfall.	Monthly for at least 1 year	Developer
	Levels post development	Allows for assessment of wetland and drain levels in comparison to predevelopment state	Results above agreed upon standards and or 10% variation from pre development monitoring results.	Investigate and identify source of change. Undertake appropriate responses to rectify the level change if not due to extreme weather conditions.	Quarterly for two year after final stage of construction.	Developer until handover to the Council

12 Implementation Plan

The developer is committed to undertaking the water management strategies outlined in this report. Implementation of the strategies outline in this report will be undertaken prior to developmental works, as part of subdivisional works and into the post development phase. To assist with this implementation, an Urban Water Management Plan (UWMP) will be completed as part of subdivisional works. The UWMP will provide more detailed information on the relevant implementation of the water management aspects. This is to include:

- Detailed WSUD treatment design, including full calculations to rationalise water quality treatment sizing and location.
- Clearly identify geotechnical requirements for imported fill to meet assumptions of groundwater modelling.
- Prepare detailed lot stormwater management requirements for the proposed residential and commercial lots.
- Identify interim management measures for stormwater and groundwater if necessary.

Should a groundwater licence not be secured prior to construction, a water efficiency and conservation strategy will be required, in consultation with Local Government, to secure an irrigation source for POS areas in the subject land.

The following is a summary of activities and responsibilities that are to happen as part of the remaining development process.

12.1 Commitments by Developer

- Construction of overall drainage system including treatment and storage basins.
- The maintenance of the plants within the gardens and swales until handover to the Council.
- Appropriate fill used across the site.
- Provide lot owners with information regarding Waterwise practices inside and outside the house.
- Provide lot owners with information regarding nutrient wise practices and designs for gardens.
- Produce and implement a landscaping plan based on Waterwise and Nutrient wise principles.
- Undertake more detailed drainage analysis of the site as a part of subdivisional work.
- The preparation of Urban Water Management Plans as part of subdivision conditions.
- Monitoring of the sites water as outlined in the monitoring regime.
- Sediment control during construction.

12.2 Commitments by the Local Government

- Responsibility for the maintenance of the stormwater system installed, after a mutually agreed upon time period after construction. The Local Government will monitor and maintain the system as per their asset management programs and legal requirements.
- Ongoing encouragement of Waterwise and nutrient wise practices for residents.
- Approval of drainage design and other water management works.
- Approval of building licences including appropriate finished floor levels.

12.3 Commitments by Department of Water and Environmental Regulation

- Assist the Local Government in relation to assessing the UWMP as required.

12.4 Commitments by the Water Corporation

- Responsibility for the management of the sewer system.
- Responsibility for the management of the potable water supply to residents.

12.5 Lot Owners

- The lot owners will need to implement on lot water management in keeping with the guidelines set out in the UWMP and the Local Government guidelines.

13 References

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ANNEXURE 9
Aboriginal Heritage Strategy
Ethnoscience,
Thomson Cultural Heritage Management

Report on the Results of an Ethnographic Survey Lots 50, 10, 11, 12, 13 and 14 Keirnan Street, Lang Road Reserve & portion of Lot 101 Lang Road, Mundijong, Western Australia

Prepared for Peter Webb & Associates

By Edward M. McDonald

July 2020

Disclaimer

The results, conclusions and recommendations contained within this report are based on information available at the time of its preparation. Whilst every effort has been made to ensure that all relevant data has been collated, the author can take no responsibility for omissions and/or inconsistencies that may result from information becoming available subsequent to the report's completion.

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Abbreviations

ACMC:	Aboriginal Cultural Material Committee
AHA:	Aboriginal Heritage Act 1972
AHIS:	Aboriginal Heritage Inquiry System
Bilya:	Bilya Noongar Organisation
DJMM:	DJM Mundijong Pty Ltd
DPLH:	Department of Indigenous Affairs
GKB:	Gnaala Karla Booja Native Title Claimants
MHA:	McDonald, Hales and Associates
PDA:	Proposed Development Area
PWA:	Peter Webb & Associates
TCHM:	Thomson Cultural Heritage Management
Winjan:	Winjan Aboriginal Corporation

Acknowledgements

Clarry Walley (Bilya)	Harry Nannup (WAC)
Mary-Rose Walley (Bilya)	Franklyn Nannup (WAC)
Barbara Abraham (Bilya)	Mark Nannup (WAC)
John Michael (Bilya)	Joseph Nannup (WAC)
Jo-Anne Thomson (TCHM)	Clare McLean (PWA)

Summary & Recommendations

Peter Webb & Associates (PWA) commissioned Ethnoscience in December 2019, on behalf of DJM Mundijong Pty Ltd (DJMM), to undertake an Aboriginal heritage assessment of Lots 50, 10-14 Keirnan Street, Mundijong; the unmade section of the Lang Road Reserve; and the eastern portion of Lot 101 Lang Road, Mundijong.

PWA are preparing a Local Structure Plan (LSP) on behalf of DJMM for a proposal to build a residential development on Lots 11, 12, 13 and 14. The Department of Education, which owns Lot 50, plans to construct a High School on the Lot and the adjacent Lot 10 will be used as a District Playing Fields Reserve. The unmade portion of the Lang Road Reserve and the eastern portion of Lot 101 will be given over to public open space (POS)/foreshore reserve along Manjedal Brook.

Ethnoscience undertook the ethnographic survey on March 27, 2020 and commissioned Ms Jo-Anne Thomson of Thomson Cultural Heritage Management (TCHM) to undertake the archaeological survey. The archaeological field survey was conducted on 19-20 February 2020 and March 27, 2020. The results of the archaeological survey are reported under a separate cover (Thomson 2020) and should be read in conjunction with this report.

The ethnographic survey was undertaken with four Aboriginal consultants from each of the Bilya and Winjan Aboriginal organisations. These organisations had provided the Aboriginal consultants for the lengthy (2011-2020) archaeological and ethnographic investigations and consultations in respect of the extensive Aboriginal heritage on the adjacent Lots 9000, 3 and 5 Taylor Road to the immediate north of the present survey area and their members have demonstrated associations with, and knowledge of, the Aboriginal heritage of the Mundijong area.

The desktop research, which included a review of the AHIS, did not reveal the presence of any ethnographic Aboriginal sites or OHPs within the PDA. However, one archaeological site, an OHP: DPLH ID 37115 (MJ-09), a scarred or modified tree, is listed on Lot 101.

One ethnographic site, Sam Woods' Camp (MJ20-01), which also has archaeological components (Thomson 2020), was reported on Lot 50. The people who occupied the camp were members of the Woods/Hart/Nannup extended family and included the mother of one of the Aboriginal consultants, who participated in the present investigations.

The Aboriginal consultants requested that the campsite is preserved on the planned school ground and used for educational purposes or at minimum commemorated with interpretive signage.

The Aboriginal consultants also requested that ground disturbance associated with the proposed development is monitored.

They asked that where possible mature native trees are retained in the development, including those in the Lang Road Reserve.

The Aboriginal consultants also requested that runoff into Manjedal Brook is treated appropriately and that nutrients and other pollutants are stripped prior to entering the Brook.

Recommendations

1. It is recommended that the LSP for Lots 50, 10, 11, 12, 13 and 14 Keirnan Street, the eastern portion of Lot 101 and the undeveloped Lang Road Reserve Mundijong, is implemented on the basis of the concept plans presented to Bilya and Winjan in March 2020.
2. It is recommended that the landowner preserve the scarred tree ID 37115 (MJ-09) in foreshore reserve along Manjedal Brook in accordance with the archaeological recommendations.
3. It is recommended that the landowner preserve Sam Woods' Camp (MJ20-01) and that its heritage values are commemorated and used for educational purposes.
4. It is recommended that the landowner implement the archaeological recommendations in respect of Sam Woods' Camp (MJ20-01).
5. It is recommended that where the original ground surface is disturbed by earthworks that that disturbance is monitored in accordance with the archaeological recommendations.
6. It is recommended that where possible mature native trees, including those in the Lang Road Reserve, are retained in the development.
7. It is recommended that in accordance with best practice, nutrients and other pollutants are stripped from runoff and treated prior to entering Manjedal Brook.

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Introduction

Ethnoscience was commissioned in December 2019 by Peter Webb & Associates (PWA) on behalf of DJM Mundijong Pty Ltd (DJMM) to undertake an Aboriginal heritage assessment of Lots 50, 10, 11, 12, 13 and 14 Keirnan Street, Mundijong; the unmade section of the Lang Road Reserve; and the eastern portion of Lot 101 Lang Road, Mundijong (Figures 1 & 2). PWA are preparing a Local Structure Plan (LSP) on behalf of DJMM. The proposal is to build a residential development on Lots 11, 12, 13 and 14. Lot 50 is held by the Department of Education and has been assigned for a future High School. Lot 10 will be used as a District Playing Fields Reserve. The unmade portion of the Lang Road Reserve and the eastern portion of Lot 101 are destined to be within public open space (POS)/foreshore reserve along Manjedal Brook (Figure 3).

Ethnoscience undertook the ethnographic survey and commissioned Ms Jo-Anne Thomson of Thomson Cultural Heritage Management (TCHM) to undertake the archaeological survey. The archaeological field survey was conducted on 19 and 20 February 2020 and 27 March 2020, the results of which are reported under a separate cover (Thomson 2020) and should be read in conjunction with this report.

The proposed development area (PDA) lies within the Gnaala Karla Boodja (GKB) Native title claim (WC98/58). The PDA is contiguous with the Peet Mundijong Syndicate' LSP for Lot 9000, Taylor Road, which lies to the north of the PDA. The Peet LSP also includes Lots 3 and 5, Taylor Road, Mundijong. As a result, it was decided to use the same panel of Aboriginal consultants which had been involved with the Aboriginal heritage assessment of the Peet Mundijong Syndicate' land for over a seven-year period from 2012 (McDonald 2020; see also Thomson and Neuweger 2014). The panel of Aboriginal consultants comprises members of the Bilya Noongar Organisation (Bilya) and the Winjan Aboriginal Corporation (Winjan), whose members are GKB native title claimants and who have demonstrated associations with, and knowledge of, the Aboriginal heritage values of the country encompassing the PDA.



Figure 1: PDA Keirnan Street, Mundijong (Source: PWA)



Figure 2: Cadastral plan proposed DJMM Mundijong development (Source: PWA)

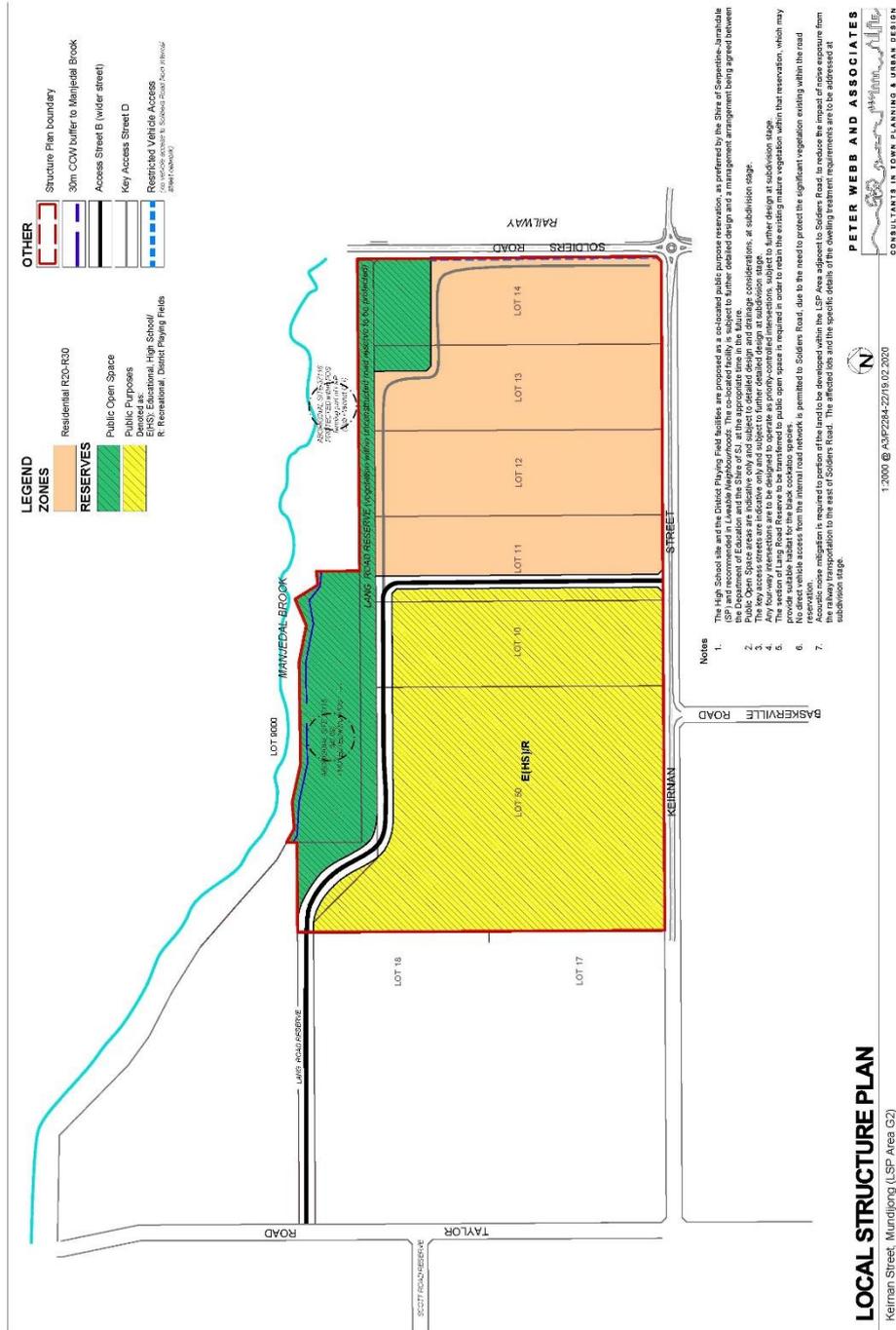


Figure 3: LSP proposed DJMM Mundijong development (Source: PWA)

Legislative Context

The *Aboriginal Heritage Act 1972* (AHA) is the primary piece of State legislation relating to Aboriginal heritage and defines and protects Aboriginal Sites and objects. Aboriginal Sites are places to which the Act applies by operation of Section 5 (outlined below) and are currently protected whether they are known to the Department of Planning, Lands and Heritage (DPLH, formerly the DAA) or not.

Section 5 of the AHA defines an Aboriginal Site as follows:

- a. any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of Aboriginal people, past or present;*
- b. any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent;*
- c. any place which, in the opinion of the Committee,¹ is or was associated with Aboriginal people and which is of historical, anthropological, archaeological, or ethnographic interest and should be preserved because of its importance and significance to the cultural heritage of the State;*
- d. any place where objects to which the Act applies are traditionally stored, or to which, under the provisions of this Act, such objects have been taken or removed.*

Under Section 39(3), the AHA gives primacy to “associated sacred beliefs, and ritual or ceremonial usage, in so far as such matters can be ascertained” in the Aboriginal Cultural Material Committee’s (ACMC’s) evaluation of the importance of places and objects. Otherwise the evaluation of the importance of places and objects is undertaken with respect to the criteria set out in s39(2) of the AHA:

- (a) any existing use or significance attributed under relevant Aboriginal custom*
- (b) any former or reputed use or significance which may be attributed upon the basis of tradition, historical association, or Aboriginal sentiment*
- (c) any potential anthropological, archaeological or ethnographical interest*
- (d) aesthetic values*

¹ The Aboriginal Cultural Material Committee (ACMC) whose role it is, among other functions, to evaluate, on behalf of the community, the importance of places and objects and to advise the Minister.

These criteria place a heavy emphasis in the evaluative process on Aboriginal custom, tradition, sentiment, and aesthetic values, which are typically assessed through ethnographic research and consultation of all places, including archaeological sites. Archaeological sites are therefore also assessable not just with respect to their 'potential archaeological interest' but also their 'potential anthropological or ethnographical interest'; that is, how they fit into Aboriginal custom, tradition and so on (McDonald & Coldrick 2020 discuss these issues with respect to archaeological sites in the Pilbara; however, as highlighted by McDonald (2016) for example, the key issues are also applicable to the Southwest).

Unauthorised disturbance of an Aboriginal Site is an offence under Section 17 which states that:

17. A person who -

excavates, destroys, damages, conceals or in any way alters any Aboriginal site; or,

in any way alters, damages, removes, destroys, conceals, or who deals with in a manner not sanctioned by relevant custom, or assumes the possession, custody or control of, any object on or under an Aboriginal site,

commits an offence unless he is acting with the authorisation of the Registrar under section 16 or the consent of the Minister under section 18.

Based on our interpretation of this section of the Act and experience, we generally advise our clients that where a place is a registered Aboriginal Site or might reasonably be expected to constitute an Aboriginal Site, that they should not undertake any of the activities outlined above that might result in a breach of Section 17, and that they should apply for Ministerial consent under Section 18 to limit their potential liability under the Act. In cases where a place is 'Lodged' with the DPLH, we also recommend that clients take a precautionary approach and seek Section 18 consent in order to clarify the status of the place under Section 5.

Section 18 provides a mechanism for landowners and proponents to seek consent to use land that might contain an Aboriginal Site(s) (i.e., a place to which the Act applies), and in effect to disturb those sites, from the Minister of Aboriginal Affairs and thereby protect themselves from potential prosecution under Section 17. After considering the recommendations of the ACMC and having regard to the "general interest of the community", the Minister may either consent to the use of the land for the purpose sought, give consent with conditions, or refuse

consent. Current guidance from the DPLH routinely advises proponents to apply the Aboriginal Heritage Due Diligence Guidelines (DIA 2013) so that they can determine whether their proposed activities have the potential to breach Section 17, and to seek advice from the Department where there is doubt (see below for further discussion).

The State Government is currently proposing to amend the AHA and have established a community consultative process with a view to producing a draft Bill in November 2020.

Other State legislation, such as the *Environmental Protection Act 1986* (EP Act), can in some instances complement the AHA (for example, in cases where physical protection of the natural environment is required to protect sites of heritage significance) (EPA 2004). Aboriginal heritage can also be afforded protection by Commonwealth legislation, in particular, the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*. Aboriginal people who believe that a significant place or object is under threat and that State Government protection is inadequate can apply to the Federal Environment Minister to protect the place or object.

Defining an 'Aboriginal Site'

In this report, we use the term 'Aboriginal Site' to refer to a place that the Aboriginal Cultural Material Committee (ACMC) has determined to be an 'Aboriginal Site' within the meaning of Section 5 of the AHA and is therefore 'registered'. While other places and objects may be listed on the AHIS and in other sources, this does not necessarily mean they are registered Aboriginal Sites. Indeed, many places and objects listed on the AHIS are in fact not Aboriginal Sites for the purposes of the AHA.²

For example, there are places and objects within the system that are referred to as 'Other Heritage Places'.³ Such places and objects may either be 'Lodged' on the system (which generally occurs following initial reporting of the place or object to the DPLH and prior to assessment by the ACMC) or for which it has been assessed that there is insufficient

² Decisions by the ACMC and the DPLH, of course, may be overturned by the courts, as was the situation in *Marapikurrinya Yintha* (DAA 22874) case (Robinson v Fielding [2015] WASC 108) and indeed may be revisited by the ACMC itself.

³ 'Other Heritage Places' were previously listed either on the 'Interim Register' or in 'Stored Data'.

information available to allow the ACMC to determine whether or not they are Aboriginal Sites within the meaning of s5. However, as there is a potential that such places might be found to be Aboriginal Sites in the future if further information becomes available, consequently, as noted above, it is prudent to treat 'Lodged' places as if they are Aboriginal Sites until a determination has been made by the ACMC and the legal status of the place has been established.

Another category of listing covered by the term 'Other Heritage Places' and which frequently is the source of confusion is that relating to places and objects archived in 'Stored Data' (also referred to as 'Archived Data'). Typically, these are places and objects for which a determination has been made by the ACMC and it has been concluded that they do not satisfy the criteria set out in Section 5 of the AHA and are therefore not 'Aboriginal Sites' for the purposes of the Act. Such places are therefore not subject to the Act's provisions. However, these places and objects are not deleted from the system (AHIS), but rather are maintained as 'Stored' or 'Archived' data in order to account for the possibility that new information may be presented in the future that might warrant a reassessment by the ACMC, and so that the DPLH is aware if the same place is reported again.

It is also important to be cognisant of the possibility that places that do not have the legal protection of State or Commonwealth heritage legislation may still have significance for Aboriginal people and could therefore potentially have implications for the community, and indeed for proposed developments, should they be impacted.

Ethnographic Survey & Consultation Methods

The ethnographic survey and consultation were undertaken in the following stages:

- ❖ Desktop research;
- ❖ Preliminary consultation with the Bilya and Winjan Aboriginal consultants;
- ❖ Ethnographic survey
- ❖ Report preparation.

Edward McDonald of Ethnoscience undertook the desktop research, which in the first instance involved an examination of the Register of Aboriginal Sites using the DPLH's online Aboriginal Heritage Inquiry System (AHIS). A review of previous consultancy reports and other published and unpublished ethnographic research material was also undertaken. Of particular relevance are the reports of heritage surveys undertaken earlier by McDonald, Hales and Associates (see Blockley & Greenfield 1995; Blockley *et al* 1996; Edwards & McDonald 1999) and more recently by other consultancies (for example, Goode, Preller and O'Reilly 2019 and McDonald 2020). O'Connor, Bodney and Little's (1985) regional study was also consulted.

The ethnographic survey, which was conducted on March 27, 2020, involved eight Aboriginal consultants drawn from the Bilya and Winjan groups. Clarry Walley led the team from the Bilya and included John Michael, Barbara Abraham and Mary Rose Walley. Harry Nannup headed the Winjan team, the other members being Franklyn Nannup, Mark Nannup and Joseph Nannup. Clarry Walley and John Michael of Bilya and Franklyn Nannup and George Walley of Winjan also had assisted Ms Thomson with the archaeological survey on February 19 and 20, 2020 respectively and Edward McDonald assisted her to complete the survey of Lot 101 on March 27, 2020.



Plate 1: Jo-Anne undertaking an archaeological survey of Lot 1010, land road, Mundijong (Photo: McDonald, March 2020)



Plate 2: Bilya Aboriginal Consultants (from left) Mary Rose Walley, Clarry Walley, Barbara Abraham & John Michael (Photo: McDonald, March 2020)



Plate 3: Winjan Aboriginal consultants (from left) Mark Nannup, Franklyn Nannup., Joseph Nannup and Harry Nannup with Franklyn's grandson, Colin in front (Photo: McDonald, March 2020)

Ethnographic Background

Berndt (1979), drawing on Tindale (1974), concludes that at the time of British colonisation, the South West was occupied by thirteen 'tribes' or, as Berndt prefers, socio-dialectal groups, which formed a discrete socio-cultural bloc. Aboriginal people in this area now generally refer to themselves as *Nyungar*.

Traditionally, the area around Perth, these researchers suggest, was part of the territory of the *Whadjuk* (Tindale 1974) or *Whadjug* in Berndt's (1979) orthography. Tindale (1974: 260) describes this group's territory as extending:

[From the] Swan River and northern and eastern tributaries inland to beyond Mount Helena; at Kalamunda, Armadale, Victoria Plains, south of Toodyay, and western vicinity of York; at Perth; south along the coast to near Pinjarra.

According to Tindale (1974:256), the territory of the *Pindjarup* was located to the south of the survey area. Bates (1985), on the other hand, uses the term *Bibbulmun* to refer to people who would today refer to themselves *Nyungar*. However, Tindale (1974) and Berndt (1979) reserve the use of the term *Pibelman/Bibelman* for a tribe on the Lower Blackwood River and the south coast of Western Australia. Bates (1985:52-54) reports that the Aboriginal people of the Perth/Swan River area were known as the *Yabbaru Bibbulmun* [northern Bibbulmun] or *Illa kuri wongi*.⁴ She reports that the people of the Murray District were the *Kuri wongi*. Bates (1985:53) gives the Serpentine River as the boundary between the Swan and Murray River people. This roughly corresponds to the boundary noted by Tindale (1974, see also Australia S.W. Sheet - Tribal Boundaries Map; see also Figure 4 below). Regardless, the current Mundijong survey area is located within the GKB native title claim area, which includes among others, the Shire of Serpentine-Jarrahdale.

⁴ From the words for coming directly = *Illa kuri* and speech or talk = *wongi*. In other words, the group that has the phrase "*Illa kuri*" in their dialect.

Keen (1997:261) has recently suggested that anthropologists should “get away from the idea of discrete Aboriginal ‘societies’, ‘cultures’, ‘groups’ or ‘communities’ as basic elements, and to substitute a more regional perspective.” He (1997:261, 273) notes that most ethnography is based on the assumption that Australia was divided into a number of discrete ‘cultures’, ‘societies’ or ‘tribes’ and that the ‘tribe’ model “has been found wanting”. The works of Tindale and Berndt are clearly based on such a model, though the latter presents a different picture with respect to the Western Desert. In contrast, Keen’s (1997: 272–73) concept of ‘focused networks’ and ‘regional system(s)’ focuses on:

A nexus of adjacencies, of chains of connection, and of a dynamic, open, and transforming systemic network, broken here and there by fissures and lesions. A ‘local system’ becomes defined in a relative way. It is possible that somewhat uniform and reproduced systems of interconnected practices might be detected, but on the other hand, what might be found is a pattern of continuous variations in one place, or a mosaic of overlapping differences in another. Whatever the pattern, any local system must be set in its wider context.

The differences between Tindale/Berndt’s and Bates’ descriptions may result from Bates’ fuller appreciation of the ‘focused networks’ which characterised Nyungar social organisation. While Bates (1985) uses the term ‘tribe’ to discuss the social organisation of the South West and other parts of the State, her actual description would seem to be closer to the model outlined by Keen with all its apparent contradictions of ‘continuous variations’ and ‘mosaic of overlapping differences’ (Palmer 2016 discusses Bates use of terms such as ‘tribe’ and her understanding and description of local organisation in some detail and feels that she over-simplified her data). She understood the interaction of local and regional systems, of the movement of people, objects and intangible phenomena within and between regions and wrote of ‘roads’ connecting people and places (Bates 1985; 1992 & 2004, see below for further comment).

The social organisation of west coast Nyungar groups, such as the *Whadjug/ Illa kuri wongi*, included matrilineal moieties, with two exogamous clans in each (Bates 1985; see also Berndt 1979 on ‘Perth’ type of social organisation). Clans had totemic associations connecting their members to their environments. However, ritual affiliations to sites occurred through an

individual's father (patrification). Berndt (1979) adds that there may have been local patrilineal descent groups, which focussed on totemic sites in defined stretches of country.⁵

The basic unit of Nyungar social organisation was the family, while the fundamental economic unit was the band, typically comprised of two or more family units. However, the actual numbers making up the band at any one time depended on a range of seasonal and social factors. Early settlers quite often referred to bands as 'tribes' and imposed further European concepts in describing both territorial affiliations and the description of Aboriginal 'leaders'. Various 'territories' have been described in which these social units were principally located and moved.

According to Lyon (in Green 1979), the survey area lies within the Aboriginal country known as *Beeliar*, which was associated with the band that included legendary Aborigines Midgegooroo and his son Yagan. To the south, marked by an approximate line from Mangle's Bay to the Darling Range, was the land of the band headed by Banyowla (Lyon in Green 1979). Other early commentators (e.g., Armstrong and Symmons) paint a somewhat different picture of land holdings and band composition shortly after colonisation (Hallam & Tilbrook 1990 discuss some of these differences; see also Brown 1983). Armstrong (1836, cited in Hallam & Tilbrook 1990), for example, wrote of the "Mangles Bay Tribe" (see Figure 2 in Brown 1983). These differences may have resulted from a lack of understanding of the complex nature and fluidity of Nyungar social organisation on the one hand and changes due to Aboriginal adjustments to the usurpation of their land by colonists on the other hand. Hallam (1975) points out that this emerging picture of Aboriginal life contradicted European observers' focus on geographic areas and patrilineal relationships. A more accurate description, she suggests, is that of a system of overlapping sets of ritual and social connections with land

⁵ Berndt's classification of South West social organisational types has been criticised on a number of grounds. Importantly, it suffers from marrying the broad mapping of social organisational types by Radcliffe-Brown (1930-31), who draws heavily on Bates' ethnography, with the specific boundaries of Tindale's tribal map (see McDonald & Christensen n.d.).

usage rights based on both patri- and matri- filiation. Individuals, families, and bands moved between areas, generating a fluid local population size and composition.

The ethnohistorical evidence shows that rivers, creeks, and wetlands in this region were most intensively occupied, given the availability of fresh water and food resources. In particular, the alluvial plains and the associated *warran* or native yam grounds and riparian resources such as *Typha* were of crucial economic importance to Aborigines (Hallam 1975). This conclusion is supported by the archaeological data. The history of contact and conflict between Aborigines and colonists in the Armadale and surrounding areas also demonstrates the importance of watercourses and wetlands to Aboriginal social and economic life (see, for example, Popham 1980; Cooper & McDonald 1988). Coy (1984:4), on the other hand, reports that according to oral history the relations between colonists and Nyungars in the Serpentine area were more peaceful than that experienced on the Canning or Murray rivers.

Wetlands and rivers were connected by a series of pads (*bidi*) that extended through this territory and from the present-day Perth area south to Mandurah and Pinjarra on the Murray River and north to Cockleshell Gully (Jurien Bay) and beyond (Bates 1985, 1992 & 2004; Hammond 1933).⁶ She (1985: 63-64) notes, for example: "From all tribal territories roads branched in various directions according to the facilities for food and water to be found along the way."⁷

A number of major roads in the South West follow the general alignment of the original Aboriginal pads. For example, Popham (1980:17) notes that Albany Highway follows a route surveyed by Hillman in 1836 which "followed the worn pathways of the Aborigines (sic) and the course of the Neerigen Brook". Similarly, Coy (1984:4) reports "[t]he South Western

⁶ Interestingly the Nyungar word to path or track - *bidi* - also means 'vein' (see Bindon and Chadwick 1992), thus metaphorically referring to the flowlike nature of human movement in addition to the flow of water (see, for example, McDonald, Coldrick and Christensen 2008 for a fuller discussion of the metaphors of flow and the human circulatory system in the Nyungar conceptualisation of water).

⁷ Bates was aware of the impact or potential for impact of "white settlement" on Aboriginal 'roads' and travel. For example, she reports (1985: 64): "Certain of these [Aboriginal] roads became closed to native traffic owing to the formation of stations, mining townships, etc. within their areas and as a consequence the tribes have had to open up new roads of late years."

Highway, known originally as the Foothills Track, vaguely follows a major *Nyungar* walking pad, which ran from the Perth Causeway to Pinjarra, then southwards to the Blackwood.”

European colonisation heralded the destruction of Aboriginal social organisation, beginning in the Perth area and expanding relentlessly into the South West. The *Nyungar* population was decimated during this process. Epidemics, shootings by Europeans and draconian policies introduced by the colonial administration (e.g., forced exclusion from urban areas, concentration on reserves, restrictions on movement, labour and so on) resulted in the attenuation of traditional ties with the land and with sites (Berndt 1979; see also Hammond 1933; Popham 1980; Coy 1984; McDonald & Cooper 1988). As a result of this dislocation, there has been some loss of traditional mythological and ceremonial associations with the land along with the knowledge which underpins these connections. However, there are still members of the *Nyungar* community who hold knowledge of mythological and other sites (Palmer 2016).

The ravages wrought by the European presence upon *Nyungar* society did not destroy *Nyungar* social bonds or identity completely. *Nyungars* did not merely disappear into history as is the impression given by several historical discussions, including the local histories cited in this report. Typically, local historical works discuss Aboriginal prehistory, culture, and “contact” history (colonisation) in the early chapters and then rarely, if ever, mention them again. For example, McDonald & Cooper’s (1988) *The Gosnells Story* does not have an indexed listing of “Aborigine” after Chapter 3 (pp. 36–46) dealing with the period 1833 to 1865. Other local histories fair little better.

Rather than disappearing, Aboriginal people continued to play a part, albeit marginal, in local social and economic life. The history of Aboriginal post-colonial habitation and participation in the local economy is not documented in as much detail for the south metropolitan region, including the survey area, as say in the Swan Valley and surrounding areas (see for instance Bourke 1987; Carter 1986, see also Biskup 1973). Nevertheless, *Nyungars* were part of the wider community south of the Swan River and participated in the local economy. There was also considerable movement of *Nyungars* between the Perth Metropolitan area and country locations

For instance, Popham (1980:18) reports that in the Kelmscott area Aboriginal people were working in the colonial economy as domestics, herders, trackers, and guides. Pope (1993:57–77) documents how Aboriginal people in the South West, particularly men, were employed as mail carriers between the early 1830s and the early 1850s. Coy (1984:65) makes a similar note in respect of the mail delivery in the Serpentine area in 1846. Aboriginal involvement in the local economy also meant that Aboriginal people lived in or on the fringes of the local community(s).

Nyungars were camping, for example, in several locations around Mundijong. From camps such as these, Nyungars were employed seasonally on farms or in other local industry or were engaged in marginal economic activities such as stick cutting (for clothesline props and crayfish pots). Popham (1980:120) reports Aborigines exchanging “the scraped-off wood of zamia palms, which were used as pillow filling in exchange for tea and flour” at the turn of the twentieth century. A number of the archaeological sites in the Mundijong area show evidence of post-contact habitation (e.g., use of bottles for flaking blades) (see for example Edwards & McDonald 1999). Further research is required to detail Aboriginal habitation in the Mundijong area from the commencement of colonisation to the 1970s. Aboriginal history is also reflected in the continuing use of Nyungar place names in the region (albeit often modified in English), for example, ‘Cardup’: place of the racehorse goanna”.

Their social and economic position, however, was further eroded by the introduction of the 1905 Aborigines Act (Haebich 1988). The adversity faced by Nyungars strengthened a sense of common identity and social bonds. New links with the country have been forged based on biographical and historical associations. In the last three decades, there also has been a growing movement to reconstruct Nyungar culture. This has been made through efforts at cultural retrieval or revitalisation as well as re-invention (see Bracknell 2020, for example, in relation to, the revitalisation of Nyungar singing traditions). These two strands have been fused, often in the crucible of political and economic interest in response to various governments’ policies concerning heritage, native title and other matters (see for example, Palmer 2016).

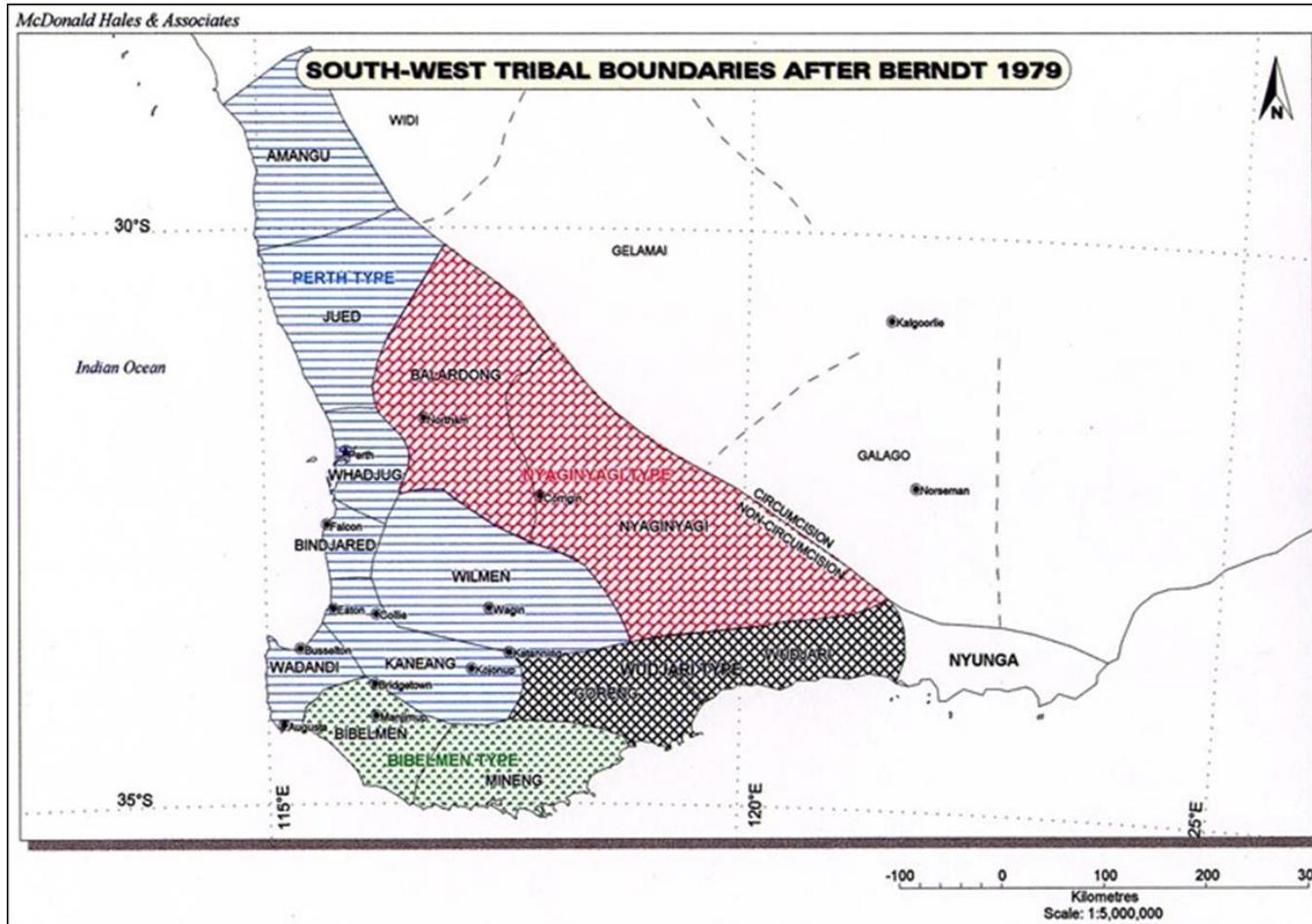


Figure 4: South-West tribal boundaries & organisatuional types after Berndt 1979

Ethnographic Survey Results

Results of the Desktop Research

A search of the AHIS revealed that there no ethnographic Aboriginal sites or Other Heritage Places (OHP) listed within Lots 50, 10, 11, 12, 13, 14 Kiernan Street, Mundijong.

Previously recorded DPLH ID 37115 (MJ-09), a scarred or modified tree, an OHP is located on Lot 101 (see Thomson 2020 for a fuller discussion). Another modified tree - ID 37116 (MJ- 08) - is located on the south side of Mandejal Brook on Lot 9000 to the east of ID 37115.

Also, on Lot 9000 but north of the Brook is located DPLH ID 3648 Soldier's Road Mundijong (Thomson 2020). This is a large artefact scatter, with an archaeological deposit, i.e., subsurface material, which is located on a large white sand dune (Bassendean Sands) adjacent to both Mandejal Brook and a conservation category wetland. The site is approximately 1500sqm in size and though partially disturbed and having had archaeological material collected from it by Hallam in the 1970s and Pearce in the 1980s, still contains 1000s of artefacts at a density of 20.8 per sqm. The artefacts include a wide variety of cores, scrapers, bipolar flakes, bipolar cores, flakes, and debris of a variety of lithic material, including quartz, metamorphic, fossiliferous chert and mylonite. This is one of several archaeological scatters located to the north of the Brook. Of these, however, ID 3648 is by far the most importance in respect of both archaeological and cultural significance (Thomson and Neuweger 2014 and McDonald 2020). As one of the senior Aboriginal consultants, who also participated in the present survey, reported:

For a number of years, I've been looking for scatters and all that and this [pointing over to DPLH IDs 3648 Soldier's Road] is by far the most extensive. I guess what it tells me is that our mob, you know, have been using the same spot over a number of years. ... You know, this is a big part of where our mob was when they were you know doing all that artefact stuff.

ID 3648 provides a point of contrast between the results of the archaeological survey on Lots 50 & 10-14 Keirnan Street and that to the north.

A review of previous heritage reports and the ethnohistorical literature also indicated that there were no earlier recorded heritage values that might reasonably be considered (ethnographic) Aboriginal sites on the land. However, Blockley & Greenfield (1995) & Blockley et al. (1996) Aboriginal consultants had recommended a 30m buffer zone along Manjedal Brook in order to accommodate Nyungar concerns about protecting the quality of the water and its flow. These concerns are in line with the principles Nyungars typically articulate with regard to developments and water courses: 'Do not interfere with (a) the riverbed, (b) the watercourse, (c) the quality of the water and (d) the foreshore areas' (McDonald 2017).

Results of the Ethnographic Survey

One ethnographic site was reported within the PDA by the Winjan Aboriginal consultants: Sam Woods' Camp (MJ20-01) located on Lot 50, which is owned by the Education Department. This camp was also recorded archaeologically and contained artefacts, the remains of the camp structure and according to Thomson (2020: 45) a potential archaeological deposit. Thomson (2020: 45-58) details the location and extent of the camp (see Figure 5, Thomson's Map 3 below). Ms Thomson has recommended further archaeological investigation of the site.

The existence and location of the camp was confirmed by Mr David Atwell. Both the Winjan Aboriginal consultants and Mr Atwell report that Sam Woods and his son Ray worked on the Atwell family farm, of which Lot 50 was a part, and lived in the camp from the late 1950s into the early 1960s. Residents included members of the Woods/Hart/ Nannup extended family. Mr Franklyn Nannup's mother, Sissy, was one of those who lived at the camp and Franklyn has memories of being at the camp as a young child. Mr George Walley, who assisted Ms Thomson with the archaeological survey, also recounted childhood memories of the camp and its residents (Thomson 2020: 57).

Other members of the Nannup, Walley, Woods and other families lived and worked on farms in other parts of the Mundijong area. Several Nyungar men, it is reported, worked as gangers on the railway and lived in railway houses adjacent to the Mundijong railway station. Another Aboriginal camp, according to the Aboriginal consultants and Mr Atwell, was located at the reserve on Baskerville Road, Mundijong. Residents of this camp also worked on surrounding farms.

The Aboriginal consultants would like to see Sam Woods' Camp (MJ20-01) preserved or at least commemorated in some form, for example, with interpretive signage. They are also of the view that the camp could fit into a broader cultural interpretative scheme for the area, as has been noted above, there is very significant prehistoric material at archaeological site ID 3648 Soldiers Road, adjacent to the conservation category wetland, north of Mandejal Brook on Lot 9000, in addition to another modified or scarred tree (ID 37116) located on the south side of the Brook. They also suggested that the camp and its interpretation could be integrated

into the school grounds and play a useful role in teaching children about the Aboriginal history of the Mundijong area.

The Aboriginal consultants requested that ground disturbance associated with the proposed development is monitored.

The Aboriginal consultants also expressed a desire that as many of the mature native trees as practicable, including those in the Lang Road Reserve, are preserved as part of the development. In making this request, they did not distinguish between Western Australian native trees and those from other parts of the continent. They also requested that, in accordance with best practice, runoff into Manjedal Brook is treated and that nutrients and other pollutants are stripped prior to entering the Brook.



Figure 5: Ethnographic & archaeological survey area and findings, Lots 10 to 14 and 50 Keirnan Street, Lot 101 Lang Rd and Lang Rd Reserve, Mundijong WA (Source: TCHM)

Conclusions & Recommendations

This report presents the findings of an ethnographic survey and consultation that Edward McDonald of Ethnoscience was commissioned by PWA to undertake in respect of Lots 50, 10, 11, 12, 13 and 14 Keirnan Street, the eastern portion of Lot 101 and the undeveloped Lang Road Reserve, Mundijong. This report should be read in conjunction with the report of the archaeological survey (Thomson 2020).

The desktop research, which included a review of the AHIS, did not reveal the presence of any ethnographic Aboriginal sites or OHPs within the PDA. However, one archaeological site, an OHP: DPLH ID 37115 (MJ-09), a scarred or modified tree, is listed on Lot 101.

The ethnographic survey was undertaken on March 27, 2020, with four Aboriginal consultants from both the Bilya and Winjan Aboriginal organisations. One ethnographic site, Sam Woods' Camp (MJ20-01), which also has archaeological components (Thomson 2020), was reported on Lot 50. The Aboriginal consultants requested that the campsite is preserved on the planned school ground and used for educational purposes or at minimum commemorated with interpretive signage.

They also requested that ground disturbance associated with the proposed development is monitored. They asked that where possible mature native trees are retained in the development, including those in the Lang Road Reserve. They also requested that runoff into Manjedal Brook is treated appropriately and that nutrients and other pollutants are stripped prior to entering the Brook.

Recommendations

8. It is recommended that the LSP for Lots 50, 10, 11, 12, 13 and 14 Keirnan Street, the eastern portion of Lot 101 and the undeveloped Lang Road Reserve Mundijong, is implemented on the basis of the concept plans presented to Bilya and Winjan in March 2020.
9. It is recommended that the landowner preserve the scarred tree ID 37115 (MJ-09) in foreshore reserve along Manjedal Brook in accordance with the archaeological recommendations.

10. It is recommended that the landowner preserve Sam Woods' Camp (MJ20-01) and that its heritage values are commemorated and used for educational purposes.
11. It is recommended that the landowner implement the archaeological recommendations in respect of Sam Woods' Camp (MJ20-01).
12. It is recommended that where the original ground surface is disturbed by earthworks that that disturbance is monitored in accordance with the archaeological recommendations.
13. It is recommended that where possible mature native trees, including those in the Lang Road Reserve, are retained in the development.
14. It is recommended that in accordance with best practice, nutrients and other pollutants are stripped from runoff and treated prior to entering Manjedal Brook.

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Final report

Archaeological assessment for Lots 10, 11, 12, 13, 14 and 50 Keirnan Street, Lot 101 Lang Road and Lang Road Reserve, Mundijong, Western Australia

July 2020

Prepared by
J. Thomson

for

Peter Webb & Associates
on behalf of Ethnoscience

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The results, conclusions and recommendations contained in this report are based on information available at the time of its preparation. Whilst every effort has been made to ensure that all relevant data has been collated, the author can take no responsibility for omissions and/or inconsistencies that may result from information becoming available after this reports completion.

Spatial Accuracy

Locations were recorded using a Garmin hand held GPS unit using the datum GDA94. Coordinates contained in this report are MGA Zone 50 K and are accurate to ± 10 m.

Abbreviations

ACMC	Aboriginal Cultural Materials Committee
AHA	<i>Aboriginal Heritage Act 1972</i>
AHIS	Aboriginal Heritage Inquiry System
ATSIHPA	<i>Aboriginal and Torres Strait Islander Heritage Protection Act 1984</i>
DJMM	DJM Mundijong Pty Ltd
DPLH	Department of Planning, Lands and Heritage
EPBC	<i>Environmental Protection and Biodiversity Conservation Act 1999</i>
LSP	Local Structure Plan
NTA	<i>Native Title Act 1993</i>
PWA	Peter Webb & Associates
SoW	Scope of Work
TCHM	Thomson Cultural Heritage Management



Executive Summary

DJM Mundijong Pty Ltd (DJMM) is proposing to undertake a residential development at its landholdings at Lots 11, 12, 13 and 14 Keirnan Street, Mundijong, Western Australia, see Maps 1 and 2. As part of this development, Peter Webb & Associates (PWA) are preparing a Local Structure Plan (LSP) on behalf of DJMM. The Shire of Serpentine-Jarrahdale require the LSP to include the DJMM landholdings as well as the Lang Road Reserve, the future High School and District Playing Fields Reserve (Lots 50 and 10 Keirnan Street) and the eastern part of Lot 101 Lang Road. The LSP area is located within Gnaala Karla Booja country.

Thomson Cultural Heritage Management (TCHM) was engaged by Ethnoscience in December 2019 to conduct an archaeological assessment for the proposed LSP area.

The archaeological survey was conducted on 19 and 20 February 2020 and 27 March 2020 by TCHM archaeologist Jo Thomson, Dr Edward McDonald of Ethnoscience, two Gnaala Karla Booja representatives through Bilya Aboriginal Corporation Aboriginal Corporation and two Gnaala Karla Booja representatives Winjan Aboriginal Corporation. The Gnaala Karla Booja representatives participated in all aspects of the archaeological assessment.

One new Aboriginal archaeological place, Sam Woods' Camp (MJ20-01), and one area with good potential for subsurface archaeological material was located during the survey. Previously recorded DPLH site 37115 (MJ-09) was also relocated and found to be in good condition.

Based on the results of the archaeological assessment, it is **recommended** that:

Lots 10, 11, 12, 13 and 14 Keirnan Street (DJMM land holdings)

- The isolated stone artefacts recorded within Lots 11, 12, 13 and 14 Keirnan Street do not, in TCHM's opinion, constitute Aboriginal archaeological sites according to sections 5 and 39 (2) of the AHA.
- There is some potential for sub surface archaeological material to be present within Lots 11, 12, 13 and 14 Keirnan Street and therefore it is recommended that initial ground disturbance be monitored by one or two Gnaala Karla Booja representatives.
- In the event that any suspected archaeological or cultural material is identified, all work must cease at that location until Gnaala Karla Booja representatives and an archaeologist have properly assessed the material. Contingency plans should be developed, before ground disturbance occurs, to allow for culturally appropriate management of such discoveries.

Lot 50 (Education Department)

- Newly recorded place, Sam Woods' Camp (MJ20-01), is likely to meet the requirements of sections 5 and 39(2) of the *Aboriginal Heritage Act 1972* (AHA), and should be **avoided** and not impacted upon in any way without Ministerial consent under section 18 of the AHA.
- The landowner undertakes further detailed recording and assessment of Sam Woods' Camp (MJ20-01), including the recording of oral histories, detailed surface recording, assessment of artefacts, and subsurface test excavations, prior to any section 18 application being made.
- The area with potential archaeological subsurface deposit (PAD-01) be archaeologically tested and assessed prior to any section 18 application being submitted.

- There is also some potential for sub surface archaeological material to be present within other parts of Lot 50 and within Lot 10 Keirnan Street and therefore it is recommended that initial ground disturbance be monitored by one or two Gnaala Karla Booja representatives.
- If Sam Woods' Camp (MJ20-01) cannot be avoided and will be impacted during future development, the proponent should consult further with Gnaala Karla Booja representatives about any proposed section 18 application, mitigation and salvage strategies and the management of salvaged materials, and comply with any other undertakings given in respect of the section 18 process.
- The landowner implements suitable controls to prevent any impacts on Sam Woods' Camp (MJ20-01) during earthworks, including adequate physical demarcation of site boundaries and effective management processes such as ground disturbance permits and operator inductions.

Lot 101 Lang Road and Lang Road Reserve (Mr Sam Lang, Shire of Serpentine)

- Heritage place DPLH ID 37115 is likely to meet the requirements of sections 5 and 39(2) of the *Aboriginal Heritage Act 1972* (AHA), and should be **avoided** and not impacted upon in any way without Ministerial consent under section 18 of the AHA.
- A protective buffer of 30 m radius be applied around ID 37115 during any ground disturbing works so that its root system is not inadvertently affected.
- A protective buffer of 30 m also be applied to Manjedal Brook.
- If DPLH ID 37115 cannot be avoided and will be impacted during future development, the landowner should consult further with Gnaala Karla Booja representatives about any proposed section 18 application, mitigation and salvage strategies and the management of salvaged materials, and comply with any other undertakings given in respect of the section 18 process.
- The landowner implements suitable controls to prevent any impacts on DPLH ID 37115, including adequate physical demarcation of site boundaries and effective management processes such as ground disturbance permits and operator inductions.

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1.0 Introduction

DJM Mundijong Pty Ltd (DJMM) is proposing to undertake a residential development at its landholdings at Lots 11, 12, 13 and 14 Keirnan Street, Mundijong, Western Australia, see Maps 1 and 2. As part of this development, Peter Webb & Associates (PWA) are preparing a Local Structure Plan (LSP) on behalf of DJMM. The Shire of Serpentine-Jarrahdale require the LSP to include the DJMM landholdings as well as the Lang Road Reserve, the future High School and District Playing Fields Reserve (Lots 50 and 10 Keirnan Street) and the eastern part of Lot 101 Lang Road. The LSP area is located within Gnaala Karla Booja country.

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This report presents the results of the archaeological survey. The ethnographic survey is reported on under a separate cover.

1.1 Project overview

The LSP area comprises Lots 10, 11, 12, 13, 14 and 50 Keirnan Street, Lang Road Reserve, and a portion of Lot 101 Lang Road, Mundijong (see Figure 1 and Map 1). Mundijong is located in the Shire of Serpentine-Jarrahdale, approximately 40km south east of Perth's Central Business District, 16km south of the Armadale Regional Centre and 25km east of the Rockingham Regional Centre. It is located approximately 25 km east of the Indian Ocean coastline and approximately 3.5 km from the foot of the Darling Scarp.

Lots 10, 11, 12, 13, 14 and 50 Keirnan Street, Lang Road Reserve, and Lot 101 Lang Road are located to the north of the Mundijong town site, to the north of Keirnan Street, west of Soldiers Road and south of Mandejal Brook (see Map 1). The combined area of the eight lots totals 35.978 hectares (0.35978 sq km). DJMM is the landowner of Lots 11, 12, 13 and 14 Keirnan Street, Lot 10 is owned by XX, Lot 101 is owned by Mr Sam Lang, Lot 50 is owned by the WA Department of Education and Lang Road Reserve is owned by the Shire of Serpentine-Jarrahdale.

1.2 Scope of Work

The work instructions issued by PWA in November 2019 required the conduct of a heritage assessment of the LSP area. Ethnoscience required TCHM to conduct an archaeological assessment of the LSP. This involved:

- Undertaking a professional archaeological survey of the LSP area to identify any Aboriginal archaeological places, material or values that may exist;
- Record any archaeological places, material or values to a level sufficient for reporting to the Department of Planning, Land and Heritage (DPLH);

- Make recommendations for the management, mitigation or salvage of any archaeological places, or material located within the LSP area.

1.3 Affected Aboriginal people

The project area is located in the Gnaala Karla Booja (WC98/58) native title claim area and Gnaala Karla Booja (GKB) native title claimants were involved in the archaeological work through two regionally-based Aboriginal organisations: the Bilya Noongar Organisation and the Winjan Aboriginal Corporation.

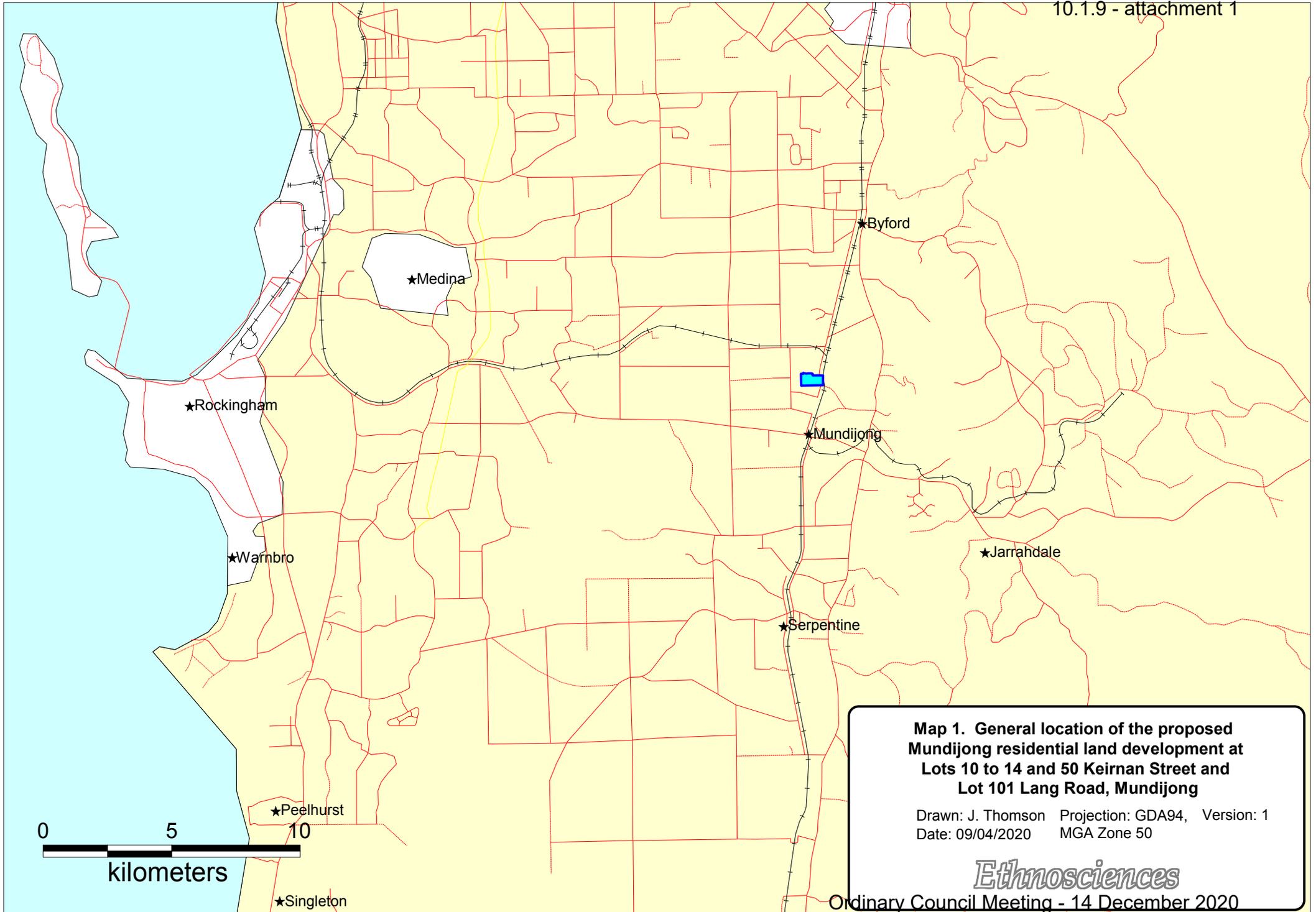
1.4 Survey participants

The following people participated in the archaeological assessment:

Clarrence Walley	GKB representative, Bilya Aboriginal Corporation	19 February 2020
John Michael	GKB representative, Bilya Aboriginal Corporation	19 February 2020
Franklin Nannup	GKB representative, Winjan Aboriginal Corporation	20 February 2020
George Walley	GKB representative, Winjan Aboriginal Corporation	20 February 2020
Jo Thomson	Archaeologist, Thomson Cultural Heritage Management	
Dr Edward McDonald	Anthropologist, Ethnoscience	

The Gnaala Karla Booja representatives participated in all aspects of the archaeological survey and were involved in setting the survey methods, conducting the survey, identifying archaeological material, site recording and providing comments on the findings.





Map 1. General location of the proposed Mundijong residential land development at Lots 10 to 14 and 50 Keirnan Street and Lot 101 Lang Road, Mundijong

Drawn: J. Thomson Projection: GDA94, Version: 1
Date: 09/04/2020 MGA Zone 50

Ethmosciences



6428360 mN

6428350 mN

404000 mE

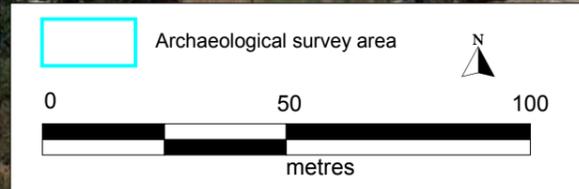
405000 mE

404000 mE

405000 mE

6427810 mN

6427830 mN



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Map 2. Archaeological survey area
Lots 10 to 14 and 50 Keirnan Street, Lot 101 Lang Rd
and Lang Rd Reserve, Mundijong WA

Drawn: J. Thomson
Date: 9 April 2020
Projection: GDA94, Zone 50 UTM

Ordinary Council Meeting - 14 December 2020

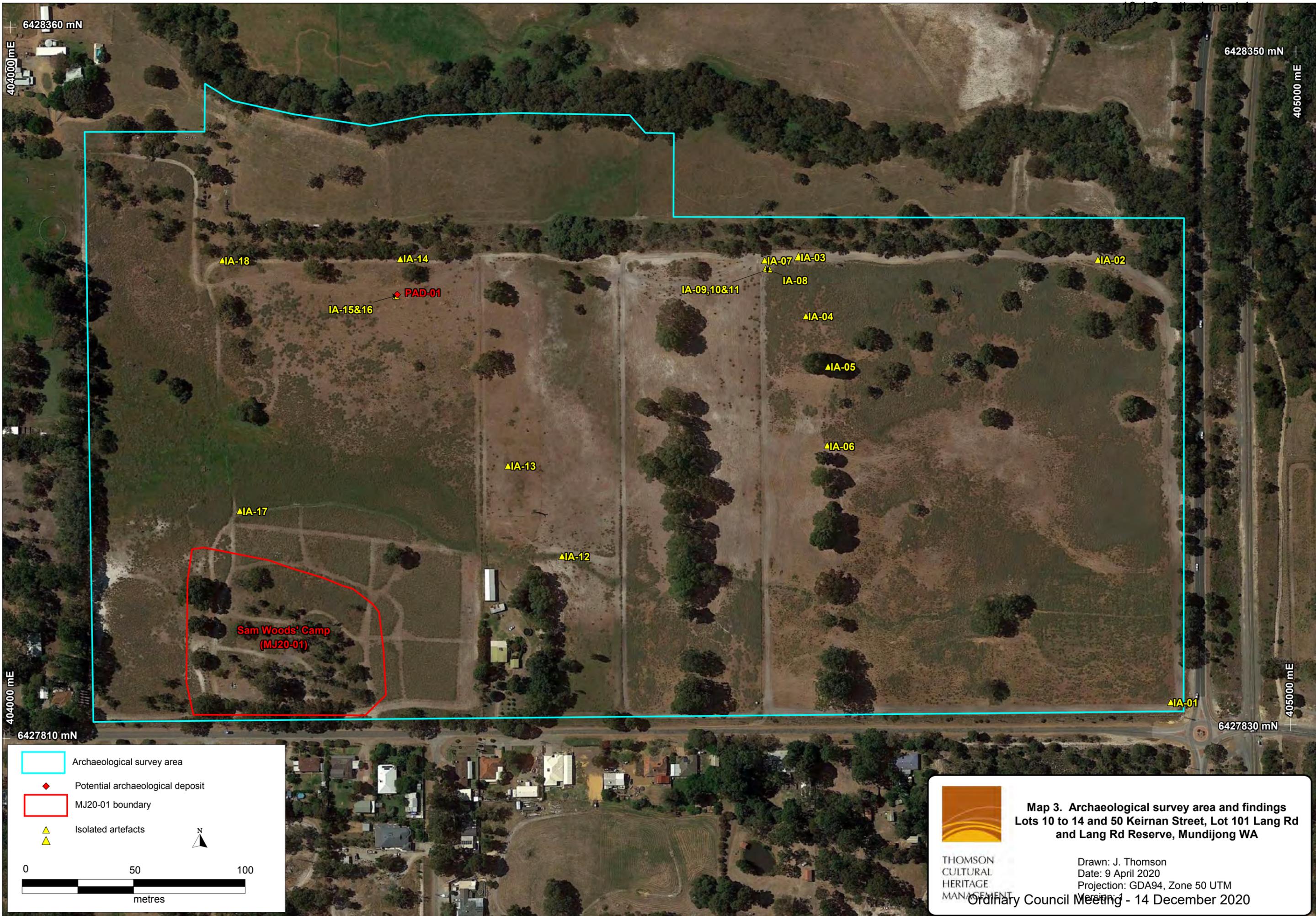


Figure 1. Landgate cadastral plan (provided by Peter Webb & Associates)



2.0 Methods

2.1 Assessment strategy

The purpose of this archaeological assessment is to:

1. Identify and report on the existence, potential for existence, and the nature of the archaeology located within the proposed works areas. This includes locating, recording and assessing artefacts and archaeological sites.
2. Advise land users whether their proposed activities may impact on any Aboriginal Sites or Objects as defined under sections 5 and 6 of the AHA.
3. Provide management advice and recommendations to landowners. This includes recommending site management, mitigative and/or administrative strategies and advising on how proponents may meet their obligations under sections 16 and 18 of the AHA.

To achieve this purpose, this archaeological assessment comprised the investigation, location, recording and assessment of the archaeological content of the survey area. As the nature of the research involved in this assessment is primarily investigative and evaluative, the appropriate methods are inductive and descriptive. Overall the research strategy comprised:

- Desktop research and review;
- Archaeological field survey;
- Artefact and site recording;
- Assessment and recommendations.

2.2 Desktop review

A desktop study was undertaken prior to fieldwork which comprised a search of the Department of Planning, Lands and Heritage (DPLH) Aboriginal Heritage Information System (AHIS) and a review of previous heritage survey reports relating to the survey areas. The purpose of the desktop review was to identify what previous heritage surveys have been conducted within the vicinity of the survey areas, and what heritage places including Aboriginal Sites and Other Heritage Places exist within survey areas and surrounding areas. The results of the desktop review are presented in Section 3.0 below.

2.3 Archaeological field survey

Based on the required SoW, results of the desktop review and nature of the activities proposed, the archaeological survey employed a systematic-based pedestrian survey method in order to give comprehensive coverage of the assessment area. Three people participated in the archaeological survey on 19 and 20 February and two people on 27 March 2020. Transect spacing consisted of approximately 10-15 m apart and was oriented approximately north–south across the survey area.

2.4 Artefacts, archaeological features and site identification

The following schemas were employed during the survey to identify artefacts and archaeological features and sites.

2.4.1 Artefacts

Archaeological artefacts are objects that have been used, modified or manufactured by humans. In an Indigenous context, artefacts primarily comprise stone artefacts, including: flaked artefacts and debitage, grinding stones, grinding patches, edge ground axes and manuports. These artefacts may be manufactured from a wide range of materials including rock, glass and ceramic. The criteria used for identifying flaked and ground stone artefacts and their recording methods are included in Appendix 5.

2.4.2 Types of archaeological features

DPLH's standard site type categories were used during this assessment to classify archaeological features (or 'sites'), see Appendix 4 for full definitions. Based on the desktop research, it was anticipated that the following archaeological features could be encountered during the survey: artefact scatters; rock shelters with artefacts, grinding material, rock art and/or potential deposit; modified/scarred trees; ground material including grind/millstones, mullas, grinding patches/grooves; rock art including engravings and paintings; quarries, stone arrangements and water sources such as gnamma holes.

From previous research undertaken within the Swan Coastal Plain and local region, the following archaeological site types¹ or features may be expected:

- Artefacts/scatter
- Archaeological deposit
- Modified tree
- Grinding material
- Shell
- Historic
- Skeletal material / burial

See Appendix 5 for full definitions of site types.

Artefact scatter classifications

Artefact scatters are concentrations of stone artefacts either on the ground surface or in stratified deposits. In order to classify artefact scatters the following definitions were employed during this assessment. These definitions were based upon existing classification schemes from similar environments on the Swan Coastal Plain. Artefact scatters were further characterised by the types of activities evident from surface remains at the site.

Table 1. Artefact scatter classifications

Site size		Artefact density		Raw material diversity	
Small	< 7,500 sq m	Low	<0.1/m ²	Low	>90% of one raw material
Medium	7,500–50,000 sq m	Medium	0.1–1/m ²	Medium	two raw material types >10% each
Large	>50,000 sq m	High	>1/m ²	High	three or more raw material types >10% each

¹ Based on DPLH's site type classification within the AHIS.

Potential archaeological deposits

Potential archaeological deposits (PADs) are 'deposits with high (but justifiable) likelihood of containing buried artefacts or other evidence relating to past occupation at that location, even when little or nothing is visible on the ground surface' (Burke et al 2017: 96). PADs are *only an argument for potential* archaeological remains and can only be tested by subsurface investigation (Burke et al 2017: 97).

2.4.3 Isolated artefacts and background scatter

Isolated artefacts are individual stone artefacts found by themselves in no obvious association with any other artefacts (Burke et al. 2017: 133). Attenbrow (2006: 46) interprets isolated artefacts as 'an accidental loss or chance discard when... people were out hunting or en route from one habitation site to another'. It is thus common practice in Australian Indigenous archaeology to make a distinction between isolated artefacts (also referred to as background scatter) and archaeological sites. Within the Swan Coastal Plain, the commonly accepted definition of a 'site' is where two or more different artefacts, or different classes of artefacts, are present within a radius of 5 m of each other. Isolated artefacts are defined as being spatially discrete and are unlikely to reflect any purposeful activity (Edwards 2008:13).

2.5 Site recording

The following information was recorded for archaeological sites:

- location and boundary of the site, including multiple GPS coordinates to define a polygon representative of the site's boundary;
- site type;
- environmental context;
- site description including nature of site, major cultural features, site dimensions, orientation and size;
- a sample of the artefact assemblage including artefact density, lithology and types;
- an estimate of the total number of artefacts within the site;
- assessment of the site's potential for sub-surface content (where applicable);
- site condition and integrity, including the nature and origin of any disturbance to the site;
- site plan and profile; and
- photographs of the site and its context.

2.5.1 Methods for determining site boundaries

The site boundary for Sam Woods' Camp (MJ20-01) was determined by walking a series of pedestrian transects around the elevated sand dune on which the site was located. The boundary was placed where no surface artefacts were found. Boundary coordinates were recorded by handheld GPS.

3.0 Desktop review results

This section details the results of the desktop review and provides details on the legislative, environmental and archaeological contexts for this assessment.

3.1 Legislation

There are several State and Federal heritage-related laws that affect how Aboriginal heritage is managed in Western Australia. Relevant legislation includes:

- *WA Aboriginal Heritage Act 1972*;
- *Commonwealth Aboriginal and Torres Strait Islander Heritage Protection Act 1984*;
- *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*;
- *Commonwealth Native Title Act 1993*.

The *Aboriginal Heritage Act 1972* (the AHA) is the principle piece of legislation relevant to this assessment. The AHA provides automatic protection for all places and objects in Western Australia that are important to Aboriginal people because of connections to their culture. These places and objects are referred to as Aboriginal Sites and Aboriginal Objects. Under section 17 of the AHA it is an offence to disturb, damage, alter or conceal an Aboriginal Site without consent of the Minister under section 18, or authorisation by the Registrar of Aboriginal Sites under section 16.

Section 5 of the AHA defines an Aboriginal Site as:

- a) any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present;
- b) any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent;
- c) any place which, in the opinion of the Committee, is or was associated with the Aboriginal people and which is of historical, anthropological, archaeological or ethnographic interest and should be preserved because of its importance and significance to the cultural heritage of the State;
- d) any place where objects to which this Act applies are traditionally stored, or to which, under the provisions of this Act, such objects have been taken or removed.

When assessing the importance of a place or object, section 39(2) of the AHA directs the ACMC to have regard to:

- a) any existing use or significance attributed under relevant Aboriginal custom;
- b) any former or reputed use or significance which may be attributed upon the basis of tradition, historical association, or Aboriginal sentiment;
- c) any potential anthropological, archaeological or ethnographical interest; and
- d) aesthetic values.

Section 39(3) further emphasises that 'associated sacred beliefs, and ritual or ceremonial usage, in so far as such matters can be ascertained, shall be regarded as the primary considerations to be taken into account in the evaluation of any place or object for the purposes of this Act'.

The Commonwealth *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (ATSHIP) protects places of significance to Indigenous Australians and is administered through the Federal Department of Environment, Water, Heritage and the Arts. The Act offers protection for significant places or objects through ministerial decision. Aboriginal people who believe that a place or object is threatened and that State Government processes offer inadequate protection can apply to the Australian Government Environment Minister to protect the place or object.

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) protects the environment, particularly matters of National Environmental Significance. It streamlines the national environmental assessment and approvals process, protects Australian biodiversity and integrates management of important natural and cultural places.

The Commonwealth *Native Title Act 1993* (the NTA) also deals with Aboriginal heritage and mandates processes for managing and resolving conflicts over heritage. Native title is the legal recognition, under the NTA, of the rights and interests of Aboriginal and Torres Strait Islander people in land and waters (Hayes 2009: 8; Herriman 2013: 86). The right to protect and manage heritage can be one of these rights.

3.2 Regional environmental context

3.2.1 Geology

The project area is located on the central Swan Coastal Plain at the base of the Darling Scarp.

The dominant geological element in south western Australia is the Archaean-aged Yilgarn Block, which forms the nucleus of the Western Australian Shield (Johnstone et al. 1973). The shield extends from near the south coast of Western Australia for 900 km to the north and has an east-west width of 700 km. Around this nucleus, belts of younger Precambrian rocks have accreted, including granite and gneiss with dolerite dykes, and its western margin is marked by the deep Mesozoic graben of the Perth Basin.

The Perth Basin is an elongate north-south rift-trough with a series of sub-basins, shelves, troughs and ridges. The basin overlies the Pinjarra Orogen and contains a sedimentary succession up to 15 km thick that mostly accumulated from the early Permian to the late Cretaceous, with a veneer of Neogene sediments (Freeman and Donaldson 2006). There are very few outcrops of Perth Basin strata south of Perth, as much of the area is covered by Cenozoic deep-weathering products or Pleistocene to Holocene aeolian sand deposits.

The eastern margin of the Perth Basin is defined by the Darling Scarp, the surface expression of the Darling Fault and the colluvial foothills of the Darling Range. The scarp represents the dissected remnants of a sand covered wave-cut platform known as the Ridge Hill Shelf, which is the eastern boundary of Tertiary and Quaternary marine erosion (McPherson and Jones 2005). The Darling Range comprises Archaean igneous and metamorphic rocks, capped by an extensive lateritic crust which has been dissected by later drainage (Hook 2001). Basement rocks underlying the lateritic profile include granite and banded and migmatitic gneiss, paragneiss, and granitic gneiss and metamorphosed argillite and felsic to mafic volcanic rocks (Freeman and Donaldson 2006).

The Cardup Group, an exotic suite of rocks, is located along the scarp between Mundijong and Perth which consists of generally low-grade metamorphic rocks formed by relatively low pressure and temperature metamorphism of sedimentary rocks (metasediments) although some sections appear

unmetamorphosed and include shale, sandstone and siltstone with dolerite intrusives. The lowermost unit of the Cardup Group unconformably overlies the granitic gneiss of the Yilgarn Craton.

Local geology is particularly relevant to archaeology of the Swan Coastal Plain, as summarised by Hook:

The Darling Range provided the only source of stone, with the exception of fossiliferous chert, for Aboriginal people occupying the Swan Coastal Plain. The Darling Range provided a number of stone types suitable for implement manufacture. The lithologies utilised ranging from the coarse and hard rocks granite, gneiss and dolerite to the finer rocks quartz, crystal quartz, feldspar, mylonite and silcrete... The historical and archaeological evidence suggests that the coarser stone such as granite gneiss and dolerite was used for *Kodj* and grindstones. Finer stone with better conchoidal fracturing characteristics, predominantly small pieces of quartz, was used for hafting in knives and spears (Meagher and Ride 1980: 77). (Roth 1903: 58) states that both the quartz and stone for the *kodj* came from the Darling Range. Stone was transported and Grey (1841: 266) and Salvado (1977: 149) list stone, including quartz and “stone for hatchets” as being carried in women’s bags for subsequent use in fabrication... (Hook 2001:: 4-5).

3.2.2 Soils

The Swan Coastal Plain physiographic unit is a narrow 20–30 km wide strip generally low in relief and comprised mainly of Quaternary and Aeolian sediments which form a series of coastal dunes that are overlying or situated adjacent to alluvial deposits (Anderson 1984). These dune systems vary in orientation, physical characteristics and age. The youngest systems occur at the west and increase in age towards the east. The geomorphic systems comprise (from west to east):

- **Quindalup dune system** – the youngest system, comprised of calcareous sands occurring as both beach ridges and parabolic dunes that trend north–south.
- **Spearwood dune system** – a core of aeolian limestone (Cottesloe Limestone) overlain by limestone-derived yellow and brown sands of varying depths (Karrakatta Sands). Some permanent lakes occur in chains parallel to the coast, some are saline and brackish, whilst lakes situated along the boundary between the Spearwood and Bassendean Dunes are all fresh;
- **Bassendean dune system** – a 15 km wide belt of low, vegetated sand dunes and sand plains with pale, highly leached white and grey quartz sands with interdunal swamps and lakes. The dunes to the north of Perth generally have greater topographic relief than to the south of Perth. The dunes have probably accumulated as shoreline deposits and coastal dunes during interglacial periods of high sea level and originally consisted of mostly lime (calcareous) sand and minor, fine grained black heavy mineral concentrations. Carbonate material has been completely leached leaving dunes consisting entirely of quartz sand. This system was formed mainly during the middle to late Pleistocene; and
- **Pinjarra plain** – a piedmont and valley flat alluvial plain consisting predominantly of clayey alluvium that has been transported by rivers and streams from the Darling and Dandaragan Plateaus (also referred to as the Guildford formation). Approximately 1.5 to 25 km wide, this system is located between the Bassendean Dunes and the Darling Scarp, but also abuts the Spearwood Dunes south of Perth.

SMEC (2009:: 68) reports that there are three soil complexes within the Mundijong-Whitby Structure Plan study area including Forrestfield, Pinjarra and Bassendean. Within the current project area, the

Pinjarra and Bassendean soils are predominant. SMEC (2009: 99) describes the Pinjarra soils within the study area as comprising 'alluvial materials deposited across the plain extending from north to south adjacent to the Forrestfield group, including through the centre of the Shire to its Western boundary'. They also note that in isolated pockets, the alluvial soils are overlain by windblown sand typical of the Bassendean System.

3.2.3 Hydrology

The major hydrological features of the Swan Coastal Plain comprise several major watercourses, such as the Swan and Canning Rivers, which are flanked by clayey floodplains and river terraces of recent origin. Other wetlands, including a north-south oriented chain of swamps and lakes, have formed in the inter-dunal swales of the Bassendean Dune System, in the interbarrier depressions between the Spearwood and Bassendean Dune Systems, and within the Spearwood Dune System.

SMEC (2009) identify three types of wetland present within the local region around Mundijong, including:

- Plausiplain – a seasonally waterlogged flat;
- Sumplands – a seasonally inundated basin of variable size and shape; and
- Creeks – a seasonally inundated channel.

Both SMEC (2009) and GHD (2009:8) highlight that the Mundijong-Whitby area is known to experience regular water logging in the low-lying areas of the study area, such as on the plausiplains. This inundation is due to a combination of persistent winter rainfall elevating the shallow water table, which rises to the surface and inundates vast areas of the flat terrain, as well as sparse drainage, with insufficient capacity that does not allow runoff to leave the area. There is also the potential for wetlands within the study area to receive additional flood water from outside their natural catchment by overtopping of drains and watercourses.

One water course and two small wetland lakes are located within the current project area. Manjedal Brook runs east-southeast to west-northwest through Lots 9000, 98 and 37 Bishop Road. The two small wetland lakes are located in the southeast corner of Lot 9000. Cardup Brook and Gingagup Brook are located just outside the survey area to the northeast. A significant proportion of the current project area is comprised of plausiplain wetland (see Figure 2), interspersed by elevated sandy rises or dunes of Bassendean sands.

3.2.4 Flora and fauna

The project area is situated within the Drummond Sub District vegetation system of the South West Botanical Province (Beard 1990). SMEC (2009:25) describe the general vegetation of the Pinjarra plain as represented by *Corymbia calophylla* (marri) open forest and the Bassendean System by banksia low woodland, generally *Banksia attenuata* (slender banksias), *Banksia menziesii* (firewood banksias), *Banksia ilicifolia* (holly leaf banksias), *Eucalyptus todtiana* (coastal blackbutt) and *Nuytsia floribunda* (Christmas tree).

SMEC (2009:16) report that the current project area includes only remnants of the Guildford and Forrestfield vegetation complexes due to previous land clearing. There are remnants of both vegetation systems along the Manjedal Brook in Lot 9000, and the Guildford system along the western boundary of Lot 98 (see Figure 6 in SMEC 2009: 32). SMEC (2009:31) characterise the vegetation complexes present within the current project area as follows.

- Forrestfield vegetation system: ranges from open forest of *E. calophylla* – *E. Wandoo* – *E. Marginata* to open forest of *E. Marginata* – *E. Calophylla* – *C. Fraseriana* – *Banksia sp.* Fringing woodland of *E. rudis* in the gullies that dissect this landform;
- Guildford vegetation system: comprises a mixture of open forest to tall open forest of *E. calophylla* – *E. Wandoo* – *E. marginata* and woodland of *E. wandoo* (with rare occurrences of *E. lane-poolei*). Minor components include *E. rudis* – *M. raphiophylla*.

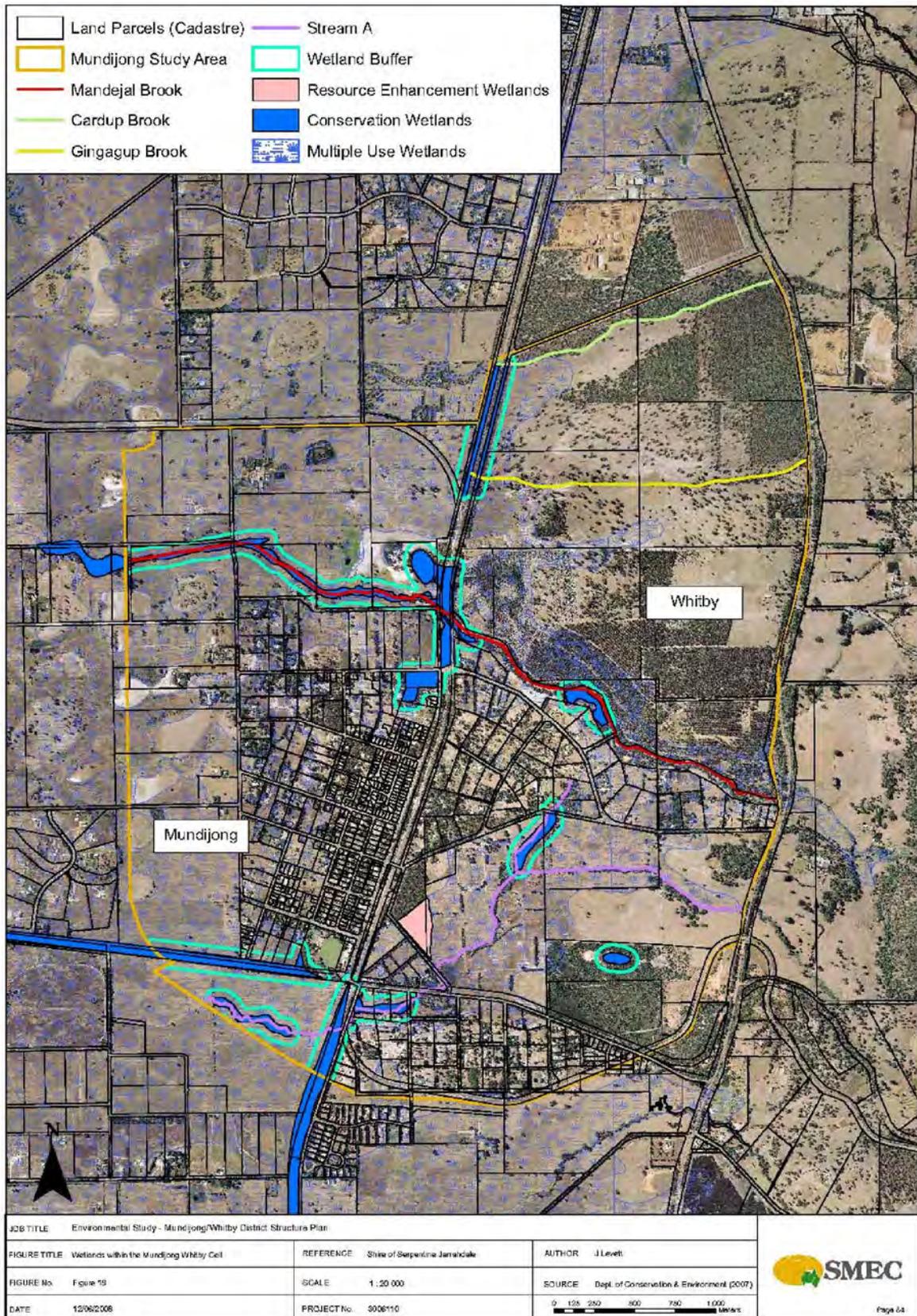
SMEC (2009: 47) indicated that despite the previous vegetation clearance, local flora studies suggest that to the east (towards the base of the Darling Range) a rich and diverse suite of faunal assemblages still exists. Key fauna identified include the Brush tail Possum, Brush-tailed Phascogale, Chuditch and Western Grey kangaroo. The wetland located in Lot 9000 also supports a wide variety of fauna including birds.

3.2.5 Previous land use

SMEC (2009) report that approximately 87% of land within the local Mundijong region has been previously cleared of vegetation, with agriculture being the main clearance-related land use activity. Historically Mundijong was also a major junction along the South West rail network.

In a review of historic aerial photos from 1953 to 2006, SMEC noted that during the 1950s and 1960s, land use within the project area predominantly comprised low density agriculture with some residential development. Past and current agricultural activity has included land clearing, ground excavation of some areas for landfill and rubbish dumps, construction of tracks, fences, farm infrastructure and buildings, running of stock and growing crops. SMEC note the historical presence of dairy and poultry farms and a timber mill. Other noted changes in the use of the landscape included the extension of residential housing along Paterson Street in Mundijong in the 1970s, the appearance of pine plantations in the 1980s and extension of residential developments in the 2000s.

Figure 2. Geomorphic wetland regimes (source: SMEC 2009: 84)



3.3 Previous heritage assessments

The desktop review found that a number of previous archaeological assessments have been conducted within the local region² surrounding the project area for a variety of development and infrastructure projects including 330 kV and 22 kV power transmission lines, optic fibre cable, natural gas pipeline, road developments, mining infrastructure and processing facilities, light industrial and residential subdivisions. In addition, several broad-scale regional archaeological studies have been undertaken relating to the Swan Coastal Plain, which are useful for developing the research agenda for this assessment and interpreting the survey and test excavation results.

3.3.1 Regional archaeology

Archaeological research on the Swan Coastal Plain has focused primarily on the themes of antiquity, social, demographic and occupation patterns over time, site spatial distribution patterns, site characterisation and stone tool technologies. A short summary of these themes is presented below.

Antiquity

The southwest region of Western Australia has well established chronologies of human occupation from the Pleistocene onwards (Dortch 1974, 1979a, 1979b, 1984; Dortch and Merrilees 1971, 1973). The majority of dates for the southwest region have been gained from rock shelter or cave sites, however, on the Swan Coastal Plain very few rock shelter sites exist. The majority of sites that have been excavated on the Swan Coastal Plain have comprised open sites located mainly within the Bassendean sands geomorphic unit (Bowdler et al. 1991; Strawbridge 1987). Based on the results of these excavations, Bowdler et al. (1991) have commented that on the Swan Coastal Plain there is a 'consistent lack of good stratified sites' and 'with respect to open sites, only three to five are known with any kind of stratigraphic integrity, and these are not all straightforward cases' (Bowdler et al. 1991: 21,24). Of these five stratified sites, four are located within the Swan River Alluvial Deposits and the fifth (Walyunga) is located in a unique geomorphic context in 'a sand dune part of the Yoganup formation, comprising fossil shoreline sands on the Ridge Hill Shelf' (Bowdler et al. 1991:24).

To date, no stratified open sites have been located within the Bassendean sands. Anderson (1983: 50) suggests that this is mainly due to the geomorphology of the Bassendean dune system, which she describes as 'a stable core with a superficial mobile layer of continually reworking sands' and through the process of deflation artefacts which may have been deposited at sites over a considerable time period now occur on one level.

Sites that have been dated on the Swan Coastal Plain include DPLH Id 4299 Upper Swan Bridge (39,500 ± 2300 BP and >31,500 BP)³, DPLH Id 3967 Helena River A-C (29,000 BP to 2120 BP), DPLH Id 3382 Walyunga (8,260 BP to 1,330 BP), DPLH Id 4404 Orchestra Cave (6,500 BP – 1,730 BP), DPLH Id 4073 Millendon 05 (~8,000 BP), DPLH Id 3294 North Lake North (2,300 BP), DPLH Id 3648 Soldiers Road (1,620 BP). The Upper Swan and Walyunga sites are of particular significance as they have both been interpreted as representing phases of cultural and technological shifts. At Upper Swan, Pearce and Barbetti (1981) found a divergence in the artefact assemblage from the 'Australian core-tool and scraper tradition' found in sites of similar age in eastern Australia and view these

² Within a 5 km radius of the project area.

³ Pearce and Barbetti (1981) provisionally take the mean date of 38,000 BP as an age for the artefact layer.

differences as reflecting a cultural difference or cultural changes occurring around 40,000 BP. Similarly at Walyunga, Pearce (1979) reports the introduction of backed tools and flat adzes after a period of aridity and shortly after the sea reached its present level, thus representing a link between changes in environment and tool technologies.

Due to the shortage of dateable archaeological sites on the Swan Coastal Plain, Hallam (1987; 1986) developed a relative dating scheme for surface artefact scatters based on the presence/absence of temporal markers such as fossiliferous chert⁴. Strawbridge reports that

Studies on sea level changes in the region (Veeh et al.: 1979; Playford & Leech: 1977) indicate that the sea level reached its present level around 6000-6500 years BP. Artefacts of Eocene chert have been found frequently among artefact assemblages from sites on the Swan coastal plain but no source of this material is exposed west of the Darling fault line. Eocene chert has been found at shallow depths in offshore drilling cores (Glover, 1979).

This suggests that the outcrops of Eocene chert were available when the sea level was lower and that the source is west of the current coastline and was submerged in the mid-Holocene. It should be borne in mind, however, that some reuse of quarried material probably occurred after the source was submerged. Research into sites in the Perth metropolitan region has attempted to use the presence of chert artefactual material in sites as a chronological indicator (Strawbridge 1987:: 13).

Using such chronological markers, Hallam (1987) defined four primary phases of occupation, see Table 2. These phases have been critiqued and refined by Schwede (1990) based on whole of assemblage analyses. Schwede (1990) has also highlighted the difficulties relating to the use of fossiliferous chert as a chronological marker.

Table 2. Occupation phases for the Swan Coastal Plain, comparison of Hallam's and Schwede's definitions

Phase	Hallam (1987)	Schwede (1990)
Early	Pre-5000 BP. Assemblages containing artefacts made of Eocene fossiliferous chert	4600–40000 BP. Absence of backed pieces, larger flake and platform sizes
Middle	5000–1000 BP. Assemblages containing backed artefacts and elements of the 'Australian Small Tool Tradition'	3000–4600 BP. Presence of backed pieces, significant differences in debitage from late phase sites. Associated with introduction of microlith technology to the Swan Coastal Plain.
Late	Post-1000 BP. Quartz-rich assemblages with high proportions of waste flakes	0-3000 BP. Characterised by flake assemblages with no significant variation in flake shape and platform size, increase in small edge-damaged pieces.
Final	Post-contact. Artefacts made on European materials such as glass or ceramics	Post-contact. Artefacts made on European materials such as glass or ceramics

Site distribution

Analysis of site distribution data collected during the Swan Area Archaeological Survey (SAAS) project directed by Hallam (1987; 1986) identified the following spatial and temporal patterns in site distribution across the Swan Coastal Plain.

⁴ Also referred to as Eocene chert or Bryozoans chert.

- In all phases, virtually no sites are located within the zone of the most seaward dunes (Quindalup);
- the limestone belt (Spearwood) has relatively few sites, most of those are towards its eastward margin;
- the majority of sites lie to the east, on the coastal sand plain (Bassendean Sands) and on the alluvium of the Pinjarra Plain;
- the foothills appear to be well used, but the small sample of the scarp and uplands showed little use.

In addition, Hallam examined the distribution of sites according to artefact population and noted that densities were initially similar in the sand plain and alluvial zones, with the alluvial zone showing higher density in the Middle Phase. The Late Phase saw an increase in numbers on the sand plain due to an increase in smaller sites, whilst the alluvial zones displayed greater concentration of usage into larger sites. Final Phase figures show Europeans becoming the resource and Aboriginal usage of the landscape peaking around homesteads and in the fertile alluvial zone (Hallam, 1987:20–23).

Anderson's (1984) subsequent study used additional data from surveys at North Dandalup, South Canning, Perth Airport, Avon headwaters and the Canning River catchment area to build on the results of the SAAS project. Anderson (1984:34) found that the archaeological evidence indicated a greater exploitation, spatially and/or temporally, in the coastal environment than in either the forest or plateau areas. Site density on the Swan Coastal Plain was three to six times greater than forested areas and two to four times that at the Avon headwaters. Sites were mainly located adjacent to water sources across all areas; however whilst sites on the plateau were situated on low-lying and gently sloping ground, sites on the coastal sand plain are commonly located on elevated dunes or sand ridges.

Strawbridge's (1987) computer analysis of SAAS and Anderson's data sites developed the following defining principles for site distribution on the Swan Coastal Plain (after Edwards 2008:: 10). Sites are:

- most likely to be situated on sandy, well drained dune ridges;
- most likely to be located within 350 m of a potential water source, including (in decreasing frequency) swamps, creeks, rivers, lakes, surface water, springs and soaks;
- unlikely to be located in low-lying, poorly drained or seasonally inundated areas; and
- unlikely to be located more than 350 m away from potential water sources.

Strawbridge (1987:: 35) attributes the large number of sites located in the Bassendean sands geomorphic zone to a combination of factors, including the greater stability of the formation, greater abundance of resources within the zone and better access to water sources. Strawbridge comments that 'a site is likely to have been returned to and/or occupied for greater lengths of time if it lies close to a reliable, long term supply of water. Such water is also likely to provide increased numbers of plant and animal resources. The amount of archaeological material is likely to be greater at sites in close proximity to reliable water sources' (Strawbridge 1987:: 35).

Site characterisation

During the SAAS over 400 sites were recorded, with more than half being interpreted as indicative of ephemeral usage of the landscape by small groups. The remainder of sites included large sites comprised of tens of thousands of surface artefacts such as retouched artefacts, cores, debitage and

grinding and percussion material, with the latter few types being interpreted as reflecting the presence of women and family groups. Thus the large sites were seen as representing occupation for long periods of time by large groups of Aboriginal people (Edwards, 2008:5).

The range of lithic types present on the Swan Coastal Plain is also much broader than in the forest or on the plateau, but relative proportions vary at different sites. Quartz is nearly always dominant, except at a very few sites of the post-contact period where European glass only is found, or where fossiliferous chert, which is the next most prevalent material, occurs in high concentrations. The variable proportion of the latter is attributed to both distance of sites from the probable source of the chert to the west of the present coastline, and to its unavailability when the sea reached its present level in mid-Holocene times. Dolerite and mylonite both occur to a much lesser extent, the former usually as larger tools like steep edged scrapers, hammer stones or grinding material, and the latter possibly as a replacement for fossiliferous chert when it became unobtainable. Silcrete is represented only in very minor quantities. Anderson also notes that except for the fossiliferous chert, all lithic materials had to be transported or traded from beyond the Yilgarn block or from other distant areas (Anderson, 1984:25).

As pointed out above, with regards to the subsurface character of archaeological sites on the Swan Coastal Plain, very few sites with stratified archaeological deposit have been identified and those that are stratified are primarily located within the Swan River alluvial zone. No stratified open sites have been located within the Bassendean Sands (Bowdler et al. 1991). Bowdler et al. highlight the impact of the nature of the Bassendean Sands on the integrity of sites, stating that because the Bassendean Sands dune system consisted of a stable core with a superficial mobile layer of continually reworking sands, artefacts which may have been deposited over a long period of time will have become mixed on one level due to continual deflation and reworking (see also Anderson 1983). In addition, Bowdler et al. argue that the impacts of European farming practices have further served to disturb any site integrity. Despite this, there is evidence to suggest that there is potential for subsurface artefactual material to be present in both open sites and areas with no archaeological surface expression within the Bassendean Sands (see Anderson 1983; Thomson and Neuweger 2014: for example).

Stone tool technologies

Few stone tool technology analyses have been conducted on artefacts from the Swan Coastal Plain (Bird 1985; Pearce 1979; Schwede 1990). Bird (1985) has highlighted that the predominant use of quartz for the manufacture of artefacts on the Swan Coastal Plain, and its particular fracturing properties, have led to some significant differences in the artefact assemblage composition and technological processes to those manufactured in other regions from rocks such as chert. Specifically, Bird notes that as the available pieces of quartz are generally small in size, methods to flake it are constrained and necessitate the use of anvils and bipolar flaking techniques. The irregularities of quartz's internal structure also means that very large quantities of debris and debitage can be produced during the flaking process and much of this debris does not exhibit evidence of conchoidal fracture, but rather lots of small angular pieces (Bird 1985). This can have some significant implications for artefact identification and assemblage analysis.

Pearce (1979) examined the distribution of small tools within Western Australia, specifically backed tools, flat adzes and micro scrapers. Pearce (1979: 171) commented that in morphological terms, tools from the south-western region of Western Australia are on average small in size, have mainly

squat asymmetric shapes and are usually made of quartz. Pearce found that backed tools occur less frequently in Western Australia than in eastern Australia and proposes a later development of this tool technology in the west. He argues that the backed tool tradition was introduced into Western Australia by 4,000 BP probably somewhere along the eastern border of the State and reached the western coast by about 3,200 BP then disappearing out of dated sequences several hundred years before European contact (Pearce 1979:: 169). Pearce (1979:: 173) also suggests a possible trend towards smaller sizes of backed tools in upper layers of excavated sites. With regards to flat adzes, Pearce proposes that the section of the Darling Scarp around Bullsbrook and Walyunga may have been a 'centre of popularity for the flat adze industry' after being introduced around 3,200–4,600 BP and utilised until after European contact (Pearce 1979:: 170).

Schwede's (1990) PhD research focused on comparing assemblages from both dated and undated artefact scatter sites from the Swan Coastal Plain. This research identified a number of changes in quartz manufacturing technologies over time including statistically significant differences in artefact size, shape and platform between assemblages from the Late phase (0–3000 BP) and those from 3000 BP to 40,000 BP. Schwede also observed the appearance of backed artefacts and an increase in edge damage or rejuvenation flakes after 4600 BP. Such changes are attributed by Schwede to a reorganisation of stone working technology during the mid-Holocene associated with the introduction of backed artefact technology.

Social organisation

The aim of Hallam's (1986) study was to relate population to resources by mapping demographic patterns across different ecological zones and sub-zones for successive phases of Aboriginal occupation of the Swan Coastal Plain and its immediate hinterland (Anderson 1984:1). Hallam combined ethnographic data with archaeological survey and excavated data in order to adopt a social rather than exclusively and mechanistically environmental approach to changing Aboriginal adaptations and life patterns (Strawbridge, 1987:11). The conclusions from Hallam's SAAS study indicated that the Swan Coastal Plain with its lakes and swamps, along with the alluvial zone with similar wetlands and rich alluvial soils, attracted the heaviest use and exploitation over time. However, Hallam argues that at all periods the seaward margin failed to show significant usage, and although detail shifts between phases, the general picture of densities being highest near the scarp and lowest towards the sea holds throughout (Hallam, 1987:23).

Anderson (1984) refined Hallam's model and proposed a land-use model that 'delineates a flexible but structured usage of the resources of the Swan Coastal Plain, the central and northern jarrah forest, and the western plateau area, and which allows for the movement between areas required by social and ritual activities' (Anderson, 1984:37). Anderson (1984:34) interpreted the distribution of site types and sizes in the three environmental zones as reflecting actual resources available to Aboriginal people in those respective environments, the period of the year when they were obtainable, and the more intangible facets of the Aboriginal life way, which laid such stress on social and ritual activities. The Swan Coastal Plain had food resources to sustain a relatively large population for most of the year, which would explain the existence of the major sites found on the plain (Anderson, 1984:35).

Anderson's model proposed that during summer and autumn, Aboriginal groups gathered on the coastal plain around estuaries, wetlands, swamps and other water sources in order to exploit their resources. Hence, the major sites on the Swan Coastal Plain were generated as a result of annual

visits to the area. During winter and spring, groups would disperse into the forest and plateau areas in order to relieve pressure on the water-based resources. The relatively small size of sites within those two areas is seen as reflecting high group mobility necessitated by less predictable resources and pursuit of game animals. During spring groups gradually moved back to the coastal areas (Anderson, 1984; Edwards, 2008).

In a critique of Anderson's model, Schwede (1990) suggests that the Jarrah forest was used by both coastal and plateau groups primarily as sources for stone and food year round, as well as the river valleys of the Canning and Helena Rivers being used as direct travel routes for social, ceremonial or trade purposes. Schwede (1990) proposes that rather than camping in the Jarrah forests during the winter months, the forest was utilised from base camps on the coastal plain during this time.

3.3.2 Previous archaeological studies within the project area

The Department of Planning, Lands and Heritage (DPLH) Aboriginal Heritage Information System (AHIS) indicates that there have been seventeen previous archaeological surveys undertaken within approximately 5 km of the current project area, see Table 3 and Appendix 1.

Whilst not all surveys conducted comprised systematic pedestrian surveys, collectively the results of the surveys all point to some strong site location spatial patterning within the local region, namely that archaeological sites, in particular artefact scatters, are most likely to be located on or within elevated sand rises, hills or dunes, and within approximately 300 m of a water source.

3.4 Existing Aboriginal Sites and Other Heritage Places

A search of the DPLH's AHIS was undertaken on 18 February 2020 to confirm the number and nature of any previously located Aboriginal Sites within a 5 km radius of the survey area. The search boundary was defined by a box with the following diagonally opposite corner points (GDA94, MGA Zone 50):

1. 397460 mE 6434378 mN
2. 409908 mE 6421013 mN

The search identified that 66 sites, including 24 Registered Aboriginal Sites⁵ and 42 Other Heritage Places⁶ are located within a 5 km radius of the project area (see Tables 2 and 3 and Appendices 2 and 3)⁷.

According to the AHIS search results one Other Heritage Place is located within the LSP area. DPLH Id 37115 (MJ-09), a modified tree, is located within Lot 101 Lang Road.

3.4.1 DPLH Id 37115 (MJ-09)

DPLH Id 37115 was located and recorded by Thomson and Neuweger (2014) in 2012. Its current status is Lodged. DPLH Id 37115 is located at 404263 mE, 6428244 mN and was described as follows:

⁵ Sites that have been assessed by the Aboriginal Cultural Material Committee (ACMC) and placed on the Register of Aboriginal Sites.

⁶ Includes sites that have been lodged for assessment, sites that are awaiting an ACMC determination, sites with insufficient information provided to be assessed and places determined not to be sites by the ACMC.

⁷ An additional AHIS search was undertaken on 6 July 2020 to confirm the previous results.

MJ-09 is a modified *Eucalyptus marginata* (Jarrah) tree, approximately 20-25m high with one main trunk. The girth of the tree had a diameter of approximately 4 m. The tree was alive and growing at the time of recording and the Aboriginal Consultants present estimated based on the tree's size that the tree could be over 100 years old.

The bark has been removed from the middle section of the east-southeast side of the trunk, approximately 3.25 m above the ground. The single scar is roughly circular in shape, measuring approximately 1240 mm long by 2350 mm wide. Regrowth depth was not measured at the time of recording due to difficulty in accessing the scar.

...This tree represents a single event of the procurement of bark for manufacturing artefacts such as a shield or container. (Thomson and Neuweger 2014: 150).



Table 3. Heritage surveys undertaken within 5 km of the LPS area (source: DPLH AHIS 2020)

Report ID	Authors	Report Title	Survey Type	Spatial Accuracy	Field Survey	Desktop Survey
17927	Blockley, E. & Greenfeld, P.	List of Informants (For Report 95/139). Oct. 1995.	Archaeological & Ethnographic	Good	Yes	Yes
19121	Edwards, K	Report of an Aboriginal Heritage Survey : proposed Tonkin Highway extension and Mundijong Road Realignment Project	Archaeological & Ethnographic	Good	Yes	Yes
22366	Dortch, Joe	Indigenous heritage of the Peel - Harvey Region : a review of previous research and archival data for phase 1 of the Peel Cultural Landscape Assessment Project	Archaeological & Ethnographic	Good	Yes	Yes
22416	Tempus Archaeology	Report on phase 1 archaeological investigations : proposed Byford residential sub-division Shire of Serpentine-Jarrahdale, WA	Archaeological	Good	Yes	Yes
22981	Edwards Kevin	Report on a Phase 1 Archaeological Survey, Lot 2 Nettleton Road, Byford	Archaeological	Very Good	Yes	Yes
28551	Western Heritage Research Pty. Ltd.	A Report of an Aboriginal Heritage Survey of the Proposed Southern Corridor Infrastructure Upgrade Project	Archaeological & Ethnographic	Good	Yes	Yes
101972	Blockley, E	Report of an Aboriginal Heritage Survey, South-East Corridor Structure Plan. Oct.1995.	Archaeological & Ethnographic	Good	Yes	Yes
102051	Blockley, E	Revised Report of an Aboriginal Heritage Survey South-East Corridor Structure Plan. March. 1996.	Archaeological & Ethnographic	Good	Yes	Yes
103014	Quartermaine G	Addendum to Aboriginal site survey of Dampier to Perth natural gas pipeline - gas lateral facilities Carnarvon lateral	Archaeological & Ethnographic	Unreliable	Yes	Yes
103259	Quartermaine G	Report on an Archaeological Investigation for Aboriginal Sites Proposed Roadworks at Mundijong Road. October 1996.	Archaeological	Very Good	Yes	Yes
103328	Burke, S	Aboriginal Heritage : report on additional ethnographic consultation, mitigative recording, and newly recorded sites	Archaeological & Ethnographic	Very Good	Yes	Yes
103490	Prince, C	Report of an Aboriginal heritage survey, Byford Village, Byford	Archaeological & Ethnographic	Very Good	Yes	Yes
103564	University of Western Australia.	An Archaeological Survey Project: The Perth Area, Western Australia. Apr 1972.	Archaeological	Indeterminate	Yes	Yes
104275	O'Connor, R. & Quartermaine, G.	Report on a Survey for Aboriginal Sites on the Proposed Byford-Collie and Ongerup-Jerramungup Sections of the Perth to Adelaide Optic Fibre Cable Route. December 1989.	Archaeological & Ethnographic	Unreliable	Yes	Yes
200217	Hovingh, Ryan	A Report on the Archaeological Assessment of Six Heritage Places within the Byford on the Scarp Estate, Byford, Western Australia : August 2014. [TBD]	Archaeological	Moderate	Yes	Yes
200444	McDonald, Edward M	Report on an Ethnographic Consultation Regarding Cedar Woods' Proposed Development Lot 9021, Sites, Byford & Ethnographic Assessment of Archaeological Sites, Byford on the Scarp Byford Western Australia	Archaeological & Ethnographic	Good	Yes	Yes
201130	Brad Goode, Grant Preller, Thomas O'Reilly	Report of an Aboriginal Heritage Survey for the Tonkin Highway Extension: Thomas Road to South Western Highway in Shire of Serpentine-J Dale, Western Australia	Archaeological & Ethnographic	Very Good	Yes	Yes

Table 4. Registered Aboriginal Sites with archaeological components within 5 km radius of the LSP area

Site Id	Site Name	Site type	Dimensions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
396	South-East Corridor 07 / Cardup Siding	Artefact scatter	240 x 65m	15600	180	Low sand dune ridge	Bassendean sands overlying Guildford formation	-	-	-
448	South-East Corridor 01	Artefact scatter	100 x 60m	600	700	Eroded dune ridge	Bassendean sands	-	13	Artefacts = flake (n= 7), flake fragment (n=3), core fragment (n=1), transverse broken flake (n=1), backed blade (n=1) Lithologies = quartz (n=8), fine grained sedimentary material (n=5) also noted at site metamorphic, silcrete, glass
449	South-East Corridor 02	Artefact scatter	15 x 5m	75	430	Low sand dune	Bassendean sands	Disturbed	7	Artefacts = flake (n=3), core fragment (n=3), transverse broken flake (n=1) Lithologies = quartz (n=7)
450	South-East Corridor 03	Artefact scatter	100 x 150m	20670	420	White sand dune	Bassendean Sands	Partially disturbed	20-85	Artefacts = flake (n=4), core fragment (n=1), Transverse broken flake (n=6), longitudinal broken flake (n=5), cores (n=2), grinding implement (n=1) Lithologies = quartz (n=13), fine grained sedimentary material (n=4), Quartzite (n=1), medium grained sedimentary material (n=1)
3648	Soldiers Road, Mundijong	Artefact scatter Archaeological deposit	50 x 30m	1500	0	White sand dune	Bassendean Sands	Partially disturbed	20.8	Artefacts = wide variety of cores, scrapers, bipolar flakes, bipolar cores, flakes and debris Lithologies = quartz, metamorphic, fossiliferous chert, mylonite
16089	Byford 01	Artefact scatter	2 x 5m	10	450	Sandy exposure	Bassendean sands	Partially disturbed	0.8	Artefacts = 8 artefacts Lithologies = quartz (n=5), glass (n=3)
16090	Byford 02	Artefact scatter	3 x 5m	15	570	Sandy exposure	Bassendean sands	Partially disturbed	0.27	Artefacts = 4 artefact Lithologies = quartz (n=4)

Table 5. Details of Other Heritage Places with archaeological components located within 5 km of the project area

Site Id	Site Name	Register status	Site type	Dimensions	Site size (sq m)	Distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
3310	Cardup	Stored	Artefact scatter	-	-	-	-	-	-	-	-
3313	Mundijong	Insufficient information	Artefact scatter	-	-	-	-	-	-	-	-
3590	Whitby	Insufficient information	Artefact scatter	30 x 10m	300	100	Sandy-clay exposure on road verge	-	Disturbed	-	Numerous stone flakes mainly quartz
3591	Yarrabah	Insufficient information	Artefact scatter	40 x 40m	1600	850	Sandy-clay exposure on road verge	-	Disturbed	-	Numerous stone pieces including quartz flakes and retouched scrapers as well as quartz and mylonite backed tools.
17923	If #2	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
18189	Tonkin Highway – Mundijong Road Scatter #13	Stored	Artefact scatter	30 x 20m	600	410	Low sandy rise	Bassendean Sands	-	0.23	No detailed artefact information given
18190	Tonkin Highway – Mundijong Road Scatter #14	Stored	Artefact scatter	Not given	2	1100	Not given	Not given	Disturbed	1.0	Four artefacts recorded, not likely in original context
18192	Tonkin Highway – Mundijong Road Scatter #16	Stored	Artefact scatter	100 x 2m	200	170	Not given	Bassendean sands	Disturbed	0.03	No details
21305	Byford village isolated finds	Stored	Isolated artefacts	-	-	-	-	-	-	-	-

Site Id	Site Name	Register status	Site type	Dimensions	Site size (sq m)	Distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
23914	Byford archaeological survey 001	Stored	Artefact scatter Modified tree	33 x 19m	625	80	Low sandy rise	Bassendean sands overlying Guildford formation	Partially disturbed	0.25-1.25, average = 0.05	Artefacts = debris (n=17), complete flakes (n=6), flake fragments (n=6), broken flakes (n=3), possible manuports (n=2) Small in size, ranging between 6.4mm – 29mm (mean = 13.1m) All artefacts made from quartz Artefacts clustered around erosion areas. Modified tree = Marri (?) tree with two scars, had been felled.
23915	Byford archaeological survey 002	Stored	Artefact scatter	6 x 12m	12	20	Sandy exposure/lens	?Pinjarra Plain colluviums	Partially disturbed by stock movement	0.5	Artefacts = Debris (n=3), complete flakes (n=2), bipolar broken flake (n=1) Artefact size = maximum dimension range 5.2-21.3mm, mean size is 11.6mm All artefacts manufactured from quartz
23916	Byford archaeological survey 003	Stored	Artefact scatter	20 x 12m	240	115	Low sandy rise	Bassendean sands overlying Guildford formation	Disturbed	0.1	Artefacts = debris (n=7), complete flakes (n=3), flake fragments (n=2), bipolar flakes (n=1), SPC (n=1) Size = maximum dimension range 7.6-41.3mm, mean = 16.9mm Lithology = all artefact manufactured from quartz
23918	Byford archaeological survey 005	Stored	Artefact scatter	36 x 12m	436	90	Low sandy rise	Bassendean sands overlying Guildford formation	Partially disturbed	0.05	Artefacts = debris (n=10), flake fragments (n=6), bipolar flakes (n=4), bipolar core (n=1), manuport (n=1) Artefact size = maximum dimension range 5 – 25.5mm, mean = 14.6mm Lithologies = all artefacts manufactured from quartz

Site Id	Site Name	Register status	Site type	Dimensions	Site size (sq m)	Distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
23919	Byford archaeological survey 006	Insufficient information	Artefact scatter	80 x 3m	240	140	Low sandy rise	Bassendean sands overlying Guildford formation	Partially disturbed	0.125	30 quartz flaked stone artefacts
23920	BAS / Iso - 001	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23921	BAS / Iso - 002	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23922	BAS / Iso - 003	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23923	BAS / Iso - 004	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23924	BAS / Iso - 005	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23925	BAS / Iso - 006	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
24979	Nettleton Road 19-09-07/001	Stored	Artefact scatter	3 x 1.5m	4.5	10	Gravel and sand exposure	Bassendean sands overlying Guildford formation	-	0.88	Artefacts = flake fragments (n=2), complete flakes (n=1), debris (n=1) Lithologies = greenstone (n=2), quartz (n=2)
24980	Nettleton Road 19-09-07/002	Stored	Artefact scatter	4 x 1m	4	123	Sandy firebreak	-	Partial disturbance	0.75	Artefacts = flakes (n=1), flake fragments (n=1), debris (n=1) Lithologies = quartz (n=3)
24981	Nettleton Road 19-09-07/003	Stored	Artefact scatter	18 x 9m	162	150	Deflated dunes	Bassendean sands overlying Guildford	Partial disturbance	0.07	Artefacts = flakes (n=1), broken bipolar flakes (n=1), flake fragment (n=1), debris (n=1)

Site Id	Site Name	Register status	Site type	Dimensions	Site size (sq m)	Distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
								formation			Lithologies = quartz (n=4)
24982	Nettleton Road Isolated Finds	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
24983	Nettleton Road 1-06	Stored	Artefact scatter	35 x 5m	175	147	Deflation area within dunes	Bassendean sands overlying Guildford formation	-	0.03	Artefacts = flakes (n=4), manuport (n=1) Lithologies = quartz (n=4), igneous (n=1)
24984	Nettleton Road 2-06	Stored	Artefact scatter	30 x 9m	270	342	Sandy exposure	Bassendean sands	Disturbed	0.06	17 flaked quartz stone artefacts
24985	Nettleton Road 3-06	Stored	Artefact scatter	13 x 10m	130	490	Sandy exposure	Bassendean sands	Disturbed	0.06	8 quartz flaked stone artefacts
32591	MJ-01	Stored	Artefact scatter, Arch deposit	133 x 157m	16580	470	Low, white sandy rise above low-lying plausiplain	Bassendean sands overlying Guildford formation	-	1.48	Artefacts = debris (n=32), flaked pieces (n=25), flakes (n=18), longitudinally broken flakes (n=5), manuports (n=2) and a transversely broken flake (n=1). The majority of artefacts were small in size and light in weight. No retouch was observed on any of the artefacts recorded. Lithologies = white quartz (n=62), crystal quartz (n=18), dolerite (n=2) and pink quartz (n=1)
32615	MJ-04	Stored	Artefact scatter, Arch deposit	36 x 13m	303	160	Low, white sandy rise above low-lying plausiplain	Bassendean sands overlying Guildford formation	-	0.013	Artefact types recorded on the surface comprised flaked pieces (n=2, 40%), a flake (n=1, 20%), a transversely broken flake (n=1, 20%) and debris (n=1, 20%). All artefacts were manufactured from

Site Id	Site Name	Register status	Site type	Dimensions	Site size (sq m)	Distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
											quartz, including white quartz (n=3, 60%) and crystal quartz (n=2, 40%). The majority of artefacts were small in size (less than 0.7g in weight and median length of 9.8 mm) and no retouch was noted
32616	MJ-03	Lodged	Artefact scatter, Arch deposit	38 x 22m	663	200	Elevated white sand lens above low-lying plausiplain	Bassendean sands overlying Guildford formation	Partially disturbed	0.015	Artefact types recorded within the site comprised flaked pieces (n=6, 60%) and flakes (n=4, 40%). All artefacts were manufactured from quartz, including white quartz (n=7, 70%), crystal quartz (n=2, 20%) and pink quartz (n=1, 10%). The majority of artefacts were small in size (less than 0.6g in weight and median length of 10.5 mm) and no retouch was noted.
32617	MJ-06	Lodged	Artefact scatter, Arch deposit	52 x 48m	1877	1.89km	Sand dune surrounded by low-lying plausiplain	Bassendean sands overlying Guildford formation	-		14 surface artefacts were recorded, predominantly debris and flaked pieces manufactured on white quartz. A total of 794 artefacts were recovered from Test square A, 80 were recovered from Excavator trench J and 42 from the probe holes. The assemblage is dominated by debris (total subsurface assemblage: n=611, 66.7%), flaked pieces (total subsurface assemblage: n=166, 18.1%) and flakes (total subsurface assemblage: n=83, 9.1%) Multi platform cores are the most

Site Id	Site Name	Register status	Site type	Dimensions	Site size (sq m)	Distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
											abundant core type. The assemblage contained a limited amount of retouched/utilised artefacts (total subsurface assemblage: n=4, 0.4%), which included two steep edge scrapers. No grinding material was recovered.
32619	MJ-02	Stored	Artefact scatter, Arch deposit	117 x 103m	9354	300 m	Large, low white sand hill above low-lying plausiplain	Bassendean sands overlying Guildford formation	-	6.5	Artefact types recorded within the site comprised debris (n=19, 59.3%), flaked pieces (n=9, 28.1%), flakes (n=3, 9.3%) and one retouched/utilised flaked piece (n=1, 3.1%). The majority of artefacts were manufactured from white quartz (n= 30, 93.7%) and a small proportion from crystal quartz (n=2, 6.2%). All artefacts were small in size, weighing between <0.1g and 1.3g with a median weight of 0.4 g.
37115	MJ-09	Lodged	Modified tree	-	-	-	Flat alluvial plain above creek	Bassendean sands overlying Guildford formation	-	-	-
37117	MJ-07	Lodged	Artefact scatter, Arch deposit	-	-	1.48km	Low white sand hill above low-lying plausiplain	Bassendean sands overlying Guildford formation	-	-	Subsurface deposit. The assemblage is dominated by debris (n=17, 32.7%), flaked pieces (n=12, 23.1%) and flakes (n=13, 25%). Three multi platform cores (5.8%) were also recovered. No retouched artefacts or formal tools were identified within the assemblage.

Site Id	Site Name	Register status	Site type	Dimensions	Site size (sq m)	Distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
											<p>Cortex was present on only one artefact recovered from MJ-07, indicating that the majority of the assemblage comprises tertiary or late stage reduction associated with artefact trimming and resharpening.</p> <p>Most of the artefacts were made on quartz, smoky quartz is predominant (n= 36, 69.2 %); with lesser quantities of white quartz (n=8, 15.4%) and crystal quartz (n= 6, 11.5%). Two mylonite artefacts were also present.</p>

3.4.2 Archaeological site characterisation

Of the 29 Registered Aboriginal Sites and 29 Other Heritage Places located within a 5 km radius of the project area, 57 have archaeological components. Utilising the limited available information for these sites the following characterisation of archaeological sites within the local region was made.

The most common type of archaeological site feature in the local region is 'artefacts / scatter', see Figure 3. Single occurrences of a reduction area, archaeological deposit, shell and a modified tree have also been recorded within the search area.

Artefact scatters are predominantly low in density (less than 0.1/m²) and small in size (less than 7500 sq m), see

Figure 4. Artefact scatter assemblages are typically dominated by quartz⁸ but often include lesser amounts of other materials such as fossiliferous chert, dolerite, basalt, crystal quartz, quartzite, mylonite, silcrete, granite and glass. The majority of scatters recorded comprise debitage including flakes, chips⁹, flaked pieces, cores and manuports, with bipolar flaking noted at multiple locations. Very low numbers of retouched flakes and formal tools have been reported within the local region, with backed blades and tools having been reported at three sites including DPLH Id 448 South-East Corridor 01, DPLH Id 3591 Yarrabah and DPLH Id 3648 Soldier's Road Mundijong.

No sites within the search area, apart from DPLH Id 3648 Soldier's Road Mundijong, have been reported as having archaeological deposit. From the scarcity of information it is difficult to characterise the subsurface components of archaeological sites within the local region.

Site file information on archaeological sites within the local region indicate that over half the sites have been subject to some form of disturbance associated with European land clearance and landscape modification including farming and agricultural activities, mineral exploration, infrastructure and urban housing developments, see Figure 6.

⁸ Assemblages are typically over 90% quartz artefacts with less than 10% other lithologies.

⁹ Chips are classified by Hallam as flakes less than 1.5 cm in size.

Figure 3. Types of features commonly contained within archaeological sites within 5 km of the project area

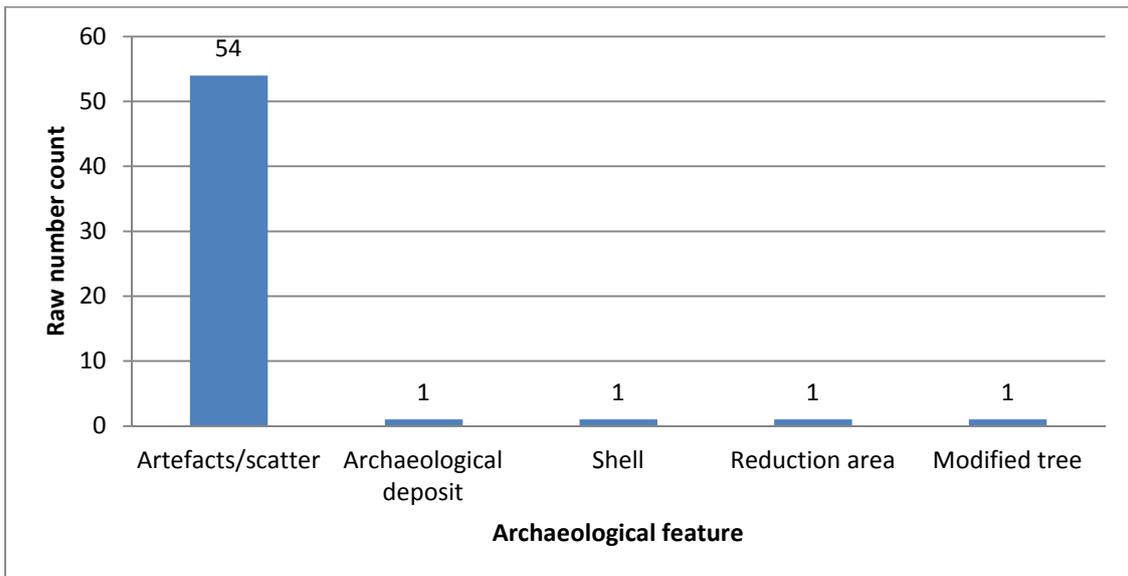


Figure 4. Local region artefact scatter sizes

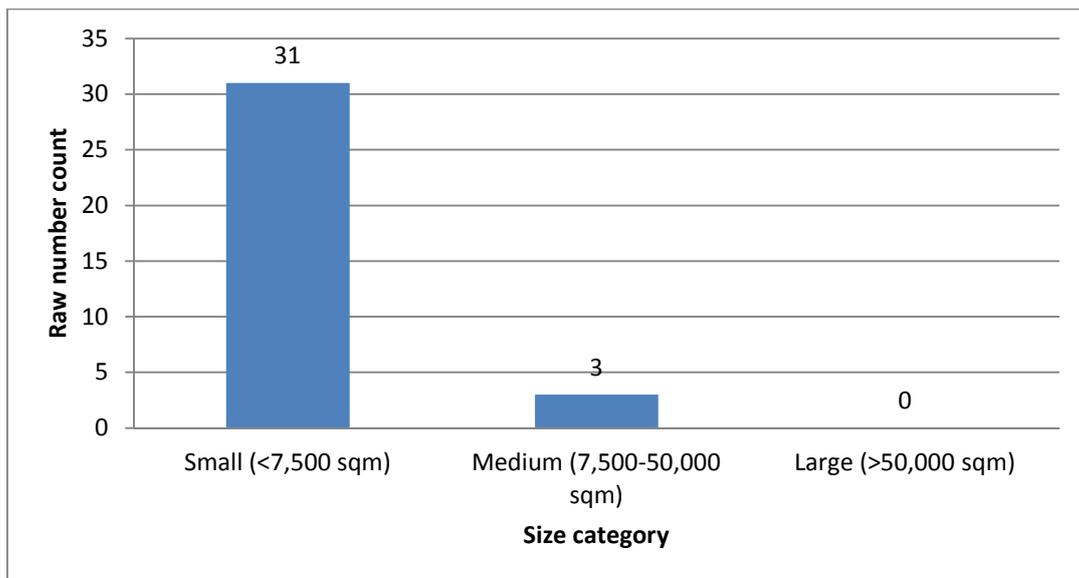


Figure 5. Geomorphologic location of archaeological site features within the local region

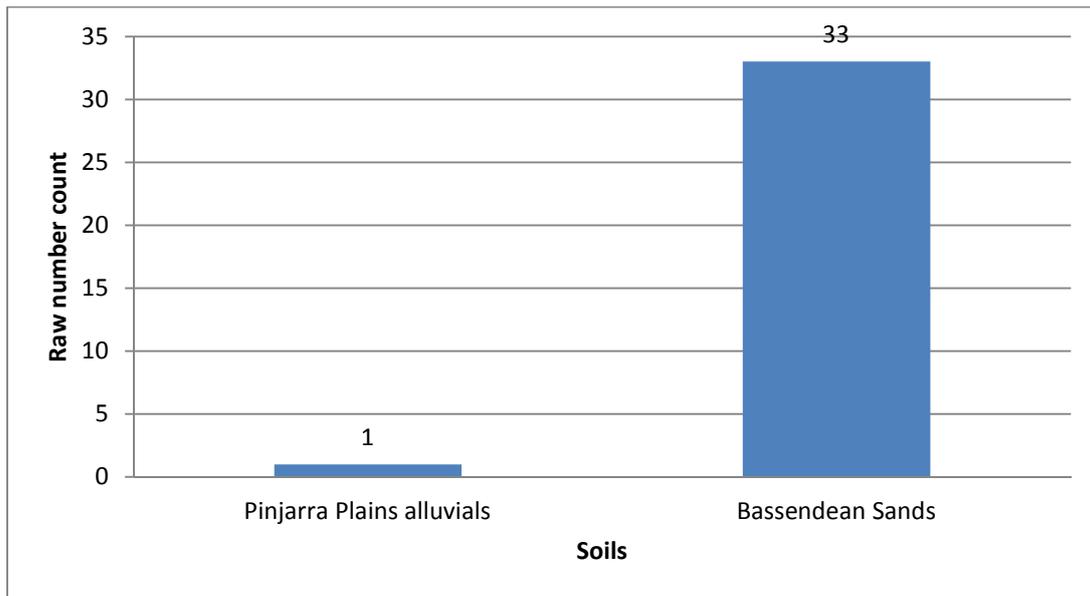
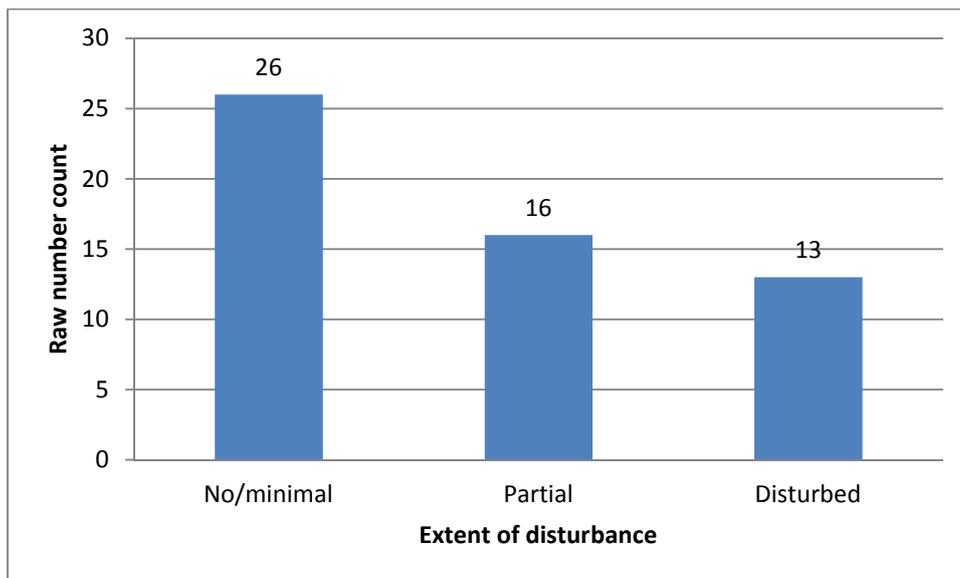


Figure 6. Extent of disturbance to sites within local region



3.4.3 Archaeological site distribution

Site distribution within the local region exhibits strong spatial patterning. The Pinjarra Plains geomorphic unit has generally been considered in conjunction with the Bassendean Sands and, as Hallam identifies, is commonly assumed to contain a significant proportion of the Swan Coastal Plain’s archaeological sites. Three recent studies on the Pinjarra Plains have identified distinct spatial patterning with regards to the location of archaeological sites.

Tempus Archaeology (2006) conducted an archaeological survey for a proposed residential development at Byford in 2005. The project area was located within Guildford formation sandy clay soils (a unit of the Pinjarra Plain alluvials) which were overlain by a thin veneer of Bassendean Sands. Tempus (2006: 1) indicated that the vast majority of the project area would have “formed part of a

vast seasonal wetland extending between the Foothills to the east and the Bassendean Dunes to the west” prior to colonisation. Similar to the current project area, the Byford survey area had been cleared of the majority of vegetation and used for agricultural purposes. The Tempus survey examined an area of 367 hectares by a combination of intensive systematic pedestrian survey and purposive pedestrian survey. Eight sites were located, all of which were found within either elevated sand dunes or rises, or on lower-lying sand lenses within the sandy clay formations.

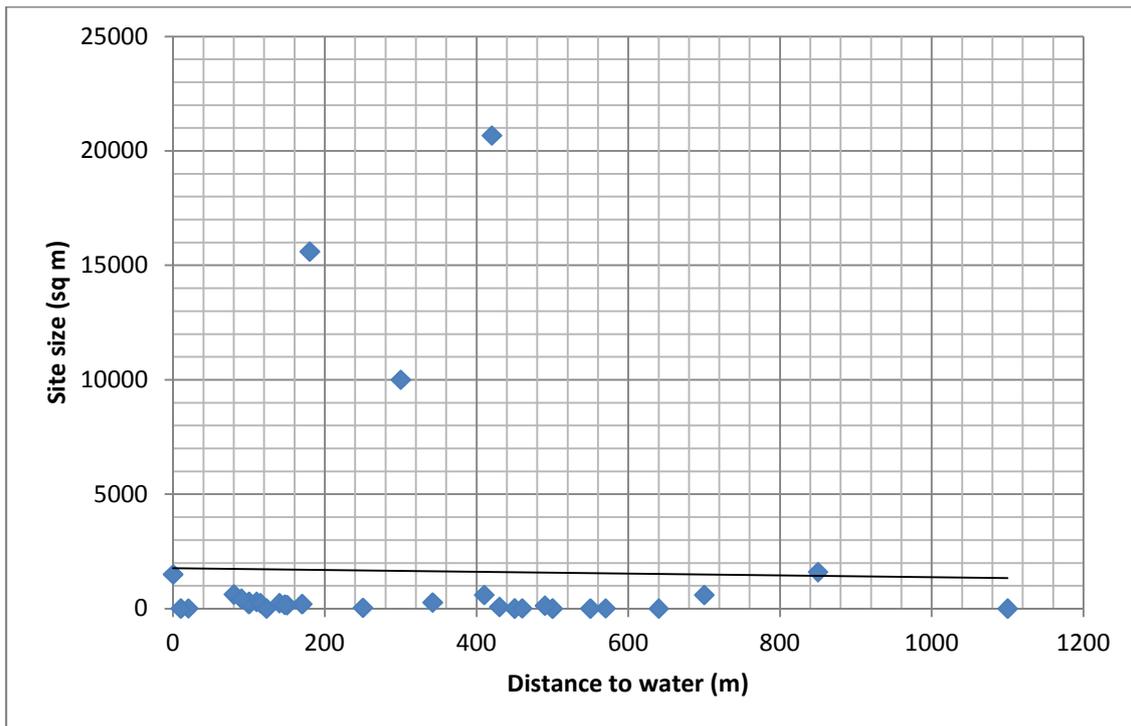
Additional surveys were conducted at Lot 2 Nettleton Road Byford by Tempus Archaeology in 2006 (Edwards 2007). This survey examined 38 hectares of land which consisted of Bassendean sand dunes and thin lenses of Bassendean sand overlaying Guildford formation plausiplain and alluvials. The survey employed both systematic pedestrian survey transects and additional purposive transects of all fire breaks, tracks and other areas of relatively high ground surface visibility. In total, six archaeological sites were located in the survey area, all of which comprised open flaked stone artefact scatters and all situated on either deflating Bassendean sand dunes or thin lenses of Bassendean sand overlying the alluvial deposits.

Further to this, a survey conducted by Thomson and Neuweger (Thomson 2011) at Pinjarra, approximately 40 km south of the current project area, provides a specific examination of site distribution within the Pinjarra Plain plausiplains geomorphic system. This survey examined an area of 3.457 sq km (345.7 hectares) which consisted of low-lying wetland subject to seasonal inundation, interspersed with elevated white Bassendean sand rises and remnant dunes. Similar to the current project area, the Pinjarra survey area had been previously used for agricultural purposes. This area was intensively surveyed by systematic pedestrian transects spaced at 20 m apart, with additional purposive examination of all elevated sand rises and dunes. The survey not only confirmed the association of artefact scatters and sites with elevated sand rises and dunes within the Pinjarra Plain plausiplain geomorphic context, but further elucidated that within these sand dunes, surface artefacts were consistently exposed on the tops and eastern slopes of the sand rises and dunes. Very few isolated artefacts were located within the low-lying plausiplain areas. Sites located within this project area have subsequently been excavated by Gavin Jackson Cultural Resource Management and the publication of results was pending at the time of writing this report.

Considering the consistency in results between these studies and also with Strawbridge’s GIS-based predictions that sites are mostly likely to be situated on sandy, well-drained dune ridges and unlikely to be situated within in low-lying, poorly drained or seasonally inundated areas, it is more than plausible to hypothesise that within the Pinjarra Plains geomorphic unit, all elevated Bassendean sand dunes, hills and rises overlaying the alluvial plausiplain will have high potential for containing archaeological material, whilst the low-lying plausiplain areas will conversely have low potential for locating any archaeological material.

With regards to distance to water, sites within the local region generally conform to the regional trend of larger sites being located closer to water sources (see Figure 7), however, it should be noted that there are issues with the particular analysis due to variations in classification of water sources and the impacts of historic landscape modifications.

Figure 7. Comparison of site size vs distance to water



3.5 Non-Indigenous heritage

SMEC's (2009:136-137) environmental assessment report reviewed the Register of Heritage Places and Municipal inventory for non-Indigenous historical places. This review indicated that there are no sites listed in the Register of Heritage Places within the LSP area. Thirteen sites were listed on the Shire of Serpentine-Jarrahdale's municipal heritage inventory; however, none of these sites are located within the project area.

3.6 Summary of desktop findings

In summary, the desktop review found that:

- Lot 101 Lang Road has been subject of one previous archaeological survey (Thomson and Neuweger, 2014).
- One previously recorded Other Heritage Place, DPLH Id 37115 (MJ-09) is located within Lot 101 Lang Road.
- The most common type of archaeological sites in the local region is 'artefacts / scatter'. Single occurrences of a reduction area, archaeological deposit, shell and a modified tree have also been recorded within the search area.
- Regional archaeological research and assessments have indicated that artefact scatters on the Swan Coastal Plain are more commonly small in size, low-medium density, dominated by quartz with some potential for fossiliferous chert, dolerite, granite, silcrete, crystal quartz, quartzite or glass, and comprised predominantly of debitage with very few specialised or 'formal' tool types.
- The spatial distribution of sites in the local region is largely determined by the geomorphic setting, as the majority of sites are located either on Bassendean sands or within lenses of Bassendean sands overlying Pinjarra Plain alluvials. Larger, denser sites are also located close to water sources such as swamps and lakes.

4.0 Field assessment results

An archaeological survey was conducted on 19 and 20 February 2020 and 27 March 2020 by TCHM archaeologist Jo Thomson, Dr Edward McDonald of Ethnoscience, two Gnaala Karla Booja representatives through Bilya Aboriginal Corporation Aboriginal Corporation and two Gnaala Karla Booja representatives Winjan Aboriginal Corporation. The Gnaala Karla Booja representatives participated in all aspects of the archaeological assessment.

4.1 Survey area

The archaeological assessment surveyed Lots 10, 11, 12, 13, 14 and 50 Keirnan Street, a portion of Land Road Reserve, and the eastern section of Lot 101 Lang Road, Mundijong; see Table 6 and Map 3.

Table 6. Area subject to archaeological survey

Node	Easting (mE)	Northing (mN)
1	404917.27	6427839.66
2	404914.08	6428221.08
3	404516.91	6428218.27
4	404516.63	6428282.97
5	404494.54	6428283.01
6	404482.15	6428296.64
7	404396.77	6428297.49
8	404323.68	6428294.85
9	404279.96	6428286.38
10	404219.89	6428294.97
11	404173.2	6428304.8
12	404058.41	6428279.61
13	404151.66	6428280.71
14	404151.6	6428317.92
15	404069.36	6427823.39

4.1.1 Environment

The majority of the survey area consisted of flat, low-lying plausiplain alluvial soils, interspersed with white Bassendean sand rises, overlaying the plausiplain. In some parts of the project area the sand rises have been excavated and sands deposited across the plausiplain.

The survey area comprises farming paddocks and has been previously cleared and used for agricultural purposes. Several fences and vehicle tracks dissect the project area. Sheep were present in some of the paddocks at the time of the survey.

Remnant vegetation, comprising *Eucalyptus* sp. trees, exists along the northern and eastern boundaries of the survey area. Ground cover consisted of low grasses.

4.1.2 Visibility

Visibility was reasonably good and consistent across all survey areas, ranging between 60 and 100 % and averaging approximately 70 %.

Plate 1. View northeast of survey area



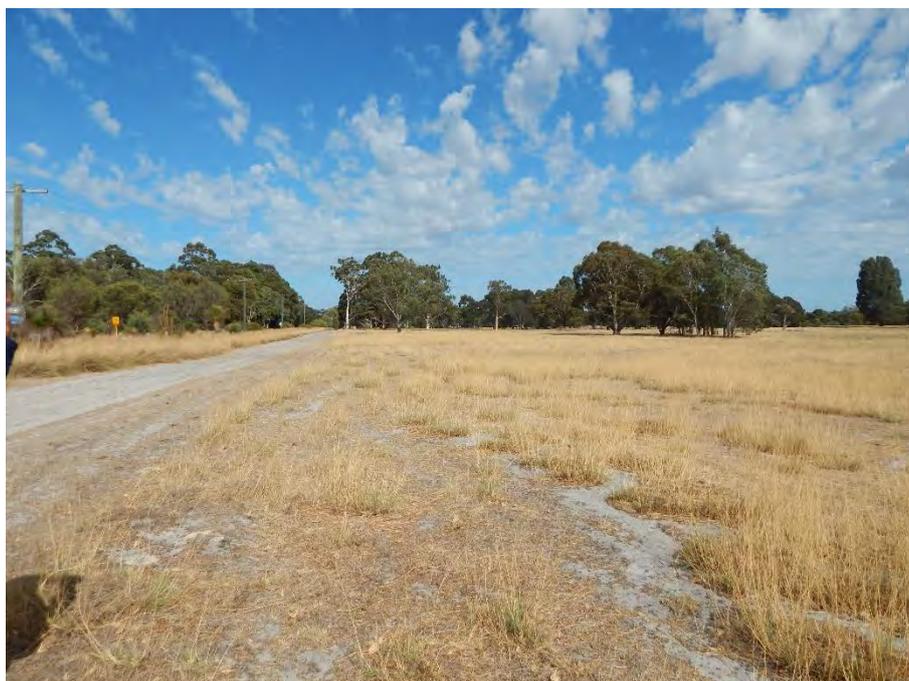
Plate 2. View west of survey area



Plate 3. View northeast of survey area



Plate 4. View west of survey area



4.2 Survey results

The archaeological assessment of the LSP has been completed. In summary, the previously recorded DPLH site 37115 (MJ-09) was relocated, one new Aboriginal archaeological place (Sam Woods' Camp [MJ20-01]) was located. One area was also identified by the Traditional Owners and archaeological team as having good potential for subsurface archaeological material.

4.2.1 Previously recorded site – DPLH ID 37115 (MJ-09)

Previously recorded DPLH site ID 37115 (MJ-09) was relocated and inspected in the field. It was confirmed that ID 37115 is located at the reported coordinates: 404263 mE; 6428244 mN.

Site ID 37115 comprises a modified *Eucalyptus marginata* (Jarrah) tree, approximately 20-25m high with one main trunk, with a large circular-shaped scar on its east-southeast side approximately 3.25 m above the ground. The tree was still alive and growing at the time of this assessment, and the scar was in good condition.

It is recommended that a management buffer with a radius of approximately 30 m should be applied around the tree to avoid impacting upon the tree's root system.

4.2.2 New heritage place – Sam Woods' Camp (MJ20-01)

One new heritage place was located during the archaeological assessment. Sam Woods' Camp (MJ20-01) comprises an historic camp site with historic artefacts, structural remains and potential archaeological deposit. It also has historical associations with known Aboriginal people and offers the potential to contribute significant knowledge about the history of the Mundijong region. A site description is provided in Section 5 below.

4.2.3 Potential archaeological deposit, PAD-01

Although there were minimal surface artefacts located during the survey, one elevated sand dune located at coordinates 404303 mE 6428156 mN, Lot 50 Keirnan Street, was identified by the Gnaala Karla Booja representatives and archaeological team as having moderate potential to contain subsurface archaeological material. The Gnaala Karla Booja representatives on the archaeological survey requested that this area be archaeologically test excavated and assessed prior to any section 18 being lodged for the project.

4.2.4 Isolated archaeological material

Eighteen (18) isolated artefacts were recording during the assessment, see Table 7. These artefacts are not considered to meet section 5 of the *Aboriginal Heritage Act 1972*.

Table 7. Isolated artefacts

Artefact #	Easting (mE)	Northing (mN)	Lot #	Artefact Type	Lithology	Artefact Dimensions			Platform Type	Platform Dimensions		# Dorsal flake scars	Cortex %	Retouch/ Utilisation?	R/U Location	R/U Length
						Length	Width	Depth		Length	Width					
IA-01	404907	6427847	14	FF	Q	9	7	4	-	-	-	-	-	-	-	-
IA-02	404847	6428188	14	FF	Q	11	11	4	-	-	-	-	-	-	-	-
IA-03	404614	6428189		DB	Q	20	10	4	-	-	-	-	-	-	-	-
IA-04	404621	6428143		FF	Q	21	6	8	-	-	-	-	-	-	-	-
IA-05	404638	6428104		F	Q	21	11	3	FO	-	-	2	-	-	-	-
IA-06	404638	6428043		FF	Q	21	12	6	-	-	-	2	-	-	-	-
IA-07	404588	6428185		RUF	Q	15	12	4	FL	5	4	2	-	Y	LLM	12
IA-08	404589	6428179		F	CQ	16	14	4	FO	-	-	2	-	-	-	-
IA-09	404592	6428179		DB	Q	10	7	4	-	-	-	-	-	-	-	-
IA-10	404592	6428179		FF	CQ	14	10	3	-	-	-	-	-	-	-	-
IA-11	404592	6428179		DB	Q	11	8	6	-	-	-	-	-	-	-	-
IA-12	404433	6427955		F	Q	24	13	5	FK	12	4	1	-	-	-	-
IA-13	404390	6428025		FP	BAS	36	30	13	-	-	-	1	-	-	-	-
IA-14	404305	6428184		RUF	Q	15	9	7	FP	10	6	-	-	Y	RLM	10
IA-15	404302	6428155		DB	Q	26	7	10	-	-	-	-	-	-	-	-
IA-16	404302	6428155		DB	Q	15	10	7	-	-	-	-	-	-	-	-
IA-17	404182	6427988		DB	Q	9	5	3	-	-	-	-	-	-	-	-
IA-18	404166	6428181		DB	Q	6	5	7	-	-	-	-	-	-	-	-

Key:

Artefact types – FF = Flake fragment, DB = Debris, F = Flake, RUF = Retouched/utilised flake

Artefact lithology – Q = Quartz, CQ = Crystal quartz, BAS = Basalt

5.0 Site description

5.1 Sam Woods' Camp (MJ20-01)

Sam Wood's Camp (MJ20-01) comprises an historic camp site with historic artefacts, structural remains and potential archaeological deposit. It also has historical associations with known Aboriginal people and offers the potential to contribute significant knowledge about the history of the Mundijong region.

5.1.1 Location and extent

Sam Wood's Camp (MJ20-01) is located on Lot 50 Keirnan Street, approximately 10 m in from the southern fence line. It is approximately 130 m (north–south) by 150 m (east–west) and covers an area of approximately 16,990 sq m. Sam Wood's Camp is bounded by the following coordinates.

Table 8. Details of the newly recorded archaeological place 'Sam Woods' Camp' (MJ20-01), Lot 50 Keirnan Road Mundijong

Lot #	Site No.	Site Name	Site type	Easting (mE)	Northing (mN)
50	MJ20-01	Sam Woods' Camp	Artefact scatter,	404281	6427830
			Historical,	404297	6427846
			Structure,	404291	6427911
			Potential archaeological	404262	6427931
			deposit	404223	6427943
				404183	6427954
				404145	6427958
				404147	6427830
			404297	6427846	

5.1.2 Site context

The site is located on an elevated sand rise close to the southern boundary of Lot 50. It is located approximately 350 m south of Manjedal Brook and a small, northwest – southeast oriented drainage line is located approximately 10 m to the north.

Sam Wood's Camp is vegetated by a range of medium to tall trees including River Gums, She Oaks, Marri, Jarrah and native pear. Ground cover comprises seasonal grasses.

5.1.3 Site description

Sam Wood's Camp comprises an artefact scatter, with the remains of a metal structure and potential archaeological deposit.

The structure is in the centre of the site and comprises several sheets of corrugated iron and wood. The structure is no longer standing. There are also numerous bricks scattered across the site. A medium sized scatter of historical artefacts manufactured from ceramics, glass and metal surrounds the structure. Approximately one hundred artefacts were observed at the site, however, further detailed recording is required to establish the content, density and distribution of the artefacts.

Plate 5. Sam Wood's Camp view northeast



Plate 6. Sam Wood's Camp view east



Plate 7. Sam Wood's Camp view northeast



Plate 8. Sam Wood's Camp view south



Plate 9. Sam Wood's Camp view northwest



Plate 10. Sam Wood's Camp view west



Plate 11. View west of artefacts along track



Plate 12. View west of artefacts along track



Plate 13. Sample of artefact scatter with ceramics



Plate 14. View south of remains of corrugated iron structure



Plate 15. Remnants of metal drum



Plate 16. Remnants of fence post

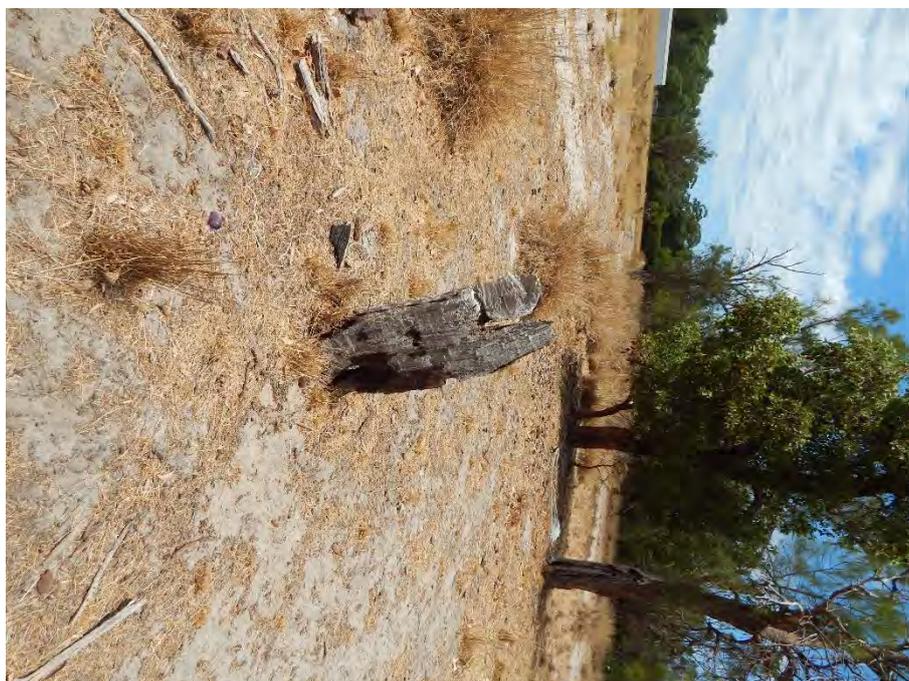


Plate 17. Remnants of fence post and metal object



Plate 18. Example of ceramics



Plate 19. Example of ceramics



Plate 20. Example of ceramics



Plate 21. Example of ceramics



Plate 22. Example of bricks



Plate 23. Example of ceramics



Plate 24. Example of ceramics



Plate 25. Example of glass bottle



Plate 26. Example of ceramics



5.1.4 Site condition

Sam Wood's Camp was in reasonable condition at the time of recording. Although it has been subject to some surface disturbance, with tracks running through the site; this has not detracted from the place's values or potential for further archaeological investigation.

5.1.5 Gnaala Karla Booja comments

The Gnaala Karla Booja representatives provided the following comments on the sentiment, cultural and historic values associated with Sam Wood's Camp (MJ20-01).

George Walley reported that historically his family lived along Keirnan Road in tin shed houses. He recalled the presence of the native pear trees around the old hut from when he was a young child.

George Walley and Franklin Nannup both reported that their parents and grandparents lived in a tin hut on Lot 50. They stated that it was the camping area of the Woods, Harts and Nannup families from the late 1950s/early 1960s. They reported that the families worked for the Atwells and Betts farming families and the Walligans (bakers) and that people would have lived there at the tin hut camp and gone out to their jobs on the farms and railway. George Walley further commented that the families firstly lived in old army tents, then tin sheds before moving into railway houses. George and Franklin noted that the site is a good camping place because of elevated ground and proximity to water.

George Walley and Franklin Nannup stated that they would like to collect further oral histories about the site and suggested that Mr Peter Humes would have further information about the place.

They also indicated that they would like to undertake subsurface testing and excavation of the place and if the place is to be developed, it is their preference that the site be incorporated into public open space with interpretive signage about the place's history, noting in particular that the place has always been a camping place. They envisaged it becoming 'an educational place for kids to learn'.

George Walley and Franklin Nannup recommended that the site be named after the old gentleman that used to live there: Sam Wood.

5.1.6 Site assessment

It is the opinion of the author that Sam Woods' Camp (MJ20-01) constitutes an Aboriginal Site to which section 5a and 39(2) of the *Aboriginal Heritage Act 1972* applies.

5.1.7 Site management recommendations

It is recommended that:

- Sam Woods' Camp (MJ20-01), is likely to meet the requirements of sections 5 and 39(2) of the *Aboriginal Heritage Act 1972* (AHA), and should be **avoided** and not impacted upon in any way without Ministerial consent under section 18 of the AHA.
- The landowner undertakes further detailed recording and assessment of Sam Woods' Camp (MJ20-01), including the recording of oral histories, detailed surface recording, assessment of artefacts, and subsurface test excavations, **prior** to any section 18 application being made.
- If Sam Woods' Camp (MJ20-01) cannot be avoided and will be impacted during future development, the proponent should consult further with Gnaala Karla Booja representatives about any proposed section 18 application, mitigation and salvage strategies and the

management of salvaged materials, and comply with any other undertakings given in respect of the section 18 process.

- The landowner implements suitable controls to prevent any impacts on Sam Woods' Camp (MJ20-01) during earthworks, including adequate physical demarcation of site boundaries and effective management processes such as ground disturbance permits and operator inductions.



6.0 Findings and Recommendations

6.1 Assessment findings

Ethnoscience and Peter Webb & Associates are informed that:

- The archaeological assessment for Lots 10, 11, 12, 13, 14, 15 and 50 Keirnan Street, Lot 101 Lang Road and the Lang Road Reserve Mundijong is **complete**.
- One heritage site, Sam Woods' Camp (MJ20-01), was located within Lot 50 Keirnan Street.
- Previously recorded heritage place DPLH ID 37115 (MJ-09) was relocated on Lot 101 and was noted to be in good condition.
- One area with moderate potential for subsurface archaeological material (PAD-01) was identified on Lot 50 Keirnan Street.
- There is also some potential for sub surface archaeological material to be present within Lots 10, 11, 12, 13 and 14 Keirnan Street.
- Eighteen isolated artefacts were located during the archaeological survey.
- The Gnaala Karla Booja representatives participated in all aspects of the archaeological assessment and contributed to the results and recommendations outlined in this Preliminary Advice.

6.2 Recommendations – Lots 10, 11, 12, 13 and 14 Keirnan Street (DJMM land holdings)

Based on the results of the archaeological assessment, it is **recommended** that:

- That the isolated stone artefacts recorded within Lots 11, 12, 13 and 14 Keirnan Street do not, in TCHM's opinion, constitute Aboriginal archaeological sites according to sections 5 and 39 (2) of the AHA.
- There is some potential for sub surface archaeological material to be present within Lots 11, 12, 13 and 14 Keirnan Street and therefore it is recommended that initial ground disturbance be monitored by one or two Gnaala Karla Booja representatives.
- In the event that any suspected archaeological or cultural material is identified, all work must cease at that location until Gnaala Karla Booja representatives and an archaeologist have properly assessed the material. Contingency plans should be developed, before ground disturbance occurs, to allow for culturally appropriate management of such discoveries.

6.3 Recommendations – Lot 50 (Education Department)

Based on the results of the archaeological assessment, it is **recommended** that:

- Newly recorded place, Sam Woods' Camp (MJ20-01), is likely to meet the requirements of sections 5 and 39(2) of the *Aboriginal Heritage Act 1972* (AHA), and should be **avoided** and not impacted upon in any way without Ministerial consent under section 18 of the AHA.
- The landowner undertakes further detailed recording and assessment of Sam Woods' Camp (MJ20-01), including the recording of oral histories, detailed surface recording, assessment of artefacts, and subsurface test excavations, prior to any section 18 application being made.
- The area with potential archaeological subsurface deposit (PAD-01) be archaeologically tested and assessed prior to any section 18 application being submitted.

- There is also some potential for sub surface archaeological material to be present within other parts of Lot 50 and within Lot 10 Keirnan Street and therefore it is recommended that initial ground disturbance be monitored by one or two Gnaala Karla Booja representatives.
- If Sam Woods' Camp (MJ20-01) cannot be avoided and will be impacted during future development, the proponent should consult further with Gnaala Karla Booja representatives about any proposed section 18 application, mitigation and salvage strategies and the management of salvaged materials, and comply with any other undertakings given in respect of the section 18 process.
- The landowner implements suitable controls to prevent any impacts on Sam Woods' Camp (MJ20-01) during earthworks, including adequate physical demarcation of site boundaries and effective management processes such as ground disturbance permits and operator inductions.

6.4 Recommendations – Lot 101 Lang Road and Lang Road Reserve (Mr Sam Lang, Shire of Serpentine)

- Heritage place DPLH ID 37115 is likely to meet the requirements of sections 5 and 39(2) of the *Aboriginal Heritage Act 1972* (AHA), and should be **avoided** and not impacted upon in any way without Ministerial consent under section 18 of the AHA.
- A protective buffer of 30 m radius be applied around ID 37115 during any ground disturbing works so that its root system is not inadvertently affected.
- A protective buffer of 30 m also be applied to Manjedal Brook.
- If DPLH ID 37115 cannot be avoided and will be impacted during future development, the landowner should consult further with Gnaala Karla Booja representatives about any proposed section 18 application, mitigation and salvage strategies and the management of salvaged materials, and comply with any other undertakings given in respect of the section 18 process.
- The landowner implements suitable controls to prevent any impacts on DPLH ID 37115, including adequate physical demarcation of site boundaries and effective management processes such as ground disturbance permits and operator inductions.

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8.0 Appendices



Appendix 1 – DPLH AHIS previous surveys search results



Criteria

29 Heritage Register contains 29 Areas in coordinates - Area Port 2 s - 397460 6434378 N A50 397460 6421013 N A50 409908
6421013 N A50 409908 6434378 N A50

Disclaimer

Heritage Register is compiled from reports and other relevant data sources. Heritage Register consists of all discrete areas as noted in the relevant
Sales Reports so as not to be added to the Department of Planning Lands and Heritage DP. Please consult report folder for more information. Refer to
dpl.wa.gov.au/information-and-services/original-heritage for information on relevant reports added to DP.

The information provided is made available in good faith and is provided based on the information provided to the Department of Planning Lands and Heritage third parties. The
information is provided solely on the basis that readers will be responsible for their own assessment as to the accuracy of the information. Do not find any errors or omissions in our records
in LinkedIn or apps it would be appreciated if you email the details to the Department at OriginalHeritage@dpl.wa.gov.au and we will make every effort to rectify it as soon as possible.

Port West Settlement - A Disclaimer

The Register is on land in or adjacent to the following land parcels and sections: Naala Arla Boojanidin and sections Naala Arla Boojanidin and sections
n 8 ne 2015 situated in the land parcels and sections. As a result of the Western Australian Government and respect to the Western Australian People
Naala Arla Boojanidin and Western Boojanidin and Western Noonan and the Western Original and the Western WA.

The As indicated parties in the land parcels in the Western Australian Government and certain Western Australian entities to enter into a Noonan standard Heritage
Register N/A. The original Heritage Register Areas unless the area is a registered Heritage area. It is also intended that other Western Australian entities and
institutions enter into the N/A. The original Heritage Register Areas. This is recorded in the N/A. It is entered into and an Act is notified under the N/A. If
there is a risk that an Act will impact the area in the original Heritage Register site. The original Heritage Register Deedlines are
referenced to the N/A provide information on how to assess the potential risk to the original Heritage Register.

The use of the 2015 the Department of Planning and Infrastructure Development in the Petroleum and related Assets Act provisions in the Western
Settlement Areas will place a condition on these tenements in the Heritage Register or a N/A before any further action is taken.

For the Western Australian Government Department of Planning and Infrastructure for the Heritage Register condition placed on the original or petroleum title. Do not see advice as to the
relevant to set the N/A for the proposed Act. The Act does not apply to the Areas and the N/A. The Act is placed on the record at
<https://dpl.wa.gov.au/orphanisation-department-of-the-premier-and-act-investor-nation-title-settlement>

Further advice is also sought from the Department of Planning Lands and Heritage at OriginalHeritage@dpl.wa.gov.au.

Priority

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of Original Heritage sites established under and maintained under the Aboriginal Heritage Act 1972.

Access

Some reports are restricted.

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Original Heritage Register

List of Heritage Reserves

10.1.9 - attachment 1

For further information on this information please see the Department of Planning Lands and Heritage's Disclaimer statement at <https://dpl.wa.gov.au/attachment-site>

Report ID	Report Title	Report Authors	Area Number	Category	Area Description	Area Status	Field Status
17927	List of Informants for Report 95 139 of 1995	Blolereenfeld P	1	Ar aeolo i al t no rap i	o t - ast orridor tr t re Plan e s r e area is t e proposed on in i a tension ease ent - a orridor of appro i atel 20 lon and 100 ide i r ns et een Ranford Road in t e nort and ndijon Road in t e so t And proposed r an Villa es i o er an area of appro i atel 2263 a as s o n in i 1 1	ood	ield and Des top
19121	Report of an A ori nal erita e re proposed on in i a e tension and ndijon Road Reali n ent Proje t	d ards	1	Ar aeolo i al t no rap i	Proposed on in i a tension and ndijon Road Reali n ent Proje t e proposed de elop ent area stret es fro ills Road West osnells to arra dale Road arra dale as s o n in i 1	ood	ield and Des top
19122	ar report se tion 18 noti e to dist r A ori nal ites on in i a e tension ills Road West artin to o t Western i a ndijon ar 2001 W	B D ons ltants Pt td	1	t no rap i	on in i a tension ills Road West artin to o t Western i a ndijon - a 28 se tion as s o n in i 1	Ver ood	ield and Des top
21817	Ballar traditional oners A ori nal site re ordin proje t	a in Barrie	1	t no rap i	W adj territorial o ndaries t e lands of t e Ballar Peoples as s o n in i re 10	nrelia le	ield and Des top
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22416	Report on p ase 1 ar aeolo i al in esti ations proposed B ford residential s -di ision ire of erpentine- arra dale WA	e p s Ar aeolo	1	Ar aeolo i al	e proposed residential s di ision is i ediatel est of B ford to nsite in t e ire of erpentine- arra dale Western A stralia	ood	ield and Des top

List of Heritage Reserves

Report ID	Report Title	Report Authors	Area Number	Category	Area Description	Area Status	Field Status
22980	Report of an heritage reserve of 2 Nettleton Road Bford Western Australia	Donald dard	1	Heritage Reserve	Heritage Reserve is located approximately 30 south of the Perth CBD and is bounded on the east by the Nettleton Road and on the south by the eastern end of the present road development in the Bford area. Rise and Waterside Pass	Good	Field and Desktop
22981	Report on a Proposed Heritage Reserve of 2 Nettleton Road Bford	dards e in	1	Heritage Reserve	Heritage Reserve is located immediately south of the Nettleton Road in the Bford area of the Perth area. Western Australia	Very Good	Field and Desktop
28551	A Report of an Original Heritage Reserve of the Proposed Northern Corridor Infrastructure Project	Western Heritage Research Pty Ltd	1	Heritage Reserve	87 kilometres of pipeline in an area bounded by the Mill Reservoir in the east to the Westfield Road in the east and the northern end of the road.	Good	Field and Desktop
101972	Report of an Original Heritage Reserve of the Northern Corridor Transit Plan 1995	Blole	1	Heritage Reserve	Heritage Reserve proposed on in the area consists of a corridor approximately 200m long and 100m wide between Ranford Road in the north and the northern end of the proposed road. The area is approximately 2263ha in total situated in the Bford area and the northern end of the road. See figure 11.	Good	Field and Desktop
102051	Revised Report of an Original Heritage Reserve of the Northern Corridor Transit Plan 1996	Blole	1	Heritage Reserve	Heritage Reserve proposed on in the area consists of a corridor of approximately 200m long and 100m wide between Ranford Road in the north and the northern end of the proposed road. The area is approximately 2263ha in total situated in the Bford area and the northern end of the road. See figure 11.	Good	Field and Desktop
102073	Western Australia Regional Forest Assessment Original Report Volume 2 No 1997	Centre for Forest Research	1	Heritage Reserve	Regional Forest Assessment Original Report Volume 2 No 1997	Heritage Reserve	Field only
102074	Western Australia Regional Forest Assessment Original Report Volume 1 No 1997	Centre for Forest Research	1	Heritage Reserve	Regional Forest Assessment Original Report Volume 1 No 1997	Heritage Reserve	Field only
102670	Preliminary Report on the Original Areas of Interest in the Perth Metropolitan Region 1985	Donnor R	1	Heritage Reserve	Perth Metropolitan Region Original Report on the Original Areas of Interest in the Perth Metropolitan Region 1985	Heritage Reserve	Field and Desktop



Original Heritage Register

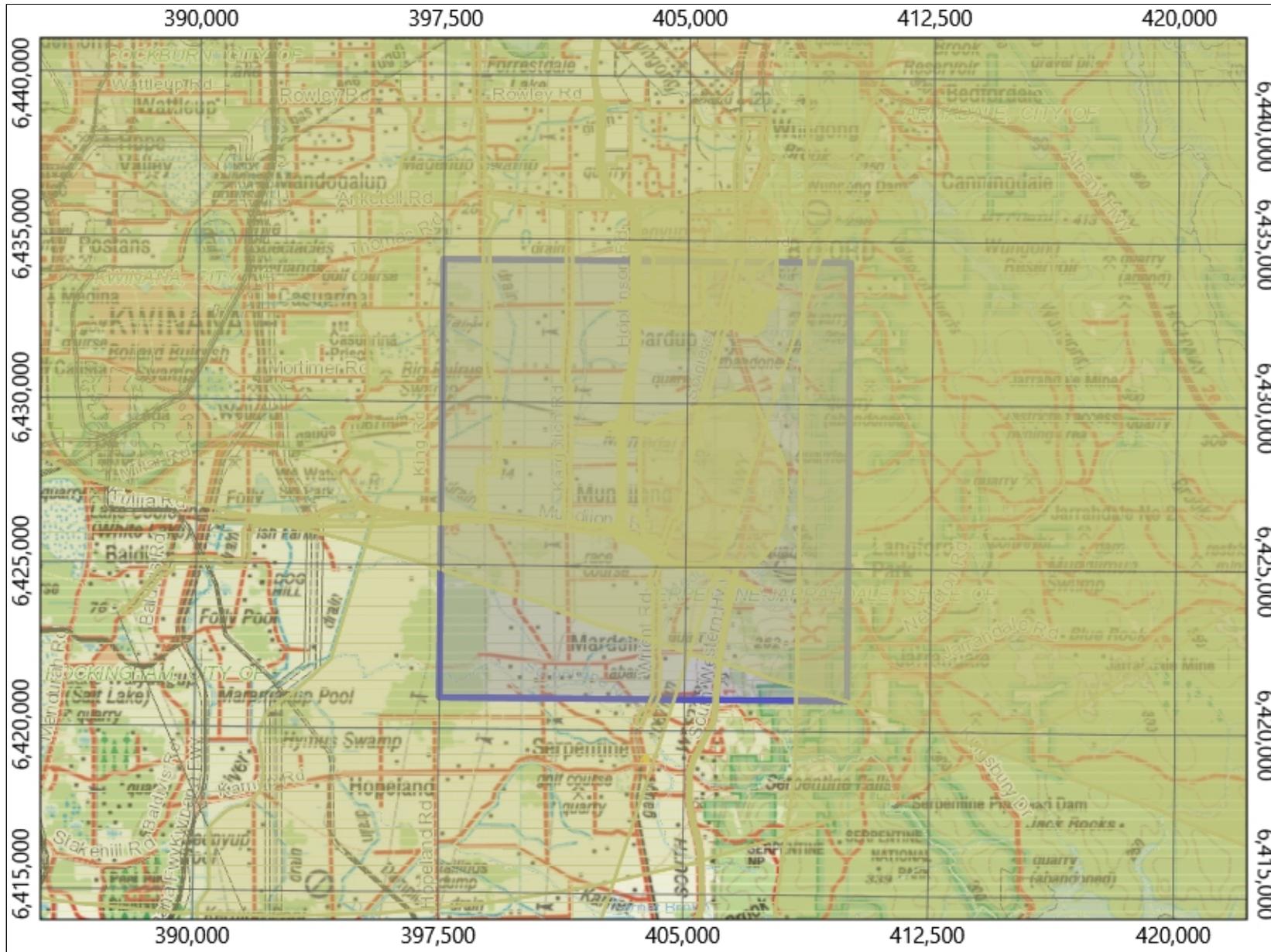
List of Heritage Reserves

For further information on this information please see the Department of Planning Lands and Heritage's Disclaimer statement at <https://dpl.wa.gov.au/attachment-site>

Report ID	Report Title	Report Authors	Area Number	Reference	Area Description	Map Area	Field Description
103014	Addendum to Original site survey of Dampier to Perth natural gas pipeline - as lateral facilities - on lateral	arter aine	1	Ar aeolo i al t no rap i	es re area consists of two major realisations of the annular on lateral gas Pipeline route and so the realisations on the DPN Heritage sites 8891 8892 8893 were identified during the survey	nrelia le	ield and Des top
103259	Report on an Archaeological investigation for Original sites Proposed Road works at ndijon Road to 1996	arter aine	1	Ar aeolo i al	Proposed road works ndijon Road the road survey is a length of 85 along ndijon Road in Baldias - an precinct of the existing road between the Inana Recreation Centre and the intersection of Road A corridor of 100 metres side of the existing alignment as surveyed as shown in plans 1 and 2	Ver ood	ield and Des top
103327	Original Heritage Reserve Conservation Bedford Villa Project 1998 W	ollard and ollard ons ltants	1	t no rap i	Bedford Villa Project	Ver ood	ield onl
103328	Original Heritage report on additional Bedford Conservation initiative reordinance	B re	1	Ar aeolo i al t no rap i	Bedford Villa Bedford archaeological matters previously discussed were re-evaluated in volume 1 which consisted of volumes 1-5 as shown in plans 1 and 2	Ver ood	ield and Des top
103490	Report of an Original Heritage Reserve Bedford Villa Bedford	Prin e	1	Ar aeolo i al t no rap i	Bedford Villa Bedford proposed development area in the desert area east of the Western Victoria immediately north of the all-terrain road project Brook east to the Barr and north to the rear of the Australian Quarantine site as shown in plan 11	Ver ood	ield and Des top
103564	An Archaeological Reserve Project the University of Western Perth Area Western Australia April 1972 Australia		1	Ar aeolo i al	Perth Area 103 site locations in 67 site reports were investigated	ndeter inate	ield and Des top
104184	Report on an archaeological survey of an Area of Proposed Road works at ndijon Road to 1996	onnor R	1	t no rap i	Proposed road works at ndijon Road the survey area comprises ndijon Road from the intersection with the Inana Recreation Centre to its junction with the intersection of Road A distance of approximately 85 metres corridor of 100 metres side of the existing alignment as considered as shown in plan 1	Ver ood	ield and Des top
104275	Report on a survey for Original sites on the Proposed Bedford-ollie and inner-perth urban precincts of the Perth to Adelaide pipeline route December 1989	onnor R arter aine	1	Ar aeolo i al t no rap i	es re area consists of the Bedford-ollie and inner-perth urban precincts of an optical fibre corridor as shown in plans 1 and 2 the width of the survey corridor is 100 metres	nrelia le	ield and Des top



Report ID	Report title	Report Authors	Area Number	Reference	Area Description	Patrol Area	Field Description
105723	Consolidation for a Section 18 Application under the Aboriginal Heritage Act 1972 of the Proposed route of the on in i a tension Al an i a ills Road West artin to o t Western i a ndijon A st 2001	Par er Ronald	1	t no rap i	on in i a tension Al an i a ills Road West artin to o t Western i a ndijon	nrelia le	ield and Des top
200217	A Report on the Archaeological Assessment of the Heritage Places in the Bford on the arp state Bford Western A stralia A st 2014 BD	o in R an	1	Ar aeolo i al	A Report on the Archaeological Assessment of the Heritage Places in the Bford on the arp state Bford Western A stralia A st 2014 BD	oderate	ield and Des top
200444	Report on an t no rap i ons ltation Re ardin edar Woods Proposed De elop ent ot 9021 ites B ford t no rap i Assess ent of Ar aeolo i al ites B ford on t e arp B ford Western A stralia	Donald d ard	1	Ar aeolo i al t no rap i	ot 9021 B ford Western A stralia	ood	ield and Des top
200926	R P R AN N RAP AB R NA R A RV BR D 4361 AND BR D 4536A N ARRA DA R AD N R RP N N - ARRA DA W RNA RA A	s o ise ta le	1	t no rap i	BR D 4361 AND BR D 4536A	ood	ield and Des top
201130	Report of an A ori nal erita e re for t e on in i a tension o as Road to o t Western i a in ire of erpentine- Dale Western A stralia	Brad oode rant Preller o as Reill	1	Ar aeolo i al t no rap i	re for t e on in i a tension o as Road to o t Western i a in ire of erpentine- Dale Western A stralia	Ver ood	ield and Des top



Legend

- Heritage Survey Area
- Search Area
- Town
- Road
- River
- Local Government Authority

Scale: 1:697,000
 Map scale: 1:211,000
 A one 50 DA94

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Information for the Petroleum Application Petroleum title and other data for the State of Western Australia. Department of Mines and Petroleum and Safety.



Appendix 2 – DPLH AHIS Registered Aboriginal Sites search results





Original entries

List of Registered Original Sites

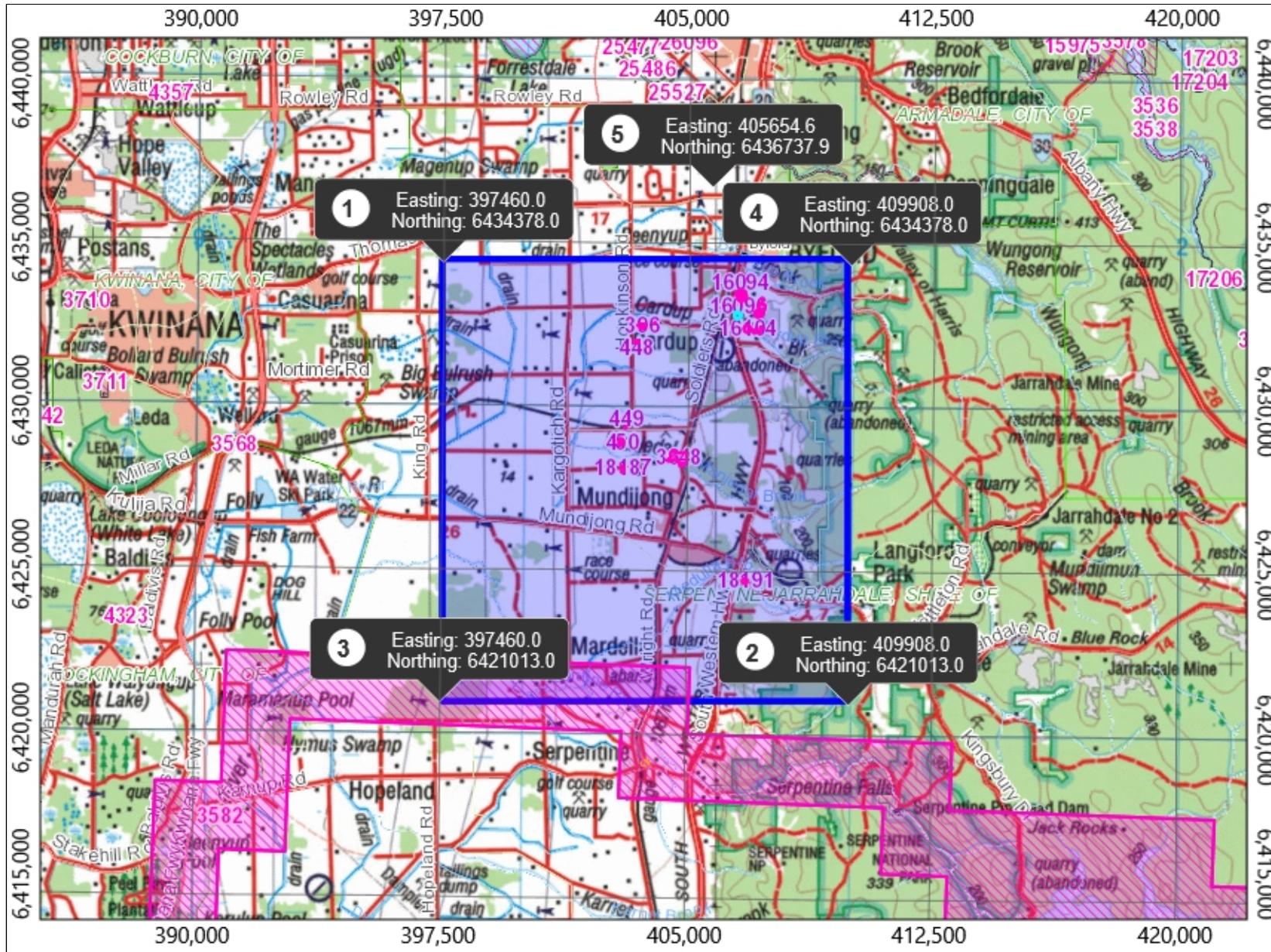
ID	Name	Site Restriction	Boundary Restriction	Restrictions	Status	Category	Coordinates	Notes
396	07 - ARD P RR D R	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger older names aila le fro DAA	403514 6432467 N one 50 Relia le
448	01 - A RR D R	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger older names aila le fro DAA	403350 6431996 N one 50 Relia le
449	02 - A RR D R	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger older names aila le fro DAA	403039 6429389 N one 50 Relia le
450	03 - A RR D R	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger older names aila le fro DAA	402915 6428941 N one 50 Relia le
3582	RP N N RV R	es	es	No other Restrictions	Registered site	ere onial t olo i al	Registered no ledger older names aila le fro DAA	Not a aila le en lo ation is restri ted
3648	R AD D R ND N	No	No	No other Restrictions	Registered site	Artefacts atter Ar Deposit BP Datin 1620BP	Registered no ledger older names aila le fro DAA	404684 6428480 N one 50 Relia le
16089	B RD 01	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger older names aila le fro DAA	407178 6433329 N one 50 nrelia le
16090	B RD 02	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger older names aila le fro DAA	407169 6433099 N one 50 nrelia le
16091	B RD 03	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger older names aila le fro DAA	407119 6432899 N one 50 nrelia le
16092	B RD 04	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger older names aila le fro DAA	407049 6432879 N one 50 nrelia le
16094	B RD 06	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger older names aila le fro DAA	406479 6433489 N one 50 nrelia le
16095	B RD 07	No	No	No other Restrictions	Registered site	Artefacts	Registered no ledger older names aila le fro DAA	406579 6433489 N one 50 nrelia le



Original entries

List of Registered Original Sites

ID	Name	Other Restricted	Boundary Restricted	Restrictions	Status	Category	Coordinates	Notes
16096	B RD 08	No	No	No other Restrictions	Registered site	Artefacts	406429 6432829 N one 50 nrelia le	Registered no led e older na es a aila le fro DAA
16097	B RD 09	No	No	No other Restrictions	Registered site	Artefacts	406539 6433359 N one 50 nrelia le	Registered no led e older na es a aila le fro DAA
16099	B RD 11	No	No	No other Restrictions	Registered site	Artefacts	406599 6433399 N one 50 nrelia le	Registered no led e older na es a aila le fro DAA
16100	B RD 12	No	No	No other Restrictions	Registered site	Artefacts	407153 6432454 N one 50 nrelia le	Registered no led e older na es a aila le fro DAA
16101	B RD 13	No	No	No other Restrictions	Registered site	Artefacts	407100 6432337 N one 50 nrelia le	Registered no led e older na es a aila le fro DAA
16102	B RD 14	No	No	No other Restrictions	Registered site	Artefacts	406931 6432348 N one 50 Relia le	Registered no led e older na es a aila le fro DAA
16104	B RD 16	No	No	No other Restrictions	Registered site	Artefacts	406729 6432419 N one 50 nrelia le	Registered no led e older na es a aila le fro DAA
18187	on in i a - ndijon road s atter 11	No	No	No other Restrictions	Registered site	Artefacts	402958 6428173 N one 50 Relia le	Registered no led e older na es a aila le fro DAA
18188	on in i a - ndijon road s atter 12	No	No	No other Restrictions	Registered site	Artefacts	402961 6428042 N one 50 Relia le	Registered no led e older na es a aila le fro DAA
18191	on in i a - ndijon road s atter 15	No	No	No other Restrictions	Registered site	Artefacts	406725 6424750 N one 50 Relia le	Registered no led e older na es a aila le fro DAA
23917	B ford Ar aeolo i al re 004	No	No	No other Restrictions	Registered site	Artefacts	403917 6432563 N one 50 Relia le	Registered no led e older na es a aila le fro DAA
37116	-08	No	No		Registered site	Modified tree	404730 6428251 N one 50 Relia le	Registered no led e older na es a aila le fro DAA



Legend

- Registered Aboriginal Site
- Search Area
- Town
- Road
- River
- Local Government Authority

Scale: 1:69,500

Map Date: 1/21/2000

Scale: 1:50,000 DA94



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Appendix 3 – DPLH AHIS Other Heritage Place search results



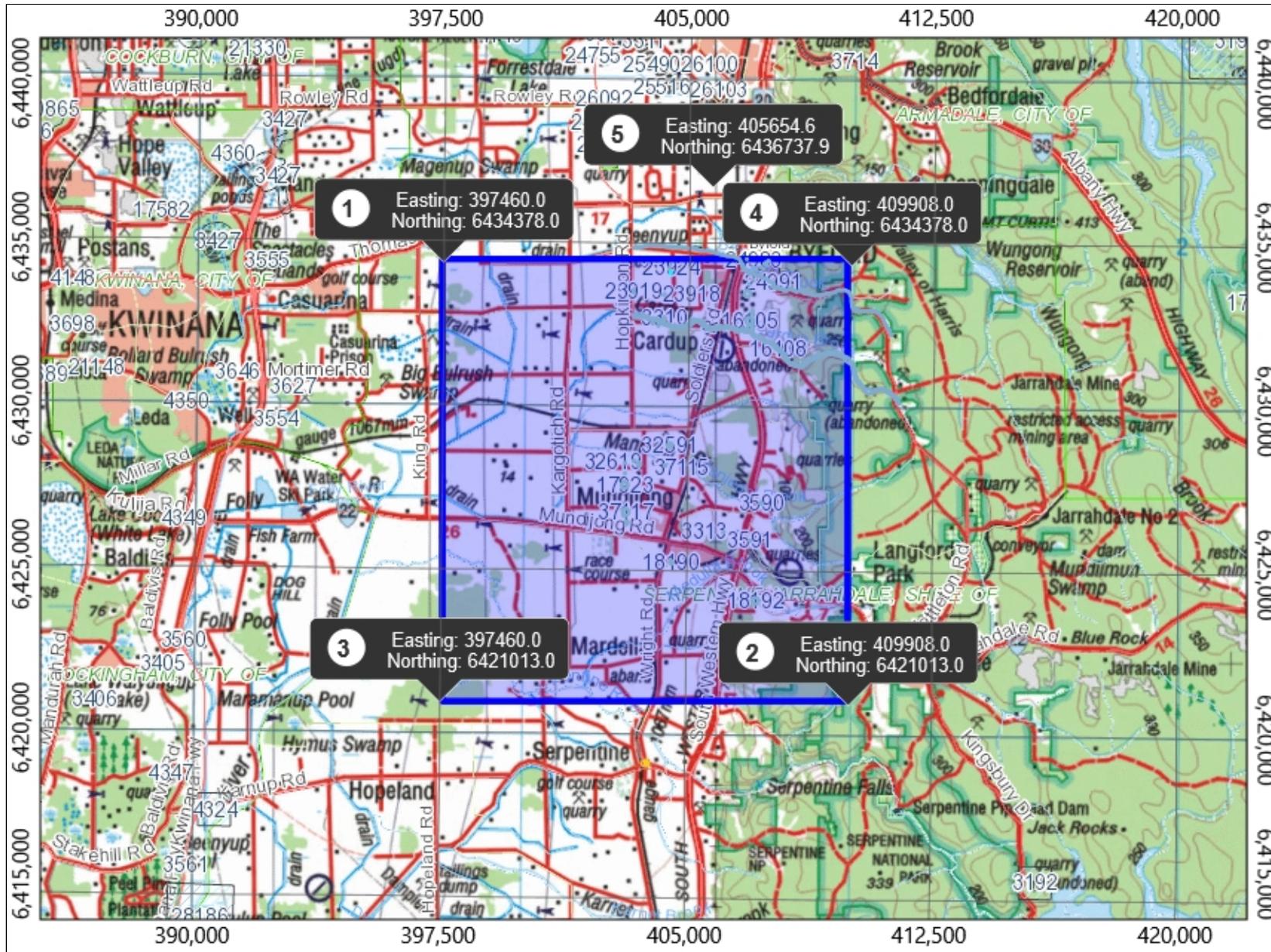
ID	Name	Other Restrict	Boundary Restrict	Restrictions	Status	Category	Notes	Coordinates	Area	
3310	ARD P	No	No	No other Restrictions	Registered Data Not available	Artefacts	atter a p	Registered no led e older na es a aila le fro DAA	404190 6432718 N one 50 nrelia le	00206
3313	ND N	No	No	No other Restrictions	Registered	Artefacts	atter a p	Registered no led e older na es a aila le fro DAA	406065 6426234 N one 50 nrelia le	00209
3590	W B	No	No	No other Restrictions	Registered	Artefacts	atter	Registered no led e older na es a aila le fro DAA	407195 6427120 N one 50 nrelia le	02416
3591	ARRABA	No	No	No other Restrictions	Registered	Artefacts	atter	Registered no led e older na es a aila le fro DAA	406870 6425980 N one 50 nrelia le	02417
16093	B RD 05	No	No	No other Restrictions	Registered Data Not available	Artefacts	atter	Registered no led e older na es a aila le fro DAA	406878 6432931 N one 50 Relia le	
16098	B RD 10	No	No	No other Restrictions	Registered Data Not available	Artefacts	atter	Registered no led e older na es a aila le fro DAA	406729 6433489 N one 50 nrelia le	
16103	B RD 15	No	No	No other Restrictions	Registered Data Not available	Artefacts	atter	Registered no led e older na es a aila le fro DAA	406819 6432419 N one 50 nrelia le	
16105	B RD 17	No	No	No other Restrictions	Registered Data Not available	Artefacts	atter	Registered no led e older na es a aila le fro DAA	406789 6432669 N one 50 nrelia le	
16106	B RD 18	No	No	No other Restrictions	Registered Data Not available	Artefacts	atter	Registered no led e older na es a aila le fro DAA	406893 6432675 N one 50 Relia le	
16107	B RD 19	No	No	No other Restrictions	Registered Data Not available	Artefacts	atter	Registered no led e older na es a aila le fro DAA	406911 6432560 N one 50 Relia le	
16108	ARD P BR	No	No	No other Restrictions	Registered Data Not available		t olo i al	Registered no led e older na es a aila le fro DAA	407530 6431805 N one 50 Relia le	
17923	2	No	No	No other Restrictions	Registered Data Not available	Artefacts	atter	Registered no led e older na es a aila le fro DAA	403038 6427638 N one 50 Relia le	

D	Name	File Restrict	Boundary Restrict	Restrictions	Status	Property	Notes	Registered	Coordinates	EA D
18189	on in i a - ndijon road s atter 13	No	No	No ender Restri tions	tored Data Not a ite	Artefa ts atter		Re istered no led e older na es a aila le fro DAA	403043 6427990 N one 50 Relia le	
18190	on in i a - ndijon Road atter 14	No	No	No ender Restri tions	tored Data Not a ite	Artefa ts atter		Re istered no led e older na es a aila le fro DAA	404475 6425300 N one 50 Relia le	
18192	on in i a - ndijon road s atter 16	No	No	No ender Restri tions	tored Data Not a ite	Artefa ts atter		Re istered no led e older na es a aila le fro DAA	407050 6424150 N one 50 Relia le	
21305	B ford Villa e solated inds	No	No	No ender Restri tions	tored Data Not a ite	Artefa ts atter t er lti ple solated inds		Re istered no led e older na es a aila le fro DAA	406780 6433772 N one 50 nrelia le	
23914	B ford Ar aeolo i al r e 001	No	No	No ender Restri tions	tored Data Not a ite	Artefa ts atter odified ree		Re istered no led e older na es a aila le fro DAA	405373 6432652 N one 50 Relia le	
23915	B ford Ar aeolo i al r e 002	No	No	No ender Restri tions	tored Data Not a ite	Artefa ts atter		Re istered no led e older na es a aila le fro DAA	404363 6432537 N one 50 Relia le	
23916	B ford Ar aeolo i al r e 003	No	No	No ender Restri tions	tored Data Not a ite	Artefa ts atter		Re istered no led e older na es a aila le fro DAA	403847 6432559 N one 50 Relia le	
23918	B ford Ar aeolo i al r e 005	No	No	No ender Restri tions	tored Data Not a ite	Artefa ts atter		Re istered no led e older na es a aila le fro DAA	404185 6433441 N one 50 Relia le	
23919	B ford Ar aeolo i al r e 006	No	No	No ender Restri tions	od ed	Artefa ts atter		Re istered no led e older na es a aila le fro DAA	403254 6433533 N one 50 Relia le	
23920	BA - 001	No	No	No ender Restri tions	tored Data Not a ite	Artefa ts atter		Re istered no led e older na es a aila le fro DAA	404022 6432479 N one 50 Relia le	
23921	BA - 002	No	No	No ender Restri tions	tored Data Not a ite	Artefa ts atter		Re istered no led e older na es a aila le fro DAA	404809 6432444 N one 50 Relia le	
23922	BA - 003	No	No	No ender Restri tions	tored Data Not a ite	Artefa ts atter		Re istered no led e older na es a aila le fro DAA	404364 6434301 N one 50 Relia le	



ID	Name	Heritage Listed	Boundary Listed	Restrictions	Status	Category	Notes	Coordinates	Address
23923	BA - 004	No	No	No Hered Restrictions	Heritage Data Not available			Registered heritage place from DAA	404343 6434232 N one 50 Relia le
23924	BA - 005	No	No	No Hered Restrictions	Heritage Data Not available	Artefacts	Heritage	Registered heritage place from DAA	404386 6434106 N one 50 Relia le
23925	BA - 006	No	No	No Hered Restrictions	Heritage Data Not available	Artefacts	Heritage	Registered heritage place from DAA	404377 6434111 N one 50 Relia le
24979	Nettleton Road 19-09-07 001	No	No	No Hered Restrictions	Heritage Data Not available	Artefacts	Heritage	Registered heritage place from DAA	406625 6434289 N one 50 Relia le
24980	Nettleton Road 19-09-07 002	No	No	No Hered Restrictions	Heritage Data Not available	Artefacts	Heritage	Registered heritage place from DAA	406896 6433922 N one 50 Relia le
24981	Nettleton Road 19-09-07 003	No	No	No Hered Restrictions	Heritage Data Not available	Artefacts	Heritage	Registered heritage place from DAA	406992 6434247 N one 50 Relia le
24982	Nettleton Road isolated inds	No	No	No Hered Restrictions	Heritage Data Not available	Artefacts	Heritage	Registered heritage place from DAA	406980 6434342 N one 50 Relia le
24983	Nettleton Road 1-06	No	No	No Hered Restrictions	Heritage Data Not available	Artefacts	Heritage	Registered heritage place from DAA	406895 6434284 N one 50 Relia le
24984	Nettleton Road 2-06	No	No	No Hered Restrictions	Heritage Data Not available	Artefacts	Heritage	Registered heritage place from DAA	407280 6434370 N one 50 Relia le
24985	Nettleton Road 3-06	No	No	No Hered Restrictions	Heritage Data Not available	Artefacts	Heritage	Registered heritage place from DAA	407357 6434486 N one 50 Relia le
24991	Beenup Brook	No	No	No Hered Restrictions	Heritage Data Not available	Historical Natural Feature		Registered heritage place from DAA	407501 6433928 N one 50 Relia le
32591	-01	No	No	No Hered Restrictions	Heritage Data Not available	Artefacts	Heritage Deposit	Registered heritage place from DAA	404402 6428854 N one 50 Relia le

ID	Name	Other Restricted	Boundary Restricted	Restrictions	Status	Category	Registered	Coordinates	Address
32615	-04	No	No	No other Restrictions	Registered Data Not a site	Artefacts after Ar Deposit	Registered no other names from DAA	403317 6428377	None 50 Reliance
32616	-03	No	No	No other Restrictions	Registered	Artefacts after Ar Deposit	Registered no other names from DAA	403046 6428302	None 50 Reliance
32617	-06	No	No	No other Restrictions	Registered	Artefacts after Ar Deposit	Registered no other names from DAA	403112 6426496	None 50 Reliance
32619	-02	No	No	No other Restrictions	Registered Data Not a site	Artefacts after Ar Deposit	Registered no other names from DAA	403470 6428279	None 50 Reliance
37115	-09	No	No		Registered		Registered no other names from DAA	404263 6428245	None 50 Reliance
37117	-07	No	No		Registered		Registered no other names from DAA	403071 6426813	None 50 Reliance



- Legend
- Other Heritage Place
 - Search Area
 - Town
 - Road
 - River
 - Local Government Authority

Scale: 1:69,500

Map Date: 1/21/2000

Scale: 1:69,500



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Appendix 4 – Site type definitions

Artefact scatter

An artefact scatter is a place where human activity is identifiable by the presence of portable object(s) (e.g., stone, glass, bone, shell) utilised or modified by Aboriginal people in relation to traditional cultural life past or present.

Background scatter

The number of isolated artefacts (see definition below) recorded in a given area is used to calculate the density of the background scatter. To calculate the estimated density of the background scatter, the following formula is used:

$$B = N/A1$$

B: estimated background scatter density (expressed as number of artefacts/km² and m²)

N: number of artefacts observed

A1: is estimated area viewed (see below).

A variety of factors can affect the survey intensity including visibility of the ground surface, limit of peripheral vision, width of transects etc. To account for these factors, the following formula is commonly used to determine the estimate the of area viewed (also known as survey intensity). (After Hiscock 1988: 73-79).

$$A1 = LxWxV$$

A1: estimated area viewed

L: length of the survey area

W: width of the area inspected (such as the width of the transect)

V: percentage of ground surface visible

Burial

(skeletal material)

A place where Aboriginal skeletal material is buried and/or where mortuary practices occurred. DPLH require at least one of the following pieces of evidence to establish that the reported place is of Aboriginal origin:

- Aboriginal skeletal material is visible;
- Aboriginal mortuary/burial markers and or ethnographic evidence about the burial/skeletal material.

Engraving

A motif (either figurative or non-figurative) on a rock surface produced by percussion or abrasion. Engravings are also often referred to as petroglyphs.

Gnamma hole

A natural or artificial rock cavity which holds water after rain or is linked to the water table. May or may not include a cap stone.

Grinding material

Grinding patches or grooves are smoothed areas or grooves on rock surfaces (non-portable) that have been created by grinding activity associated with food production such as seed milling, preparation of pigments, tool

manufacture and/or maintenance and ritual.

Historical

A place that has historical associations with Aboriginal people and may or may not contain physical evidence of those associations.

Isolated artefact

Artefact(s) that are not of sufficient density or number to be determined a site.

Midden

A place where there is an accumulation of shell refuse that is derived from exploitation of a mollusc resource by Aboriginal people. Such sites may also contain artefacts, fireplaces, burnt shell and bones. Natural events (e.g. storms) may result in the formation of "midden like" features. Such features are distinguishable from middens by their lack of artefactual material, burnt shell or their composition being of non-edible mollusc species. Therefore, DPLH require at least two of the following pieces of evidence to establish that the accumulation of shells is of Aboriginal origin:

- presence of charcoal, burnt wood, blackened shells, hearths;
- presence of bones of other edible species;
- presence of artefactual material;
- presence of layers indicating cultural rather than natural deposition;
- evidence that the shell fish have been exploited by human beings, e.g., broken open backs, edible size;
- demonstrable selection of edible, mature, shell fish species;
- ethnographic and/or historical evidence related to the accumulated shell refuse.

Modified tree

One or more tree(s), living or dead, which has been modified by Aboriginal people by removing the bark or wood resulting in the formation of a scar. This sort of modification was and is frequently done for the making of implements, tools or other materials that were used in traditional cultural practices. DPLH require at least two of the following pieces of evidence to establish that a scar is of Aboriginal origin:

- the scarred tree is an indigenous species and a mature individual;
- the scar base normally begins above ground level;
- the scar is roughly parallel-sided and fairly symmetrical in its overall shape;
- the bark regrowth is generally regular;
- the scar terminations are either squared off or pointed as a result of bark regrowth;
- axe marks are present;
- suspected toe holes are arranged in a usable pattern.

PAD (Potential archaeological deposit)	An accumulation of cultural material and sediment deposited over time.
Painting	Places where Aboriginal people have painted on surfaces. Paintings (including daubings, drawings, stencils, prints) can be figurative or non-figurative markings or motifs on surfaces such as rocks, rock walls and trees at fixed locations that are produced by adding pigments and or mediums, such as ochre, blood, beeswax, animal fats, vegetable dyes, tree saps.
Quarry	Places where there is evidence for the extraction of stone or ochre. DPLH require at least two of the following pieces of evidence to establish that a natural occurrence of raw material has been used as a quarry: <ul style="list-style-type: none"> • evidence for the removal of material/modified surfaces in the form of negative scarring, crushing, areas of excavation etc; • presence of implements used during extraction (e.g. hammer stones, fire-hardened sticks) at the source; • evidence of flaking and reduction of the stone material at the source. • presence of partially-worked material at the source; • ethnographic evidence relating to the extraction of raw material at the source.
Reduction area	Reduction area refers to a cluster of stone artefacts which represent the remains of the flaking of a core. Artefacts within a reduction area can usually be conjoined back together.
Repository/cache	A place where cultural or utilitarian objects are/were taken or stored by Aboriginal people, either past or present.
Rock shelter	A place recognisable as a cave or overhang that may have been utilised by Aboriginal people.
Structure	The placement or arrangement by Aboriginal people of stone, wood or other material made into a structure for ceremonial or utilitarian purposes.
Water source	A source of water, with ethnographic evidence of its use or modification for use by Aboriginal people in connection with traditional cultural life past or present.

Appendix 5 – Artefact identification and recording

Flaked artefact identification

Flaked stone is identified on the basis of the presence of one or more of the following features (see Plate 27 and Plate 28):

- a positive or negative ring crack;
- a distinct negative or positive bulb of percussion or force;
- a definite e-raillure scar beneath a striking platform;
- definite remnants of flake scars (e.g. dorsal scars and ridges);
- fracture termination.

Stone not exhibiting these features is regarded as **not** artefactual.

Plate 27. Features of the ventral surface of a flake produced through conchoidal fracture (Holdaway and Stern 2004:1.3.1)

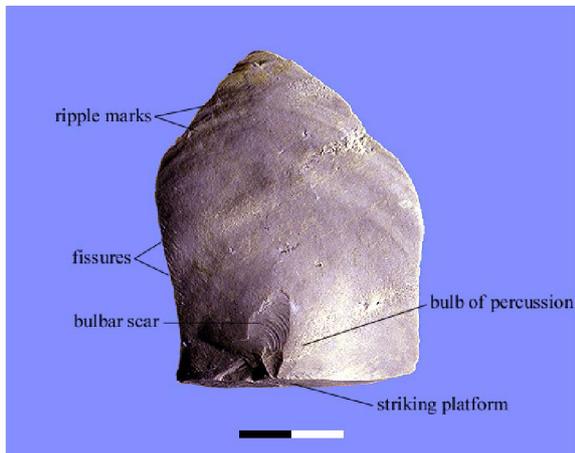


Plate 28. Features of the dorsal surface of a flake produced through conchoidal fracture (Holdaway and Stern 2004:1.3.1)



Flaked stone artefacts are classified into four types:

- flakes – exhibiting one positive ventral surface or part thereof;
- retouched flakes – containing negative flake scars created after the formation of the ventral surface;
- cores – contains one or more negative flake scars and no positive flake surfaces; and
- flaked pieces – items that cannot be placed unambiguously into one of the three above categories.

Flakes are characterised into four subcategories including complete flakes, longitudinally broken, transversely broken and flake fragments.

Artefact recording

For artefacts located within sites, artefact recording consisted of an avoidance level characterisation where type and lithology were recorded. For isolated artefacts, a full metrical recording was undertaken. The following attributes were recorded for each isolated artefact located.

Flakes

- Raw material
- thickness
- number of scars present on the dorsal surface
- colour
- termination type
- presence of retouch
- completeness
- platform type
- number of retouch scars
- length
- platform width
- length and invasiveness of retouch
- width
- platform thickness
- use wear presence/absence and location
- technological type (core, retouched flake, flake and parts thereof)
- presence/absence of platform preparation (faceting, overhang removal)

Cores:

- Raw material
- colour
- type (based on number of platforms),
- quantification of flake scars and platform characteristics

Artefact Metric Measurements**Flakes:**

Length Distance along the percussion axis from the ring crack to the distal margin.

Width Distance between the lateral margins measured at right angles to the percussion axis half way between the ring crack and distal margin.

Thickness Maximum distance between the ventral and dorsal surface of the flake half way between the ring crack and the distal margin.

Platform Width Distance along the striking platform from one lateral margin to the other.

Platform Thickness Distance across the striking platform from the centre of the ring crack to the dorsal surface.

Platform Type Type of platform may be one of the following:

- Flat – platform where it is not possible to determine whether it has a partial single flake scar, or if it has been heat fractured
- Flaked – striking platform formed by one flake scar
- Faceted – striking platform has a number of flake scars resulting from rotation of the core
- Cortical – unmodified platform consisting entirely of the outer surface of the parent rock
- Crushed – the proximal end of the flake is constituted by a sharp edge lacking a distinct platform

Dorsal Flake Scars Number of flakes taken off the dorsal side during production.

Cortex%	The amount of cortex (chemical or mechanical weathered surface on rocks) on the dorsal side of a flake.
Overhang Removal	Presence/absence of overhand removal, small flakes are removed from the edge of the platform.
Retouch/Utilisation	Presence/absence of edge modification by the removal of small flakes. Both the length of retouch and location on the artefact is recorded.
Termination types	The type of termination may be one of the following: <ul style="list-style-type: none"> • Feather – straight to the bottom of the flake with no deviation • Hinge – closing bend towards nearest free surface • Step – angled change of direction towards nearest free surface • Outré passé – plunging backwards towards the other side of the core
Weight	<ul style="list-style-type: none"> • Weight in grams to nearest 0.1g

Cores:

Length	Size recorded along maximum dimensions.
Width	Size perpendicular to length.
Thickness	Size measured at 90° to both the width and the length.
# Platforms	Count number of platforms on the core.
Flake Scars	Total number, length and width of flake scars present on the core.
% Cortex	The amount of cortex (chemical or mechanical weathered surface on rocks) on the core.
Retouch/utilisation	Presence/absence of edge modification by the removal of small flakes.
Weight	Weight in grams to nearest 0.1g

Artefact recording acronyms

The following acronyms are used for recording artefact type and lithology:

CF	Complete flake	DOL	Dolerite
FF	Flake fragment	BAS	Basalt
LBF	Longitudinally broken flake	CL	Chalcedony
TBF	Transversely broken flake	SIL	Silcrete
RUF	Retouched/utilised flake	WQ	White quartz
RUP	Retouch/utilised piece	QZT	Quartzite
BL	Blade	CQ	Crystal quartz

DB	Debris	PQ	Pink quartz
GS	Grindstone	BQ	Brown quartz
MS	Millstone	YQ	Yellow quartz
SPC	Single-platform core	SQ	Smokey quartz
MPC	Multiple-platform core	LAT	Laterite
MANU	Manuport	SCH	Schist
CH	Chert	GR	Granite
BIF	Banded Ironstone Formation		

Ground stone artefacts

Ground stone artefacts can be classified into four categories including mullers, millstones, grindstones, pestles and mortars. Full descriptions of these artefact types are included in Appendix 5. The following attributes were recorded for isolated ground material.

Length	Size recorded along maximum dimensions.
Width	Size perpendicular to length.
Thickness	Size measured at 90° to both the width and the length.
# Ground surfaces	Number of surfaces with ground patches.
Dimensions of ground surfaces	Length and width of all ground surfaces/patches.
Presence and type of any modification	E.g. pitting or hammer dressing to shape the artefact.

Other stone artefacts

Other stone artefacts include manuports, anvils and hammer stones. Manuports are natural objects that have been transported but not necessarily flaked or modified. Anvils comprise blocks or slabs of rock that have been used to support hammering of other objects and will exhibit pitting or indentations from these objects being struck. Hammer stones are usually round or ovoid rocks used to strike flakes off a core. Hammer stones usually have pitting on one or more surfaces from the percussion of other rock. The following attributes are generally recorded for manuports, anvils, shell or hammer stones.

Length	Size recorded along maximum dimensions.
Width	Size perpendicular to length.
Thickness	Size measured at 90° to both the width and the length.
Modifications	Description of any modifications, e.g. pitting, indentations, or hammer dressing to shape artefact, plus the location and extent of each modification.

Modified trees

Modified trees are trees that have been scarred by people through the removal of bark. Scars made by people tend to be regular in shape, located above ground level and will often show evidence of axe marks (Burke and Smith 2004: 226-227). The following attributes are generally recorded for modified trees:

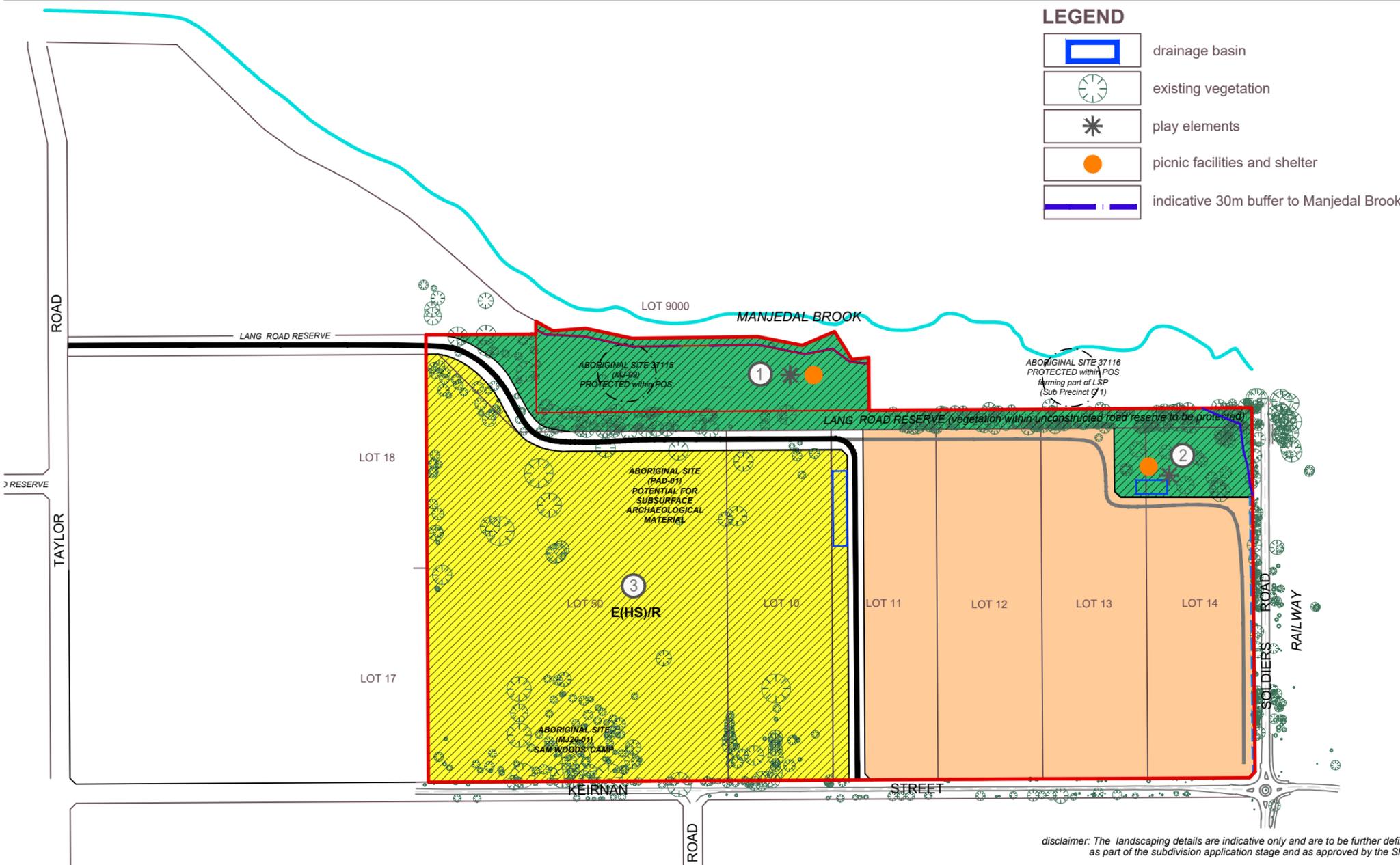
Type of tree	Tree species
Height of tree	Used to calculate the extent of the root system and therefore the boundary of the site.
Girth of tree	How wide the tree is around the middle.
# scars/modifications	Number of scars in the tree.
Type of scar	E.g. containers, canoes, access to honey.
General location of scar	General location of scar or modification on the tree
Height of scar	Height from base of tree.
Scar orientation and aspect	Direction of longest axis of each scar and compass bearing/direction scar is facing.
Scar shape	E.g. round, elongated, oval, irregular.
Degree of scar	How much bark has been removed
Scar dimensions	<ul style="list-style-type: none"> • length – maximum vertical dimension of scar • width – maximum horizontal dimension of scar • depth – distance between inner exposed wood and outer bark
Regrowth	Extent and depth of regrowth.
Implement	Type of implement used to create the scar or modification, e.g. evidence of stone axe or metal axe, where determinable.
Carvings	Presence and description of any carvings.

ANNEXURE 10

Landscape Master Plan

LANDSCAPING DESIGN PRINCIPLES

- This Landscaping Master Plan provides the overarching design principles for the development of the public open space areas and streetscapes within the Local Structure Plan (LSP) area. These design principles are to be further developed in the detailed Landscaping Management Plans to be prepared and approved by the Shire, at subdivision stage for each respective stage of development.
- The LSP design provides a balance between conservation, active and passive recreational spaces for the use and enjoyment of the future community of this residential area.
- The main objective for the landscaping design of each open space area is to enhance and protect the distinctive rural (visual) historical landscape character and amenity of Mundijong.
- In order to achieve this vision, the detailed landscaping plans prepared at subdivision stage are to ensure existing vegetation is retained (where possible) particularly within street verges and along Manjedal Brook; and that the existing natural 'green' linkages within and extending along the road reserves of Soldiers Road and Lang Road are protected.
- Perimeter roads bounding all areas of the proposed recreational reservations are necessary to ensure sufficient separation distance to vegetation, for the purposes of bushfire management.
- Landscaping within the areas of POS are to be selected with reference to the plant species identified in the Shire's *Low Flammability Local Native Species*.
- Street trees are to be planted at a rate of one (1) tree per residential lot, where possible. The trees are to be placed central to the lot frontage and set back to allow for crossovers, utility services including street lighting, and footpaths. The tree species are to be chosen from the Shire's preferred tree species list and will be identified in the site specific, detailed Landscape Management Plans, which are required to be prepared at the subdivision application stage and approved by the Shire.
- Tree planting specifications (including species and density) must take into consideration the assigned BAL rating for the nearby residential lots and ensure that the proposed landscaping will not result in any increase to the prescribed BAL rating.
- The drainage basins contained within POS #2 and POS #3 will contain planting suitable for seasonal inundation, e.g. reed and sedge species. While it is not expected that the basins will retain standing water during the summer months, it is likely that the soil profile will remain moist. As a result, the vegetation will not completely dry out and therefore, is classified as low threat vegetation.
- Footpath connections are to be provided internally within the recreational areas and will connect with the shared paths and footpaths along the internal road network.
- The method for rehabilitation of cleared areas and the control mechanisms for weeds, feral animals and plant disease are to be detailed in the Landscape Management Plans, at subdivision stage.
- Public access and the need to ensure the protection of the Aboriginal heritage sites within POS 1 and POS 3 shall be addressed, and management details included, in the site-specific Landscape Management Plans, at subdivision stage.



① MANJEDAL BROOK RESERVE

- A proposed open space reserve is to run along the length of the southern edge of the respective section of the Manjedal Brook and will include portion of the 30.0m buffer to the southern edge of the waterway channel, consistent with the LSP for Sub-Precinct G1 to the north of the Brook.
- The recorded Aboriginal Site (MJ-09) is a scarred tree, which is to be protected within the reserve. A 30.0 metre buffer around the tree to ensure its tree root system is protected.
- The Reserve is to retain remnant vegetation and will include revegetation with waterwise, native shrub species, to be determined as part of the detailed Landscape Management Plan for each respective stage of development, at subdivision application stage.
- Informal, irrigated grassed areas will be provided along the reserve, together with the integration of a footpath network to connect with the surrounding residential areas.
- Play elements will be provided within the POS area.
- There is also opportunity to provide for picnic facilities, including BBQ, seating and shelters.

② LOCAL PARK

- The design for the local park is to ensure retention of the remnant vegetation and to provide for passive recreational opportunities for local residents.
- The habitat trees within this POS area are to be protected for roosting opportunities for the black cockatoo and to provide for identify and a sense of place for the residential community.
- Landscaping is to comprise of native, waterwise shrubs, for low cost ongoing maintenance by the Shire.
- The park will comprise of informal grassed areas for passive and active recreational uses.
- The park will include play elements for children.
- There is opportunity for picnic facilities and shelter to be provided within this space.
- A drainage storage area is to be incorporated into the park and will be landscaped for recreational use.

③ DISTRICT PLAYING FIELDS

- The District Playing Fields are proposed to form part of a co-located reserve for the future High School.
- The High School and the Mundijong community are to share the facilities, ensuring maximum efficiency of the land and amenities provided.
- The development layout and design of the co-located facilities is to be determined by the Shire and the Department of Education, at the appropriate time for its development in the future.
- It is recognised that an Aboriginal Heritage site has been identified on Lot 50 as part of the Aboriginal Heritage Assessment undertaken in support of the LSP. The site is described as 'Sam Woods' Camp' (MJ20-01). An elevated sand dune (PAD-01) has also been identified on Lot 50 as having moderate potential to contain subsurface archaeological material.
- As part of the future design process to be undertaken by the Department of Education and the Shire, further detailed recording and assessment will be required of Lot 50. This assessment should include recording of oral histories, detailed surface recording, assessment of artefacts, and subsurface test excavations.

- The Department of Education in collaboration with the Shire will be required to obtain Ministerial consent under section 18 of the Aboriginal Heritage Act prior to any development on the shared Reserve.
- The Aboriginal consultants have requested that the Sam Woods' Camp be preserved or at least commemorated in some form, for example, with interpretive signage. Further, that the site could be integrated into the High School and Playing Fields Reserve to provide a useful role in teaching the children about the Aboriginal history of the Mundijong Area.
- As part of the future design, the Playing Fields will be required to be oriented 15° east of north and have a minimum area (per field) of 205m x 175m (3.587ha each) and will accord with the requirements of the Shire's Community Infrastructure and Public Open Space Strategy (2017).
- It is also noted that a drainage basin is provided along the eastern side of the Reserve, which basin forms part of the water management strategy for the residential development on Lots 11 to 14. This portion of land is to be set aside and developed to a suitable standard to allow for its seamless incorporation into the future Reserve.

LANDSCAPE MASTER PLAN

Keirnan Street, Mundijong (Sub-Precinct G2)
DJM MUNDIJONG PTY LTD

1:5000 @ A3/P2284-24LMP/03.08.2020

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ANNEXURE 11
Transport Impact Assessment
Transcore

PREPARED FOR:

March 2020

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1.0 Summary

This Transport Impact Assessment has been prepared with respect to the proposed Local Structure Plan Sub-Precinct G2 (LSPG2) and subsequent subdivision of the land owned by DJM Mundijong Pty Ltd (DJMM) comprising Lots 11-14 Keirnan Street in Mundijong, Shire of Serpentine-Jarrahdale (subject site). The subject site is situated at the northwest corner of the existing Keirnan Street/Soldiers Road intersection. The site forms part of the Local Structure Plan prepared by Peter Webb and Associates which encompasses part of the area situated between Keirnan Street (south), Taylor Road (west), Soldiers Road (east) and Manjedal Brook (north). The subject site also forms part of the wider *Mundijong-Whitby District Structure Plan* which generally occupies land between Bishop Road and Mundijong Road and the future Tonkin Highway extension and South Western Highway.

The WAPC document *“Transport Impact Assessment Guidelines for Developments, Volume 3 – Subdivision (2016)”*, stipulates that a supporting Transport Impact Assessment is to be prepared for all subdivisions generating more than 100 vehicle trips in the peak hour as part of the planning process.

Accordingly, this Revised Transport Impact Assessment (RTIA) addresses the transport implications of the traffic generated within the LSPG2 area comprising the proposed residential subdivision yielding a total of 230 residential lots. The LSPG2 area also includes a future co-located public high school and associated District Playing Fields reserve (DPF).

This TIA includes estimation of traffic that would be generated by the proposed subdivision (and the Local Structure Plan) and the resultant traffic patterns on the surrounding road network. An assessment of the proposed subdivision access system and key local intersections has been undertaken to establish the capacity of the road infrastructure to accommodate the anticipated traffic flows. The TIA also provides recommendations for any traffic management measures that may be required to ensure satisfactory traffic operations.

2.0 Introduction

This Revised Transport Impact Assessment has been prepared by Transcore on behalf of DJMM with regard to the proposed LSP and subsequent subdivision of the land owned by DJMM comprising of Lots 11-14 Keirnan Street in Mundijong, Shire of Serpentine-Jarrahdale. Refer **Figure 1** for locality map.



Figure 1: Location of the Local Structure Plan Sub-Precinct G2 within the locality

The land owned by DJMM occupies an area of approximately 15.8ha at the northwest corner of the existing Soldiers Road/Paterson Street/Keirnan Street intersection. With the additional area included in the LSPG2 being the future public high school site and the associated DPF reservation, the respective section of the unconstructed Lang Road reserve and eastern portion of Lot 101 Lang Road, the total LSP area extends to about 36ha. The subject locality is rural in nature with some higher density residential zones to the south and east of the subject site.

The subject site is presently vacant rural land. There are no formal accesses to the subject site from the adjacent road network.

3.0 Development Proposal

The location of the subject site in its regional context within the *Metropolitan Region Scheme (MRS)* is illustrated in **Figure 2**.

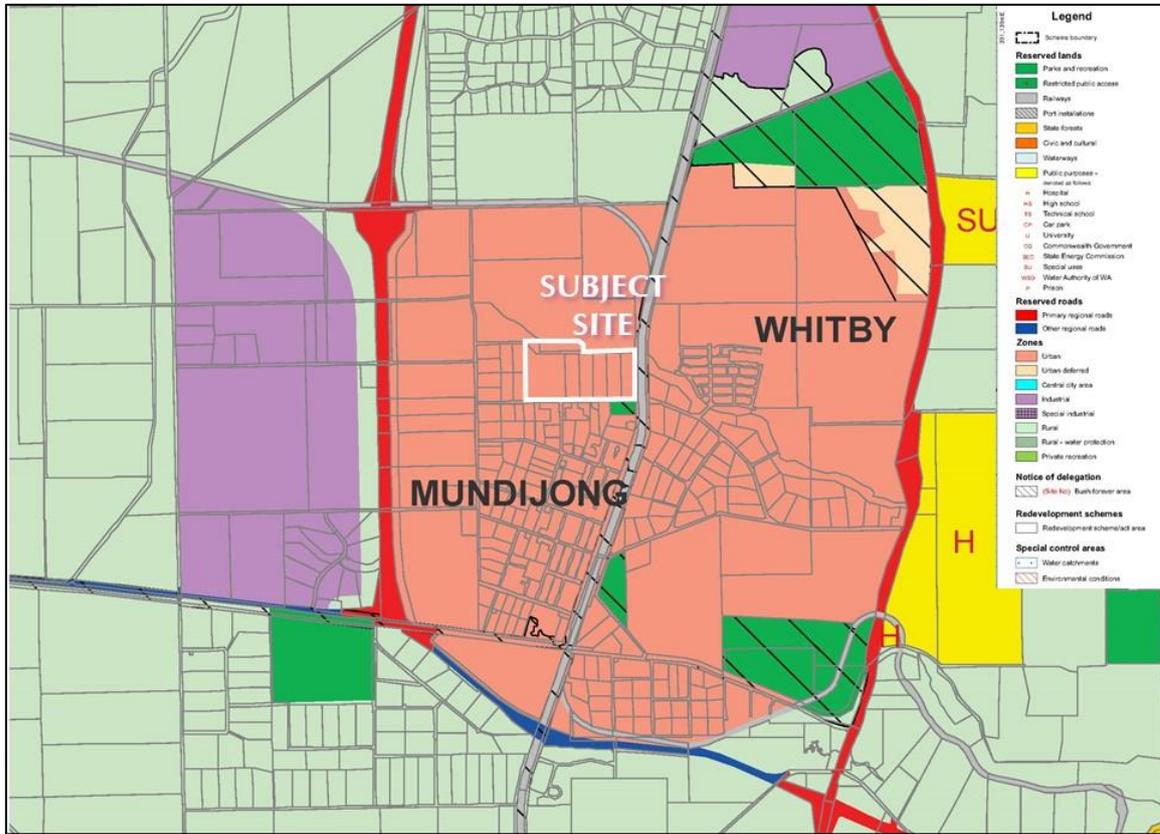


Figure 2: LSPG2 location within Metropolitan Region Scheme context

The subject site is zoned as “Urban” in the MRS. The MRS map identifies the alignment of the future “Primary Regional Road” Tonkin Highway extension which is planned to extend from current terminating intersection at Thomas Road further south to South Western Highway.

The subject site (LSPG2) occupies an area of approximately 36ha.

In addition to the residential development at Lots 11-14 the LSPG2 also comprises a public high school site with co-located district playing fields to the immediate west. Additional residential development, not included in the LSPG2, is contemplated west of the future high school site.

The LSPG2 contemplates creation of about 230 residential lots. Additional 470 lots are also contemplated to the west of the high school but do not form part of the LSPG2 proposal.

The proposed residential development's internal road system facilitates efficient and balanced distribution of traffic within the development. The internal road system for the LSPG2, which is conceptually illustrated in **Figure 4**, connects to external roads through two full-movement T-intersections on Keirnan Street. No direct access on Soldiers Road is proposed due to the protected vegetation (Bush Forever Site No. 350) within the reserve of Soldiers Road.

It is anticipated that the LSPG2 will be developed in stages starting from Lots 11-14 at the eastern end of the area with the high school and DPF reserve being part of Department of Education and Shire of Serpentine-Jarrahdale long-term planning for the locality and driven by the population demand.

Refer to **Appendix A** for the proposed LSP.

4.0 Existing Situation

The subject site occupies land at the northwest corner of the existing Keirnan Street/Soldiers Road intersection in Mundijong. The site is bound by Keirnan Street at the south, Soldiers Road at the east, Mandjedal Brook at the north (refer **Figure 1** for more details).

4.1 Existing Road Network

Soldiers Road, in the vicinity of subject site, is constructed as approximately 7.8m wide, single carriageway, two-lane road with kerb on eastern side and a wide gravel shoulder on the western side of the road. A 2.5m wide shared path is constructed along the eastern side of the road up to the rail tracks crossing of Soldiers Road (some 650m north of the site). South of Keirnan Street, Soldiers Road becomes Paterson Street. Along this section Paterson Street is a 7.2m wide single carriageway, two-lane kerbed road with a 2.5m shared path along eastern side.

The Main Roads WA *Perth Metropolitan Area – Functional Road Hierarchy* classifies Soldiers Road as a *Regional Distributor* road while Paterson Street is classified as a *Local Distributor*. Both roads are under the care and control of the Local Authority.

Soldiers Road entails a sign-posted speed limit of 80km/h while Paterson Street operates under 60km/h speed-limit regime.

Based on the latest available traffic counts sourced from the Shire Soldiers Road (300m south of Bishop Road) carried approximately 2,020vpd during the typical weekday in April 2015.

Keirnan Street provides an east-west connection between Mundijong and South Western Highway. In the immediate vicinity of the site and west of Soldiers Road/Paterson Street intersection, Keirnan Street is constructed as a 4.5-5.0m wide single-carriageway road with gravel shoulders. To the east of this intersection Keirnan Street is generally of 6.0m wide single-carriageway standard. There are no pedestrian or cyclist paths on either side of this road. The existing Keirnan Street rail crossing is planned to ultimately be closed.

Keirnan Street is classified as a *Local Distributor* road in the Main Roads WA *Perth Metropolitan Area – Functional Road Hierarchy*.

Keirnan Street operates under a default build-up area speed limit of 50km/h between Taylor Road and Soldiers Road/Paterson Street and changes to 60km/h and then to 70km/h east of this intersection.

Based on the latest available traffic counts for Keirnan Street sourced from the Shire this road carried approximately 280vpd (west of Baskerville) and 1,200vpd (east of Soldiers Road/Patterson Street) on a typical weekday in November 2016.

Taylor Road (road between Bishop Road and Lang Road) and **Adams Street** (road between Lang Road and Richardson Street) are both typical single carriageway rural roads with approximately 6.5m and 7.2m wide seal and wide shoulders with no paths. Adams Street is kerbed along one side at the northern end and on both sides further to the south.

Both roads are classified as a *Local Distributor* road in the *Main Roads WA Perth Metropolitan Area – Functional Road Hierarchy*.

Taylor Road operates under a speed limit regime of 80km/h while Adams Street operates under 70km/h speed limit regime.

Based on the latest available traffic counts made available by the Shire, Taylor Road (150m north of Keirnan Street) carried approximately 1,110vpd during the typical weekday in November 2016. Adams Street (150m south of Keirnan Street) carried about 870vpd during the typical weekday in July 2016.

Taylor Road, Adams Street and Keirnan Street form a simple, priority-controlled T-intersection a short distance west of the site.

Keirnan Street forms a four-way, single-lane roundabout with Soldiers Road and Paterson Street at the southeast corner of the subject site.

Main Roads WA *Intersection Crash Ranking Report* provides detailed crash data for Soldiers Road/Paterson Street/Keirnan Street intersection over the 5-year period ending 31 December 2017. Detailed crash report information for this intersection is presented in **Table 1**. No crashes were recorded for the Keirnan Street/Taylor Street/Adams Street intersection.

Table 1. Crash history for the Soldiers Road/Paterson Street/Keirnan Street intersection

Intersection				Total Crashes	Casualty
Soldiers Road/Paterson Street/Keirnan Street				1	1
Rear End	Hit Object	Pedestrian	Cycle	Wet	Night
0	1	0	0	1	0

4.2 Public Transport Access

At present, the subject locality is served by two bus services operating along Soldiers Road/Paterson Street with bus stops immediately south of the Keirnan Street roundabout. Both 252 and 253 routes provide connection to Armadale Station passing through Byford town centre and connecting to Mundijong town centre (route 252) and Jarrahdale (route 253). Refer **Figure 3**. Both routes are generally operating in 1-2hour slots between 7AM and 6PM with additional services on routes deviating via local schools.

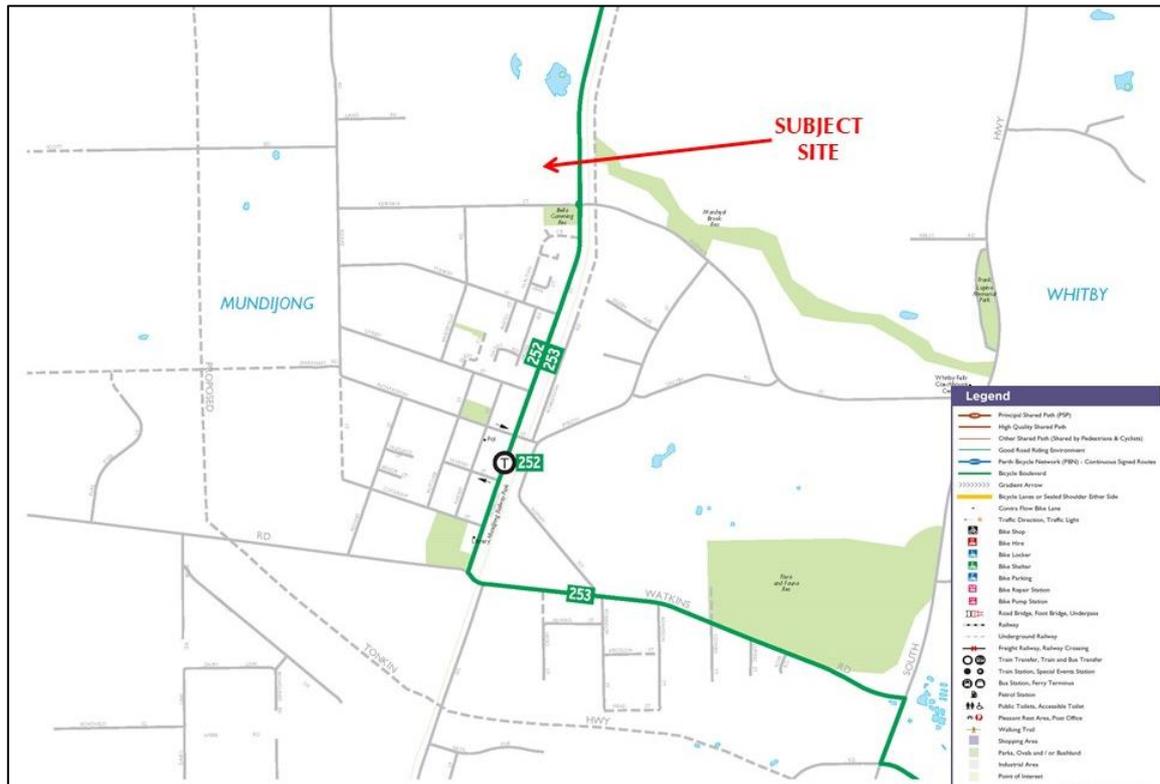


Figure 3: Existing bus routes (source: Transperth)

4.3 Pedestrian and Cyclist Facilities

The subject locality is rural in nature and as such limited pedestrian and cyclist facilities are generally provided within the locality. There are no formal pedestrian or cyclist facilities provided on Keirnan Street, Taylor Road and Adams Street in the vicinity of the subject site; however, a semi-formal track has recently been put in place along the northern side of Keirnan Street (east of the railway line) up to the recently developed residential subdivision. There is a 3.0m wide shared path recently constructed along the east side of Soldiers Road/Paterson Street between Mundijong town centre and the point where rail line crosses Soldiers Road some 1km north of the Keirnan Street intersection.

4.4 Changes to Surrounding Road Network

Lang Road is at present only partially constructed extending about 350m east of Taylor Road. It serves as an access road for a private rural property. The LSPG2 includes the construction of Lang Road along its current reservation alignment until the point at which the vegetation within Lang Road becomes denser at which point the reserve is proposed to be shifted south to within the property boundaries to ensure the matures trees contained within the local road reserve of Lang Road are able to be retained and protected. This is illustrated in the LSPG2 map.

The existing level rail crossing at Keirnan Street is proposed to be closed as indicated in (draft) *Mundijong Structure Plan* adopted for the purpose of advertising in December 2018. A new crossing will be established approximately 1.2km to the

south through re-linking of Richardson Street and Evelyn Street. In addition, a new east-west road link connecting Taylor Road and South Western Highway with a grade separated rail crossing is also proposed to be constructed just south of Bishop Road.

5.0 Proposed Internal Transport Network

5.1 Road Hierarchy

Based on subdivision traffic projections and in accordance with the WAPC “Liveable Neighbourhoods” guidelines, all internal subdivision roads can be classified as *Access Street B* (wider streets), *Access Street D* (narrow yield) and *Laneways*. Refer **Figure 4** for more details. Some key characteristics of typical *Access Street D* cross-section, defined in WAPC *Liveable Neighbourhoods* (2009, Update 02) publication are outlined and discussed in more detail further in this section.

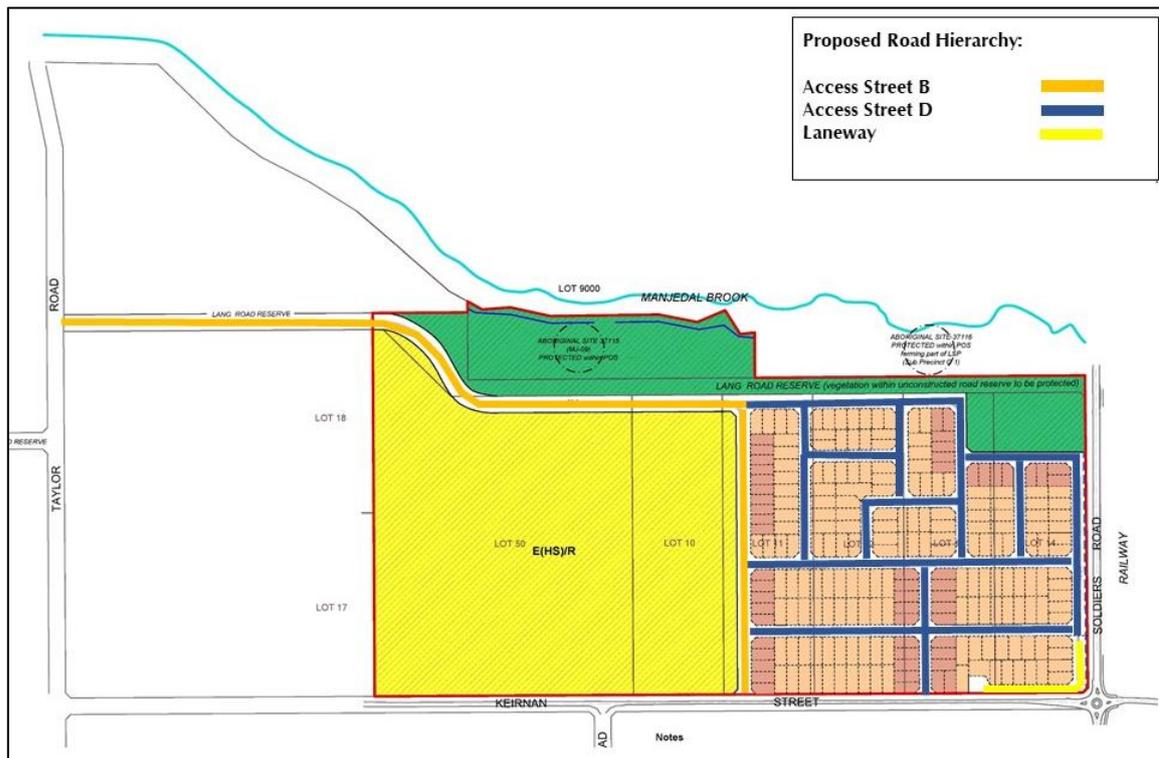


Figure 4. Proposed subdivision road hierarchy

The *Access Street B* (wider street) is a residential street projected to carry up to 3,000vpd and is common to areas with densities of R30-R40 and in areas with high parking activity (i.e. near schools) with target speed of 40km/h. This road is generally not intended to accommodate buses; however, occasional school bus traffic (i.e. hired coaches for special school events) could be accommodated if required, albeit not a regular public transport service. The final cross-section of *Access Street B* can be determined in the detailed design stages of the project.

The cross section of *Access Street B* provides for on-street parking which would be consistent with the anticipated high parking demand adjacent to the future public high school site. Accordingly, *Access Street B* is proposed to run along the school boundary including along the Lang Road reserve (east-west LSP spine road).

A typical road reserve of 17.9m with a carriageway width of 10.1m (trafficable carriageway + two parking lanes) is recommended by *Liveable Neighbourhoods* for an *Access Street B*. In this particular case a modified cross section is proposed to better suit the role and function (road bordering the High School site).

The road network bounding the High School and DPF Reserve is proposed with varying reservation widths. The road reserve to the north of the Reserve is proposed at a width of 20.0m while the road along the eastern boundary of the Reserve is proposed at a lesser width of 16.5m. The roads bounding the school and DPF site to the west and north, connecting to Taylor Road and Keirnan Street, are expected to accommodate the majority of school traffic including the traffic accessing recreational areas around Mandjedal Brook while the road along the eastern side is not anticipated to carry as much traffic. A 16.5m wide road reserve is considered suitable along the eastern side of the DPF reserve.

Accordingly, a trafficable carriageway width of 5.7m plus 2.1m wide on-street parking on both sides, a verge of 4.1m on residential side (with 1.5m footpath) and a 2.5m shared path (school side) for a total road reserve width of 16.5m is recommended in this case for the *Access Street B*. A 2.5m wide shared path should be in place along the entire school/reserve perimeter. The shared path on the western side of the road would facilitate safe access to school/DPF sites by cyclist which is particularly important for students arriving to school by bikes.

The proposed *Access Street B* cross-section allows for on-street parking on both sides of the road. Although it is expected that the future school and DPF will provide sufficient parking on-site to meet the demand the additional on-street parking along the northern and eastern perimeter roads could be also serve to address the potential car park over-flow in special circumstances.

Refer to **Figure 5** for the typical *Access Street B* cross section.

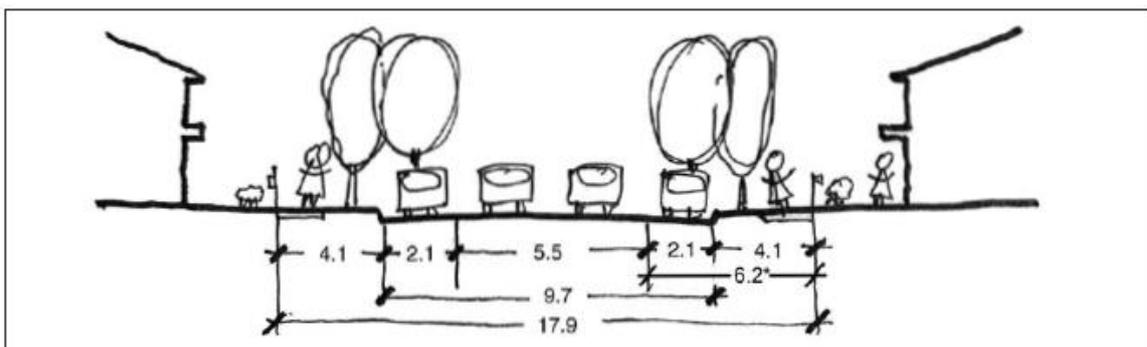


Figure 5. Access Street B (wider street) with target speed of 40 km/h (<3,000vpd)

The typical road reserve for *Access Street D (narrow yield)* in *Liveable Neighbourhoods* entails a road reserve width of 14.2m with 6.0m wide trafficable carriageway pavement and 4.1m wide verges on both sides. This type of street is recommended throughout the subdivision road network with exception of road sections along the P.O.S./Manjedal Brook reserve and Soldiers Road side.

If fronting P.O.S., access street verge adjacent to P.O.S. may be reduced. This is the case with the internal road running north-south along the southern edge of P.O.S. in the north-eastern corner of the site. In order to ensure the development within the LSP area is designed to address potential bushfire risk, the road reserve running along the northern edge of the residential area to the east of the High School and DPF Reserve is proposed to be 18.0m wide; and the road reserve running along the eastern edge of the LSP area adjacent to Soldiers Road is proposed to be 18.0m wide.

Maximum desirable daily traffic volume for this type of road is 1,000vpd. This threshold would only be exceeded along a short section of the westernmost LSP access road on Keirnan Street. The typical cross-section of the *Access Street D* sourced from "*Liveable Neighbourhoods*" is illustrated in **Figure 6**.

Visitor parking throughout the subdivision is recommended to be provided within the *Access Streets* verges.

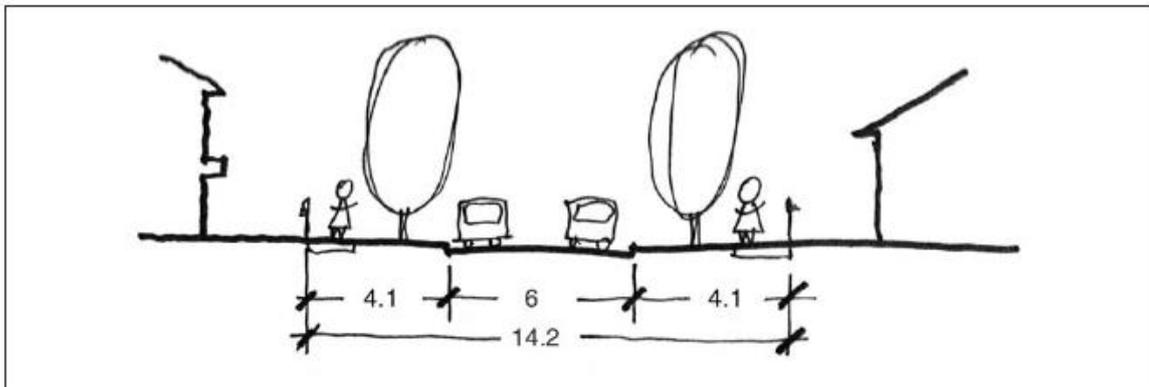


Figure 6. Access Street D (narrow yield) with target speed of 30 km/h (<1,000vpd)

The typical road reserve for *Laneways* entails a 6m wide trafficable pavement sufficient to allow two-way movements, rubbish collection and vehicle access into garages located on the rear of properties. Maximum desirable traffic volume for a laneway is 300vpd. The typical cross-section of the *Laneways* is illustrated in **Figure 7**.

The concept plan for the subdivision is designed to include a service lane (with a cul-de-sac end) to provide vehicular access to the section of lots fronting Keirnan Street at the south eastern corner of the LSP area. This service lane is provided for these lots to ensure safe movement of vehicles when entering and exiting the residential properties, without having to navigate traffic on Keirnan Street at this intersection. This service lane is proposed with a reserve width of 10.0m for the section of the lane which runs east-west, parallel to Keirnan Street. The section of the lane which runs north-south is proposed at an increased width of 18.0m to address potential bushfire risk.

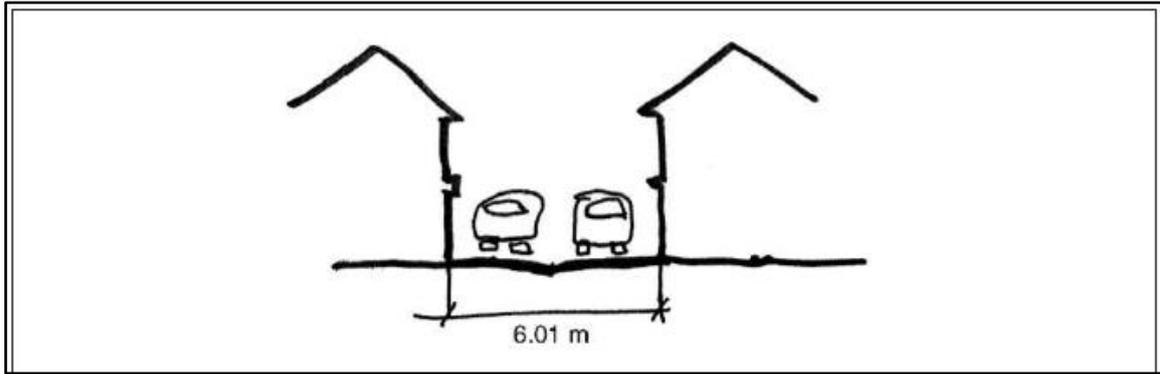


Figure 7. Laneways – for rear vehicle access with target speed of 15km/h (<300vpd)

5.2 Public Transport

The existing bus services at this locality are described in section 4.2 of this report.

The proposed residential development has some exposure to public transport opportunities and it is expected to remain so in foreseeable future.

It should be noted that once the missing pedestrian crossing facilities at Soldiers Road/Paterson Street/Keirnan Street roundabout are in place, along with the missing pedestrian path links, the existing bus services with their bus stops on Paterson Street would provide a relatively good coverage of LSP area. It is estimated that about 65% of the subject site lies within the 400m radius from the existing bus stops on San Jacinta Road.

5.3 Pedestrian and Cyclist Facilities

The existing pedestrian and cyclist facilities available at this locality are discussed in previous sections (refer section 4.3 for more details).

The proposed road system within the subdivision provides for a permeable and interconnected road network that creates opportunity for the provision of strong pedestrian links to the future school site and the future residential development west of the school. It is also designed to be consistent throughout the LSP area once fully developed.

Considering the level of forecast daily traffic volumes on the internal LSP roads provision of separate cyclist facilities in form of shared paths is not warranted. With maximum traffic volumes on busiest residential development roads of less than 1,000vpd it is reasonable to assume that cyclists and vehicles can safely share the road environment. Accordingly, pursuant to the provisions of Liveable Neighbourhoods footpaths on one side of *Access Street D* throughout the subdivision are recommended to cater for the anticipated pedestrian traffic demand.

Pedestrian paths on one and shared path on the other side of the road is however proposed on the *Access Street B* bounding the future High School site along the

eastern side due to anticipated higher-than-average pedestrian activity. Shared path is also proposed for roads bounding the school/DPF site along the north and west side as well. The shared path system around the school/DPF interfaces with the shared path proposed along Keirnan Street to form a comprehensive shared path system.

As mentioned, in addition to the internal path network, shared path along the southern boundary of LSP area is also proposed to connect to the existing shared path along Soldiers Road/Paterson Street at the east and to provide safe access to the future school and DPF sites to pedestrians and cyclists. Appropriate pedestrian crossing facilities should also be installed at the Soldiers Road/Paterson Street/Keirnan Street roundabout to facilitate safe crossing and links to the existing bus stops. **Figure 8** illustrates the proposed subdivision path network.



Figure 8. Proposed path network¹

¹ Residential lot and local street network indicative only

6.0 Integration with Surrounding Area

The proposed LSPG2 map is consistent with the planning framework for this locality including the approved *Mundijong – Whitby District Structure Plan* and the proposed revised *Mundijong District Structure Plan*, which is yet to proceed through the formal public consultation process.

The proposed subdivision road network makes provisions for interface with the future residential areas west of the future High School and DPF Reservation.

The proposed internal pedestrian and cyclist path network of the subdivision also contemplates connection to the existing regional shared path route along Soldiers Road/Paterson Street.

Based on the aforementioned district structure planning, a future neighbourhood centre (NC) and a district centre (DC) are proposed to be located off Bishop Road and off the future Bishop Road eastbound extension, about 800m to the northwest and northeast of the LSPG2 site. The existing Mundijong Townsite is located some 1.5km to the south of the site (refer **Figure 9** for more details). New train stations are also contemplated adjacent to DC and within the Mundijong Townsite.

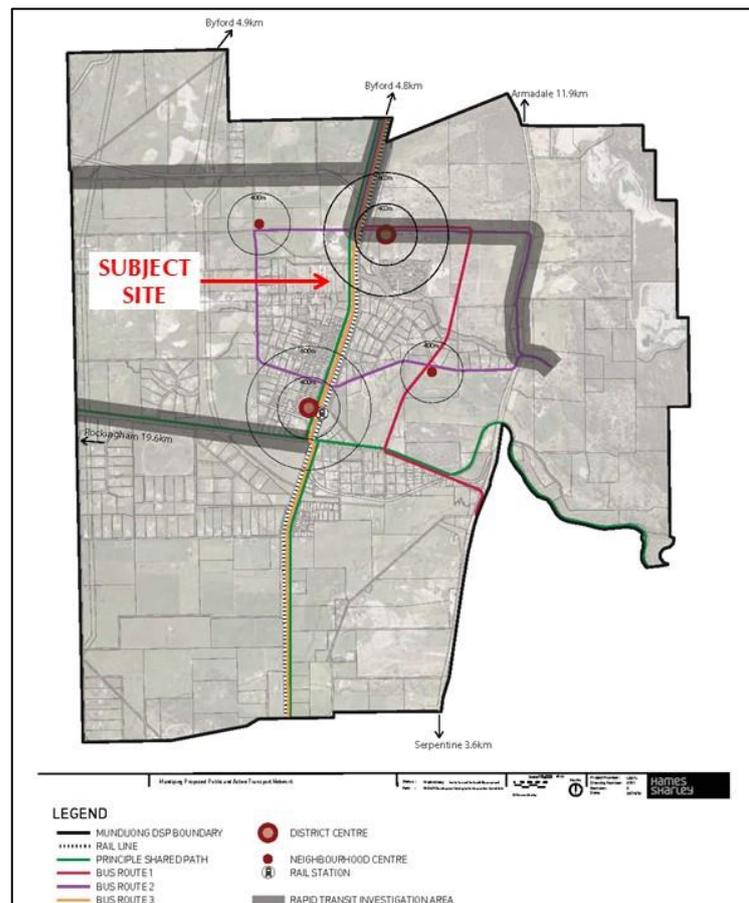


Figure 9. Mundijong DSP – Proposed Movement Network

Access to these existing and future activity nodes are available via Keirnan Street/Taylor Road/Bishop Road route (NC), Keirnan Street/Soldiers Road/(future) Bishop Road eastbound extension route (DC) and Keirnan Street/Soldiers Road/Paterson Street route (Mundijong Townsite). The planned Bishop Road extension would see Bishop Road extending east Soldiers Road for about 2km of and connecting to South Western Highway.

Limited information is available in a way of future pedestrian and cyclists links to these nodes at the district-level however the *Mundijong District Structure Plan*, recognises a need to facilitate a safe, accessible and interconnected pedestrian and cycle links between the residential areas and key destinations such as activity centres, schools, public transport stops and parks.

At present a shared path is in place along the eastern side of Soldiers Road/Patterson Street between the subject site and the Mundijong Townsite. The proposed new shared path along the northern (LSP) side of Keirnan Street will therefore facilitate direct pedestrian and cyclist link between the residential area and the future High School + DPF within the LSPG2 and the Mundijong Townsite.

Similarly, direct and legible pedestrian/cyclist link between the LSPG2 and the future DC could be established once the (proposed) Keirnan Street shared path is constructed and the missing northbound extension of the existing shared path along of Soldiers Road north of the site to the future DC is completed.

The shared path link from the LSPG2 to the future NC is reliant on the provision of a new shared path of about 1.5km in length along Taylor Road which would connect to the proposed shared path along Keirnan Street.

Accordingly, the proposed LSPG2 is well positioned to secure good vehicular and non-vehicular links to the future activity centres and public transport system facilities ensuring good integration into Mundijong District Structure Plan area.

7.0 Traffic Assessment

7.1 Assessment Period

The assessment year that has been adopted for this analysis is 2031. It is assumed that the entire LSP, including the school site, the DPF and the future residential area to the west of the school, will be fully built-out by this timeframe.

It is however recognised that the development of the school, DPF and the future residential area west of the school is a long-term plan as the development of these elements is subject to population growth reaching critical levels to create such demand. However, in order to future-proof the road network planning and design the traffic modelling allows for the development of the balance of LSP area.

Weekday morning (AM) and afternoon (PM) peak hours are typical peak traffic activity hours for the residential developments. Hence, typical weekday AM and PM peak periods are deemed appropriate for analysis of key roads and intersections in this assessment.

7.2 Trip Generation and Distribution

The daily traffic generation rate used for the proposed subdivision at Lots 11-14 as well as the balance of the LSP area is 8 vehicle trips per day (vpd) per dwelling (0.8 trips during peak AM and PM periods), which corresponds to peak hour trip generation rates recommended in the *WAPC Transport Impact Assessment Guidelines Volume 2 (August 2016)*. According to the relevant concept design for the residential portion of the LSPG2 area, this development is expected to yield 230 residential lots. Similarly, it is estimated that the future residential area west of high school and DPF site would yield approximately 470 residential lots.

Similarly, in line with the same WAPC document, school trip rate of 2 trips/student per day and 1 trip/student during peak hour was used to estimate the total daily and peak hour traffic generation. For the purpose of this assessment it is assumed that the school would at this stage enrol about 500 students.

Accordingly, Lots 11-14 subdivision is estimated to generate a total of approximately **1,850** total daily vehicular trips during a typical weekday (total of inbound plus outbound trips) with approximately **185** morning and afternoon peak hour trips.

The Shire of Serpentine-Jarrahdale has requested that the traffic assessment for the Lots 11-14 residential development also included the high school and DPF reserve. The assessment also included the area to the immediate west of LSPG2, being an area which has the potential to accommodate an additional 470 dwellings (subject to a separate LSP process being undertaken).

Accordingly, it is estimated that the entire LSP area would generate approximately **6,380** total daily vehicular trips during a typical weekday (inbound and outbound trips combined), with approximately **938** morning and **564** afternoon peak hour trips. It should be noted that afternoon peak hour trips associated with the school (typically 3:00-4:00PM) do not coincide with the afternoon residential peak hour (typically 4:00-5:00PM) and are therefore not forming part of the weekday afternoon assessment period.

It is estimated that about 18% of all home-based trips are “education trips” (i.e. school trips in this case), and as such this traffic forms part of the “internal” trips portion of all traffic. The school will primarily draw students from the LSP area and the area to the immediate west, if redeveloped for residential use, but will also have a significant portion of “external” traffic from the areas located outside of the immediate LSP zone.

The distribution and assignment of the subdivision-generated traffic was based on the local and regional road network layout, available access routes, key local and regional attraction nodes, distribution of residential areas (now and in future) and the actual location of the subject site. The proposed future closure of existing Keirnan Street rail crossing is also allowed for in the assumed distribution.

Accordingly, the following assumptions were made for the distribution and assignment of the generated traffic:

- + Approximately 18% of the traffic generated from the LSP would travel to/from the local public high school;
- + Approximately 35% of the traffic generated from the LSP would travel to/from the Soldiers Road direction;
- + Approximately 10% of the traffic generated from the LSP would travel to/from the Taylor Road direction;
- + Approximately 10% of the traffic generated from the LSP would travel to/from the Adams Street direction; and,
- + Approximately 27% of the traffic generated from the subdivision would travel to/from the Paterson Street south direction.

7.3 Traffic Flow Forecasts

The forecast daily traffic volumes on internal subdivision roads and key precinct road network around the project area is shown in **Figure 10**. The projected daily traffic flows include the traffic from the whole of LSP area, inclusive of the potential future residential development to the immediate west of high school and DPF including the external school traffic.

It should be noted that most internal *Access Street D* subdivision roads are forecast to carry daily traffic volumes significantly less than 1,000vpd with the only exception being a short section of easternmost LSPG2 access road on Keirnan Street which is forecast to carry close to 1,000vpd. *Access Street B* are also expected to carry

volumes of less than 1,000vpd with the exception of road section passing the school site along the northern boundary which would carry about 1,800vpd.



Figure 10. Daily traffic flow forecast for the LSPG2 area²

7.4 Internal Road and Intersection Analysis

The internal subdivision road network proposed to accommodate the projected traffic volumes, including the details of the proposed road hierarchy, have been detailed in section 5.1 of this transport assessment. The proposed road hierarchy provides sufficient capacity for the projected traffic volumes and is in line with the recommendations stipulated in the WAPC *Liveable Neighbourhoods (2009, Update 02)* document.

All but one internal subdivision intersections are designed as T-intersections and will therefore not require any specific traffic management measures due to relatively low traffic volumes and low speeds involved. It is recommended that all these intersections be designed as priority-controlled intersections.

The one four-way intersection is located centrally within the subdivision. Due to low traffic volumes expected to traverse this intersection, it is recommended to be designed in form of a priority-controlled intersection with the priority on major

² Conceptual subdivision layout

direction of traffic (i.e. north-south) and the threshold treatments on side road approaches, as shown in **Figure 11**.

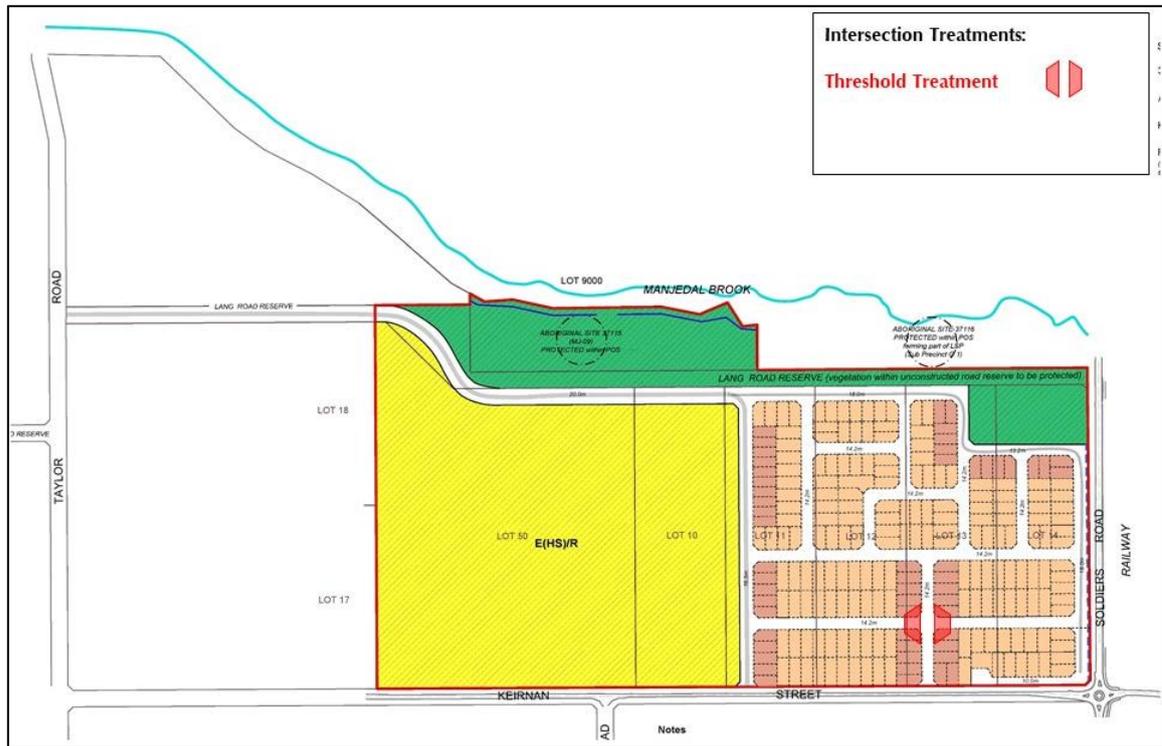


Figure 11. Intersection treatment on internal LSPG2 four-way intersection³

Table 2.4 from AUSTRROADS “Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings” illustrates the traffic volume thresholds above which a detailed intersection capacity assessment is required.

Assuming that typical peak hour traffic represents approximately 10% of the total daily traffic volume, it is concluded that very good traffic flow conditions can be expected at all internal subdivision intersections. As hourly traffic volumes through intersections are significantly below the indicative thresholds indicated in **Table 2**, sufficient capacity would be available and detailed assessment or capacity analysis is not warranted (refer **Figure 10** for structure plan daily traffic projections).

Table 2. Traffic volume thresholds warrants for detailed intersection analysis

Major Road Type	Major Road Flow (vph ⁴)	Minor Road Flow (vph)
Two-lane	400	250
	500	200
	600	100
Four-lane	1,000	100
	1,500	50
	2,000	25

³ Residential lot and local street network indicative only

⁴ vph - vehicles per hour

Accordingly, it is confirmed that the proposed internal subdivision road network layout provides for satisfactory permeability and efficient traffic distribution throughout the subdivision area with no bottlenecks or traffic congestion anticipated during typical operating conditions.

7.5 External Road and Intersection Analysis

Table 3 provides information on existing and projected 2031 traffic volumes on surrounding roads.

Table 3. Total daily traffic volumes - existing and projected 2031

Road	Total Daily Traffic Volumes	
	Existing	Post 2031
Taylor Road (N of Keirnan Street)	1,100vpd	1,740vpd
Adams Street (S of Keirnan Street)	870vpd	1,780vpd
Keirnan Street (W of Baskerville Road)	280vpd	2,110vpd
Keirnan Street (E of Baskerville Road)	320vpd	3,570vpd
Soldiers Road	2,020vpd	3,490vpd
Paterson Street	1,800vpd ⁵	3,580vpd

As can be seen from the 2031 traffic projections, once the entire LSP area is developed (including the residential area immediately west of high school/DPF), the most pronounced traffic impact is experienced on Keirnan Street, section between Baskerville Road and Soldiers Road/Paterson Street. This section is expected to ultimately carry just below about 3,500vpd.

As a Local Distributor Road, Keirnan Street is intended to accommodate daily traffic volumes of up to 6,000vpd and as such the post 2031 traffic volumes with full impact of traffic from the entire LSP area is within the desirable traffic thresholds.

The post 2031 traffic projections are also well within the desirable traffic volume thresholds for the remainder of the adjacent road network. For more details, refer **Table 3**.

The proposed external subdivision intersections on Keirnan Street and Taylor Road are expected to all carry traffic volumes significantly below the indicative thresholds indicated in **Table 2**, suggesting sufficient operational capacity would be available at all external LSP access intersections. As such, detailed assessment or capacity analysis is not warranted in this case.

The assessment of intersection of Soldiers Road/Paterson Street/Keirnan Street was undertaken for the two distinct weekday peak periods. The assessment was undertaken for existing and 2031 scenarios. The base traffic volumes for the existing situation were derived from the available traffic counts provided by the Shire. The

⁵ Estimation

available counts provide directional peak hour volumes on three out of four legs of the roundabout and as such extrapolation of available data was required to determine the turn volumes for all approaches.

The typical background traffic growth of 2%p.a. was factored for the 2031 scenario even though it is considered overly conservative. The 2031 intersection layout assumes conversion of the existing 4-way roundabout to a 3-way format as a result of planned closure of Keirnan Street rail crossing. The intersection was modelled as a single-lane roundabout as per existing standard.

Capacity analysis of the intersection has been undertaken using the SIDRA computer software package. SIDRA is an intersection modelling tool commonly used by traffic engineers for all types of intersections. SIDRA outputs are presented in the form of Degree of Saturation, Level of Service, Average Delay and 95% Queue. These characteristics are defined as follows:

- ✚ Degree of Saturation is the ratio of the arrival traffic flow to the capacity of the approach during the same period. The Degree of Saturation ranges from close to zero for infrequent traffic flow up to one for saturated flow or capacity.
- ✚ Level of Service is the qualitative measure describing operational conditions within a traffic stream and the perception by motorists and/or passengers. In general, there are 6 levels of service, designated from A to F, with Level of Service A representing the best operating condition (i.e. free flow) and Level of Service F the worst (i.e. forced or breakdown flow).
- ✚ Average Delay is the average of all travel time delays for vehicles through the intersection.
- ✚ 95% Queue is the queue length below which 95% of all observed queue lengths fall.

The results of the SIDRA analysis are summarised in **Appendix B**.

Soldiers Road/Paterson Street/Keirnan Street roundabout

The SIDRA analysis indicates that this roundabout presently operates very well, with an overall intersection Level of Service (LoS) A and with negligible queues and delays. The assessment of AM and PM peak scenarios for year 2031 suggests that the intersection will continue to enjoy overall LoS A with acceptable queues and delays. Ample spare capacity remains available for further traffic growth. Refer to **Table 4** through to **Table 7** for more details.

7.6 Access to Frontage Properties

The WAPC *Liveable Neighbourhoods* policy requires that “Development along Integrator B and Neighbourhood Connector streets with ultimate vehicle volumes over 5,000 vehicles per day should be designed either so vehicles entering the street can do so travelling forward, or are provided with alternative forms of vehicle access.

Wider lots with paired driveways and protected reversing areas in the parking lane may be used on streets with up to 7,000 vehicles per day."

No subdivision roads are experiencing these levels of daily traffic so this is not an issue in this particular instance.

7.7 Pedestrian and Cycle Networks

The proposed network of paths for pedestrians and cyclists is described in section 5.3 of this transport assessment. This network of paths will provide a satisfactorily level of accessibility and permeability for pedestrians and cyclists within the subdivision as well as provide for a safe, legible and convenient access to the future High School and DPF sites from the local and district level. In addition, the proposed subdivision path network provides for the future path connections to the balance of the LSP site via Keirnan Street and Lang Road.

The recently constructed shared path along the east side of Soldiers Road provides for a strong pedestrian and cyclist link from the subject site and the High School and DPF to the future planned activity/district centre for Whitby.

The WAPC *Transport Impact Assessment Guidelines Vol 3 – Subdivision* provides guidance on the levels of traffic volumes that are likely to affect the ability for pedestrians to cross various types of road. Based on that guidance an undivided two-lane road should be acceptable for pedestrians crossing traffic volumes of up to approximately 1,100vph and this threshold can be increased to around 2,800vph by adding a central median or pedestrian refuge islands.

None of the roads within the subdivision will reach these levels of traffic to warrant any detailed investigation of crossing facilities at this stage.

Appropriate pedestrian crossing facilities should be placed along the north-south (*Access Street B*) road separating the playing fields/high school site from the subdivision to facilitate safe and easy crossing of the road.

7.8 Access to Schools

At present, there are no schools within the 800m walking distance from the subject site. The closest existing schools are Court Grammar School, about 1km to the north and Mundijong Primary School some 1.2km to the south.

The proposed subdivision will ultimately be within the catchment area of the future high school which is planned to be co-located with the DPF reserve. All high school students residing in dwellings within the area east of the school would need to cross the *Access Street B* road separating the school/DFP from the residential area on their way to and from the school. Pedestrian path is proposed on the eastern side of this road while a shared path is proposed on the western (school/DPF) side. It is recommended that pedestrian crossing(s) facilities in the vicinity of the High School be further investigated during the subdivision design stage of the project.

Based on the estimated school student movements across the north-south *Access Street B* bordering the school site along eastern side, pedestrian crossings probably do not qualify for a warden-controlled school crossing facility to assist school students to cross this access road. Warrant criteria provided on the WA Police website indicate that a *Type A Children's Crossing* may be provided where a minimum of 20 students and 200 vehicle movements occur within the hour immediately before and immediately after school. The warrants are lower for a *Type B Children's Crossing* at 10 students and 100 vehicle movements.

In any case, such facilities can only be applied for by a School Principal or the President/Secretary of the relevant school/parent organisation (eg. P&C or P&F). The anticipated numbers of students crossing this *Access Street* road would unlikely meet these warrants; however, it is expected that the school would apply for this type of facility if/when future student numbers and movements meet those warrants.

7.9 Access to Public Transport

The WAPC *Transport Impact Assessment Guidelines* suggest that it is desirable for at least 90 per cent of dwellings to be within 400m straight line distance of a bus route.

As discussed in section 5.2 of this report it is roughly estimated that about 65% of the subdivision area is located within the 400m catchment. There is minimal likelihood that the existing bus services would be diverted along Keirnan Street and as such this situation is not expected to change in the mid-term period.

8.0 Conclusions

This Transport Impact Assessment has been prepared for the proposed LSPG2 and subsequent subdivision over Lots 11-14 Keirnan Street in Mundijong, Shire of Serpentine-Jarrahdale. The subject site is situated at the northwest corner of the existing Soldiers Road/Paterson Street/Keirnan Street intersection.

The internal subdivision road system is conceptually designed to consist of *Access Street B*, *Access Streets D* and *Laneways*, designed to facilitate internal vehicular, cyclist and pedestrian movements with provisions for future connections to the balance of the LSP and the adjacent future high school site and District Playing Fields Reservation.

The Lots 11-14 subdivision is estimated to generate approximately 1,850 total daily vehicular trips with approximately 185 trips during critical AM and PM peak weekday periods. The entire LSP area, including the future school and District Playing Fields and the potential residential development to the west of LSPG2 area, is expected to generate in order of 6,380 daily and 938/564 morning/afternoon peak hour trips.

The proposed external subdivision accesses comprise full-movement T-intersections on Keirnan Street (total of two) with links to the balance of LSP via Lang Road extension.

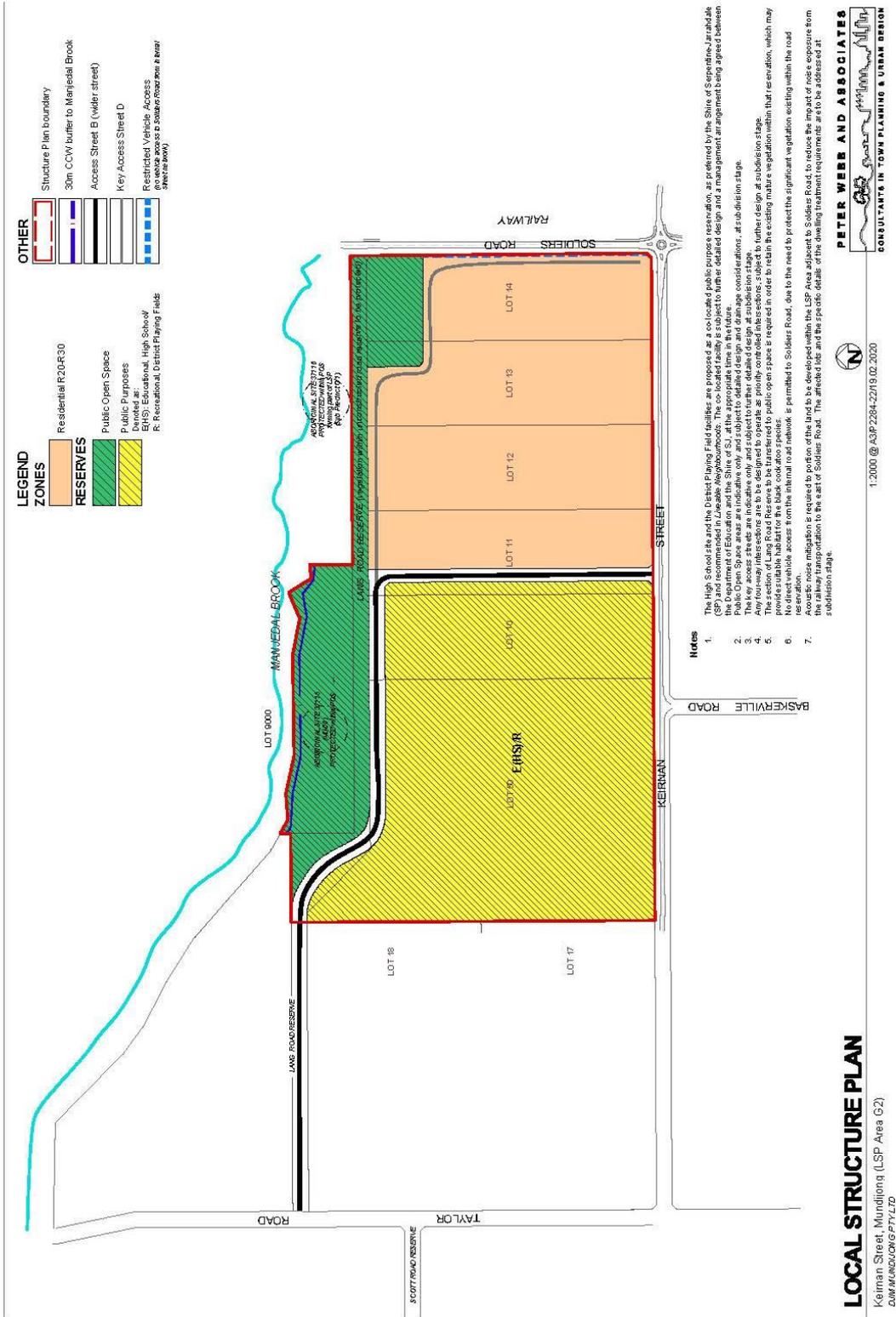
The intersection capacity assessments undertaken for the external subdivision access intersections including intersection of Soldiers Road/Paterson Street/Keirnan Street indicate that these intersections will have sufficient capacity to accommodate the anticipated traffic from the proposed subdivision and the LSP.

The proposed subdivision and LSP in general also provide for a comprehensive network of paths to facilitate non-motorised movements. The proposed path network also provides internal LSPG2 connectivity access to the future High School and District Recreational Playing Fields, makes provision for the interface with the future developments to the west of Taylor Road, as well as makes provisions for access to main future activity nodes such as future Neighbourhood and District Centres off Bishop Road to the northwest and northeast well as Mundijong Townsite to the south.

Approximately 65% of the subdivision area and some 30% of the LSP area is located within the 400m range of the existing bus stops on Paterson Street to the southeast of the site.

Appendix A

PROPOSED LOCAL STRUCTURE PLAN



LOCAL STRUCTURE PLAN
 Keirnan Street, Mundijong (LSP Area G2)
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PETER WEBB AND ASSOCIATES
 CONSULTANTS IN TOWN PLANNING & URBAN DESIGN

Appendix B

SIDRA OUTPUTS

Table 4. SIDRA results for the Soldiers Road/Paterson Street/Keirnan Street intersection – AM peak period (Existing)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Paterson Road												
1	L2	6	10.0	0.085	4.7	LOS A	0.4	3.2	0.15	0.47	0.15	49.9
2	T1	95	10.0	0.085	4.8	LOS A	0.4	3.2	0.15	0.47	0.15	57.3
3	R2	6	10.0	0.085	8.3	LOS A	0.4	3.2	0.15	0.47	0.15	53.9
Approach		107	10.0	0.085	5.0	LOS A	0.4	3.2	0.15	0.47	0.15	56.6
East: Keirnan Street												
4	L2	20	9.0	0.041	4.8	LOS A	0.2	1.4	0.17	0.57	0.17	52.4
5	T1	5	9.0	0.041	4.8	LOS A	0.2	1.4	0.17	0.57	0.17	49.8
6	R2	22	9.0	0.041	8.4	LOS A	0.2	1.4	0.17	0.57	0.17	55.8
Approach		47	9.0	0.041	6.5	LOS A	0.2	1.4	0.17	0.57	0.17	53.6
North: Soldiers Road												
7	L2	28	10.0	0.055	6.1	LOS A	0.3	2.0	0.08	0.57	0.08	58.7
8	T1	38	10.0	0.055	6.5	LOS A	0.3	2.0	0.08	0.57	0.08	60.0
9	R2	7	10.0	0.055	9.8	LOS A	0.3	2.0	0.08	0.57	0.08	55.4
Approach		74	10.0	0.055	6.7	LOS A	0.3	2.0	0.08	0.57	0.08	59.0
West: Keirnan Street												
10	L2	4	7.0	0.011	4.2	LOS A	0.0	0.4	0.28	0.50	0.28	51.7
11	T1	3	7.0	0.011	4.1	LOS A	0.0	0.4	0.28	0.50	0.28	49.6
12	R2	4	7.0	0.011	7.6	LOS A	0.0	0.4	0.28	0.50	0.28	49.3
Approach		12	7.0	0.011	5.4	LOS A	0.0	0.4	0.28	0.50	0.28	50.2
All Vehicles		240	9.7	0.085	5.8	LOS A	0.4	3.2	0.14	0.52	0.14	56.3

Table 5. SIDRA results for the Soldiers Road/Paterson Street/Keirnan Street intersection – PM peak period (Existing)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Paterson Road												
1	L2	2	10.0	0.047	4.8	LOS A	0.2	1.7	0.17	0.48	0.17	49.7
2	T1	47	10.0	0.047	4.8	LOS A	0.2	1.7	0.17	0.48	0.17	57.0
3	R2	5	10.0	0.047	8.4	LOS A	0.2	1.7	0.17	0.48	0.17	53.7
Approach		55	10.0	0.047	5.2	LOS A	0.2	1.7	0.17	0.48	0.17	56.4
East: Keirnan Street												
4	L2	25	9.0	0.050	5.1	LOS A	0.2	1.7	0.25	0.58	0.25	52.1
5	T1	2	9.0	0.050	5.1	LOS A	0.2	1.7	0.25	0.58	0.25	49.6
6	R2	28	9.0	0.050	8.7	LOS A	0.2	1.7	0.25	0.58	0.25	55.5
Approach		56	9.0	0.050	6.9	LOS A	0.2	1.7	0.25	0.58	0.25	53.6
North: Soldiers Road												
7	L2	53	10.0	0.101	6.2	LOS A	0.5	3.9	0.09	0.57	0.09	58.7
8	T1	69	10.0	0.101	6.5	LOS A	0.5	3.9	0.09	0.57	0.09	59.9
9	R2	16	10.0	0.101	9.8	LOS A	0.5	3.9	0.09	0.57	0.09	55.3
Approach		138	10.0	0.101	6.8	LOS A	0.5	3.9	0.09	0.57	0.09	58.8
West: Keirnan Street												
10	L2	6	7.0	0.016	4.0	LOS A	0.1	0.5	0.22	0.50	0.22	51.9
11	T1	5	7.0	0.016	3.8	LOS A	0.1	0.5	0.22	0.50	0.22	49.8
12	R2	6	7.0	0.016	7.4	LOS A	0.1	0.5	0.22	0.50	0.22	49.4
Approach		18	7.0	0.016	5.1	LOS A	0.1	0.5	0.22	0.50	0.22	50.4
All Vehicles		266	9.6	0.101	6.4	LOS A	0.5	3.9	0.15	0.55	0.15	56.5

Table 6. SIDRA results for the Soldiers Road/Paterson Street/Keirnan Street intersection – AM peak period (2031 Scenario)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Paterson Road												
1	L2	117	10.0	0.203	5.1	LOS A	1.2	9.0	0.28	0.50	0.28	49.6
2	T1	125	10.0	0.203	5.1	LOS A	1.2	9.0	0.28	0.50	0.28	57.0
Approach		242	10.0	0.203	5.1	LOS A	1.2	9.0	0.28	0.50	0.28	53.2
North: Soldiers Road												
8	T1	82	10.0	0.162	7.7	LOS A	0.9	6.7	0.42	0.65	0.42	57.5
9	R2	82	10.0	0.162	11.0	LOS B	0.9	6.7	0.42	0.65	0.42	53.3
Approach		164	10.0	0.162	9.4	LOS A	0.9	6.7	0.42	0.65	0.42	55.3
West: Keirnan Street												
10	L2	184	7.0	0.325	4.5	LOS A	2.1	15.3	0.38	0.58	0.38	51.1
12	R2	195	7.0	0.325	7.8	LOS A	2.1	15.3	0.38	0.58	0.38	48.7
Approach		379	7.0	0.325	6.2	LOS A	2.1	15.3	0.38	0.58	0.38	49.9
All Vehicles		785	8.6	0.325	6.5	LOS A	2.1	15.3	0.36	0.57	0.36	51.9

Table 7. SIDRA results for the Soldiers Road/Paterson Street/Keirnan Street intersection – PM peak period (2031 Scenario)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
South: Paterson Road												
1	L2	102	10.0	0.158	5.5	LOS A	0.8	6.4	0.36	0.54	0.36	49.4
2	T1	65	10.0	0.158	5.6	LOS A	0.8	6.4	0.36	0.54	0.36	56.7
Approach		167	10.0	0.158	5.6	LOS A	0.8	6.4	0.36	0.54	0.36	52.0
North: Soldiers Road												
8	T1	152	10.0	0.242	6.9	LOS A	1.4	10.8	0.25	0.61	0.25	58.1
9	R2	149	10.0	0.242	10.2	LOS B	1.4	10.8	0.25	0.61	0.25	53.8
Approach		301	10.0	0.242	8.6	LOS A	1.4	10.8	0.25	0.61	0.25	55.9
West: Keirnan Street												
10	L2	89	7.0	0.131	3.9	LOS A	0.7	5.3	0.23	0.53	0.23	51.7
12	R2	71	7.0	0.131	7.3	LOS A	0.7	5.3	0.23	0.53	0.23	49.2
Approach		160	7.0	0.131	5.4	LOS A	0.7	5.3	0.23	0.53	0.23	50.6
All Vehicles		628	9.2	0.242	7.0	LOS A	1.4	10.8	0.28	0.57	0.28	53.4

ANNEXURE 12
Engineering Servicing Report
Calibre

ENGINEERING SERVICING REPORT

Lots 50, 10, 11-14
Keirnan St, Mundijong



PREPARED FOR DJM MUNDIJONG PTY LTD

DOCUMENT CONTROL

ISSUE	DATE	ISSUE DETAILS	AUTHOR	CHECKED	APPROVED
A	29 April 2019	DRAFT	N Adams	G Hall	N Adams
B	17 May 2019	FINAL	N Adams	G Hall	N Adams
C	27 May 2019	FINAL inc LWMS Comments	N Adams	G Hall	N Adams
D	27 May 2019	FINAL inc DJM Comments	N Adams	G Hall	N Adams
E	15 May 2020	FINAL inc Revised LSP Area, Ethnographical Survey, Archaeological Survey	N Adams	R Pizzino	N Adams
F	18 May 2020	FINAL inc amendments	N Adams	R Pizzino	N Adams

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Executive Summary

This report has been prepared by Calibre for the Mundijong Local Structure Plan (LSP Area G2) and includes a review of the engineering servicing and prevailing site conditions. It has been prepared to support the Local Structure Plan (LSP Area G2) submission on behalf of DJ MacCormick for DJM Mundijong Pty Ltd.

The LSP has been prepared by Peter Webb & Associates on behalf of DJM Mundijong Pty Ltd.

Siteworks

The site grades from the south-eastern corner (and a high of about RL40.5m AHD) towards the north-western corner of the Site (RL 35.0m AHD).

Four types of subsurface conditions were identified in the geotechnical investigation; topsoil, medium grained, sand with moderate to low silt content, very dense, fine to medium grained sandy gravel with clay and clayey sand with gravel.

The highest groundwater level with respect to Australian Height Datum was at 38.4mAHD in TH10 at the south east corner of the site (1.5m below ground level). Groundwater levels decreased to the north and north west, with test holes becoming dry to at least 2m depth along the northern boundary.

The approximate hydraulic gradient is to the west north west.

The finished design levels of the Development need to take into account a number of siteworks controls and clean fill will be required to be imported to bring the final design levels up to the levels required to fit within the site controls specified above and design parameters.

Stormwater Drainage

The Drainage Report found that the effects of blocking a culvert is negligible and localised (within a small range adjacent to the Soldiers Road culvert crossings), with no effect to the upstream town centre. It is recommended that the Shire of Serpentine Jarrahdale endorse the proposal to block a culvert, to facilitate the development of Lots 50, 10, 11 to 14 Keirnan St, Mundijong.

The geotechnical investigation found that the in-situ sands contain moderate to low fines, zero plasticity and are free draining. The drainage condition within the sands prior to proof rolling is good.

A traditional pit and underground pipe system is proposed for the collection of all surface runoff within the road reserves throughout the development. This system will include all runoff from rainfall events up to and including the 20% AEP.

The stormwater will be conveyed via the pipe system to the drainage basins in the north-western and north-eastern parts of the Site. Two locations for drainage basins have been proposed.

The groundwater levels will need to be managed via a subsoil drainage system which utilises and connects to the development's stormwater drainage pit system. The proposed subsoil drainage will reduce the groundwater levels, with the high points of the mounds (located between the subsoil lines due to the drawdown effect) providing a minimum 1.5m clearance to the finished lot levels. The subsurface water collected via the subsoil drainage system will also be conveyed to the same drainage basins as the surface stormwater. It is recommended that lot soakwells should be at the front of the property, close to the road which contains the subsoil system to assist with drainage.

Roadworks

The proposed network of roads within the subdivisions' area consists of a combination of Access Street B, and Access Street D. The road cross sections will make provision (where applicable) for all utility services, parking, paths and drainage.

Wastewater

A reticulated network of DN150 gravity sewer mains will provide every lot with a single connection. The fall of the gravity sewer will be from the south-east to the north-west and will be designed in accordance with Water Corporation standard DS50. The subdivision's sewer will connect to the designated connection point within the Lang Road reserve at proposed invert level 33.0m AHD.

It is possible there may need to be a designated tankering point for the development until the WWPS and gravity sewer mains to the pump station are constructed. The ultimate scheme is for the development's wastewater to be conveyed to the future Mundijong wastewater pump station (WWPS), located west of the LSP area on Scott Road, east of Tonkin Highway.

Water Supply

The Water Corporation's Esinet website shows that there is potable water supply available via the existing 315PE water main on Soldiers Road and the existing 150PVC water main on the south side of Keirnan Street. The water reticulation through the site will be via a reticulated 150PE network.

Power, Communications and Gas Supply

The intention is to service the subdivision with underground power. Padmount sites for a switchgear and up to two transformers will most likely be required to provide network requirements within the subdivision. Servicing of the subdivision will be confirmed by the Electrical Consultant who will need to liaise with Western Power. It is expected that Western Power will need to be commissioned to undertake a feasibility study so that upgrades and reinforcement to the surrounding existing network can be determined. The Developer will need to fund the cost of the feasibility study.

Both Telstra and NBN supply service to the area and it is expected that these services can extend to service the subdivision.

An existing 160PE 1.5HP 700kPa gas main runs along Soldiers Road. It is expected that ATCO Gas's network has sufficient capacity to provide gas to this subdivision.

1 Introduction

This report has been prepared by Calibre for the Mundijong Local Structure Plan (LSP) and includes a review of the engineering servicing and prevailing site conditions for the sub-precinct G2. It has been prepared to support the Local Structure Plan (LSP) submission (refer Figure 1) on behalf of DJ MacCormick for DJM Mundijong Pty Ltd.



Figure 1. - Extract from Local Structure plan LSP Area G2,, November 2019

The LSP extends over approximately 62ha. Precinct G2 includes Lots 10, 50 and 11-14 Keirnan Street, Mundijong and encompasses approximately 16ha of land zoned “Urban” under the MRS within the Shire of Serpentine Jarrahdale. The land falls within Local Planning Scheme No.2. Lots 10 and 50 form the co-located High School and District Playing Fields Reservation.

The LSP has been prepared by Peter Webb & Associates on behalf of DJM Mundijong Pty Ltd.

2 Siteworks

2.1 Topography

The Lots 50,10, 11, 12, 13 and 14 represent a site of approximately 16ha in area. The site is bounded by Lang Road and future Lang Road reserve to the north, Soldiers Road to the east, Keirnan Street to the south, with the future development sites and co-located High School and District Playing Fields Reservation on Lot 10 to be developed by others to the west.

The existing topography is shown in Figure 2. The site grades from the south-eastern corner (and a high of about RL40.5m AHD) towards the north-western corner of the Site (RL 35.0m AHD).

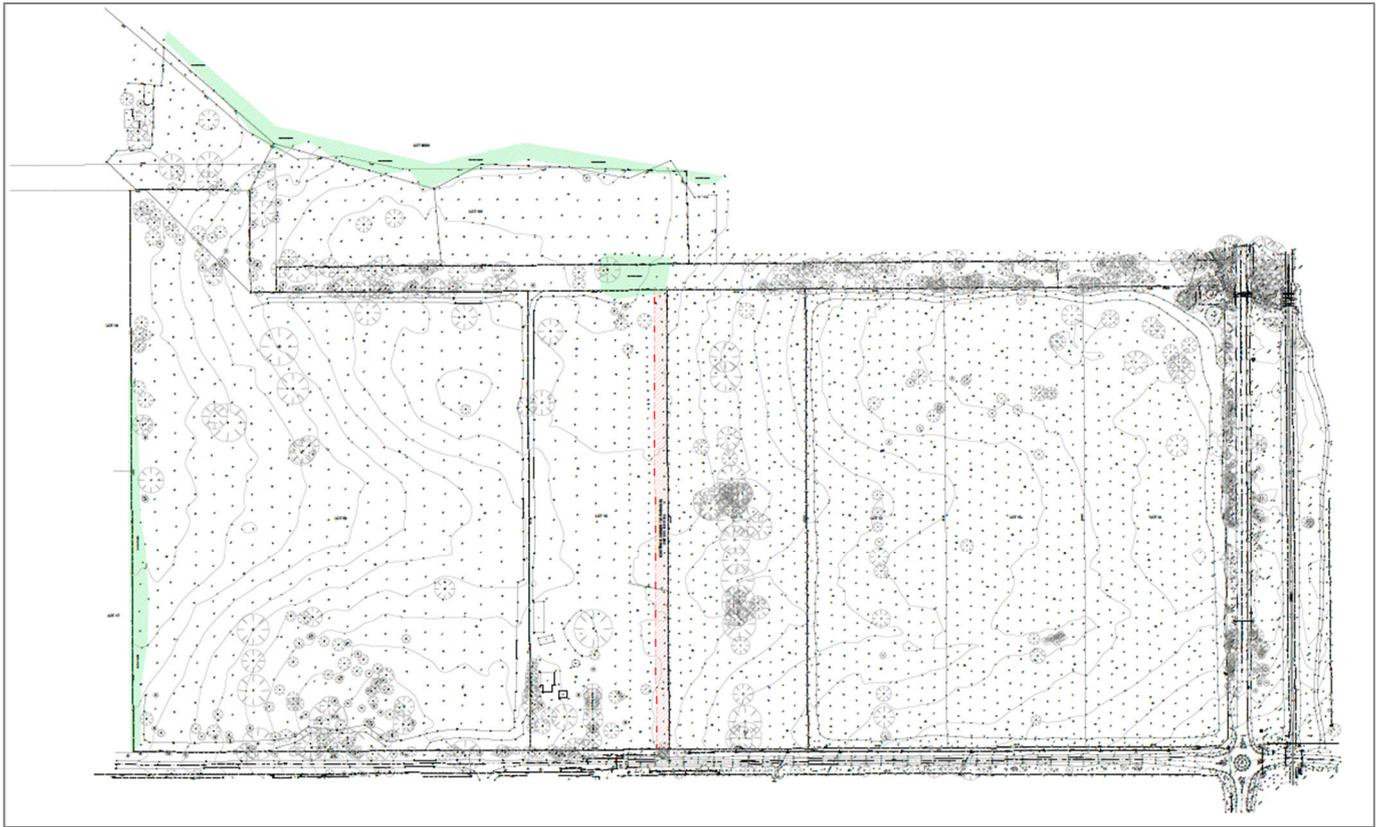


Figure 2. - Extract from Feature Survey, May 2018

2.2 Ground Conditions

2.2.1 Subsurface Conditions

A preliminary geotechnical report was undertaken by Brown Geotechnical in December 2018 and was revised in February 2020 (reference 19061.1). The report consisted of a desktop review in conjunction with limited fieldwork. The initial report completed in December 2018 notes that the Lots 11-14 site consists of four large paddocks of approximately 4ha each.

The subsequent February 2020 report also covers Lots 10, 50 and 101. The now-six paddocks cover approximately 36ha and are mostly grass covered with some areas of trees.

The report also notes that the geological map for the area (*Geological Survey of Western Australia. 1:50,000 Environmental Geology Series, Perth*) shows the majority of the site to be underlain by the Guildford Formation consisting of clay, sand, silt and gravels, with the Bassendean Sands Formation concentrated towards the centre.

Four types of subsurface conditions were identified in the February 2020 geotechnical investigation:

- **Topsoil:** The investigation noted that 100mm (on average, with a maximum of 200mm) of topsoil was found across the site. The topsoil consisted of grey silty sand with organics, locally with tree roots. The report advised that no uncontrolled fill was encountered in test holes and there were no obvious signs of old structures, foundations or infill areas within the paddocks.
- **Medium grained, sand with moderate to low silt content** was encountered in all test holes below the topsoil. The report noted that Penetrometer tests show the material to be medium dense, generally becoming dense below about 1m. The thickness varied from approximately 0.5m along the southern boundary to over 2m where the clayey soil was absent in the centre and north west. The silt content decreases slightly with depth and reduces to less than 5% in the central and north west portion of the site.

- *Very dense, fine to medium grained sandy gravel with clay* was encountered below the silty sand in the southern third and the north east corner of the site. Test results show the material to have a moderate to low fines content, intermediate to low plasticity with a low expansive nature. The material often became hard after about 1m due to pockets of iron rich cementation resulting in slow excavation and occasionally caused refusal of the 5 tonne excavator. This was particularly noticeable in TH13 and TH14 (refer to Figure 3) along the dry stream bed.
- *Clayey Sand with Gravel*: The sandy gravel often transitioned in to a clayey sand with gravel after approximately 1m. The transition was usually gradual, with the gravel content decreasing with depth. Test results show the material to have a moderate fines content, intermediate to low plasticity with a low expansive nature.

2.2.2 Groundwater Conditions

The Perth Groundwater Map (*Department of Water, Perth Groundwater Map*) does not quite cover the site but indicates minimum groundwater levels (approx. 400m to the west) to be 1.7m below ground level, and historical maximum levels (approx. 2km north) to be about 1m below ground level. The terrain and ground levels at these locations are fairly similar to the site under investigation.

Brown Geotechnical found groundwater in 27 of the 32 test holes dug. Test hole locations are shown in Figure 3. The report notes that the maximum groundwater level encountered was 0.6m below ground level in the bed of the dried-up stream, at 36.5mAHD in TH13 and 35.2mAHD in TH22.

A dried up stream channel trending from east to west and crossing the southern and central portions of the site was also identified. There was a comment for test holes along or near the channel, that the groundwater appeared to be perching on the cemented layer.

The highest groundwater level with respect to Australian Height Datum was at 38.4mAHD in TH10 at the south east corner of the site (1.5m below ground level). Groundwater levels decreased to the north and north west, with test holes becoming dry to at least 2m depth along the northern boundary. The report also noted that the groundwater levels were seasonally expected to be slightly lower due to the investigation being conducted in the month of January.

The report recommends that further permeability testing be carried out following the earthworks to confirm the proposed drainage design parameters.

The approximate hydraulic gradient is to the west north west.

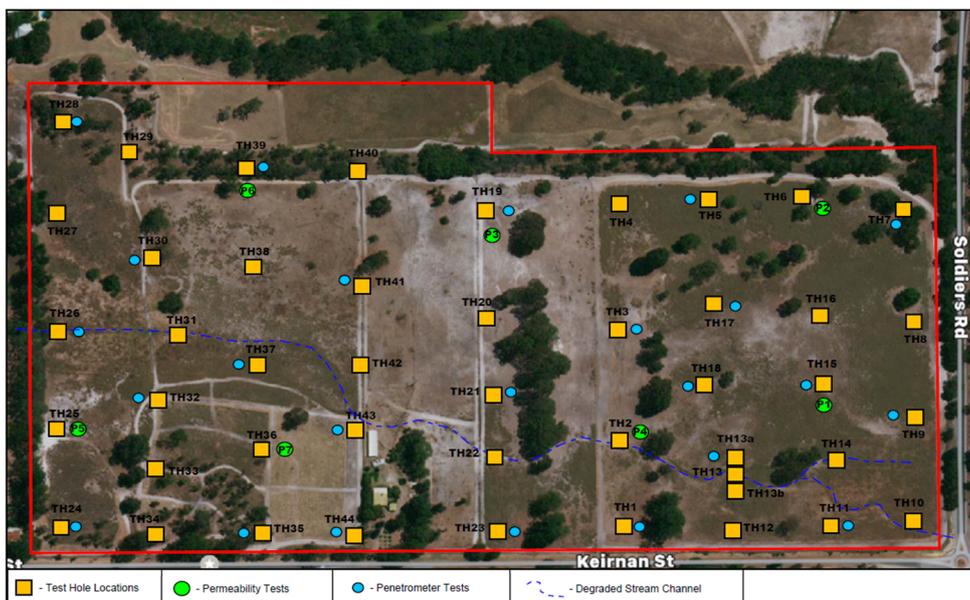


Figure 3. - Extract from Test Location Plan, Brown Geotechnical

Pre-development groundwater monitoring was carried out on the site between 2016 and 2017 by Emerge.

2.3 Siteworks Controls

The finished design levels of the Development need to take into account a number of siteworks controls:

- The revised LSP includes a proposed layout for the entire sub-precinct G2, including the portion of land west of the Lot 11 boundary. The levels to the east of the development site will need to match into the proposed District Open Space levels and acknowledge that as the lowest part of the development site, the resulting design levels will need to accommodate the drainage basin and outlet and groundwater levels. Manjedal Brook and Lang Road reserve to the north of the site contains existing mature trees to be retained in the POS in the north eastern corner of the Site and will potentially be the subject of mitigation measures during the construction phase.
- The proposed gravity DN450 sewer main that flows to the Scott Road wastewater pump station has a proposed design invert level within the Lang Road reserve that will govern the minimum fill levels required throughout the site to get gravity flow from the lot farthest to the proposed connection point via gravity flow.
- Siteworks along the eastern boundary do need to take into account the proposed existing stormwater controls. Closure of an existing stormwater culvert under Soldiers Road entering the development site in the south eastern corner needs to be accommodated as specified in the Local Water Management Strategy (LWMS) prepared by Calibre.
- The proposed entry and exit points into the developments off Keirnan Street need to be graded to tie into the existing levels on Keirnan Street.
- Groundwater levels across the site need to be taken into consideration when designing the finished levels of the development. Minimum clearance to proposed lot levels and the effects of the proposed subsoil drainage system needs to be accommodated.
- The site has been divided into two classes based upon the material deemed to be underlying the various areas. There is a portion underlain by a clayey subgrade and another underlain by sand.

2.4 Proposed Siteworks

Clean fill will be required to be imported to bring the final design levels up to the levels required to fit within the site controls specified above and design parameters, those being:

1. To obtain a site classification of "Class A";
2. To allow for the drainage requirements and clearance to groundwater levels.

The design of the Development will include the following in accordance with geotechnical advice and verification to reduce the volume of imported fill:

- Adherence to retaining wall design parameters;
- Adherence to design CBR advice;
- Conduction of further permeability testing to confirm proposed drainage design parameters;
- Stripping of all topsoil as it has been deemed unsuitable for foundation support;
- Blending of the screened topsoil with clean sand fill to reduce the organic and fines content to acceptable levels and to reduce the volume of imported fill (suggested ration of 1:2 to 1:3 screened topsoil : clean sand);
- Blending of sand with silt overlying the clayey soils for use as engineering fill, and blending of the sandy gravel with clay with clean sand to reduce the fines in accordance with the supervision and verification of a geotechnical engineer

Construction requirements (including SMDD and inspections) have been specified within the geotechnical report and will need to be included in construction specifications.

3 Stormwater Drainage

3.1 Drainage Modelling

In December 2018, Calibre was commissioned to complete a drainage analysis of the eastern culvert entering the subject land (Culvert A1) and the affects (if any) blocking the culvert has on the downstream Manjedal Brook, shown on Figure 4. The report has assessed the existing drainage system surrounding the subject land with the aim of determining the peak flow rate entering the site and the effects to the downstream Manjedal Brook from blocking the culvert.



Figure 4. - Extract from Drainage Report, December 2016, Calibre

The drainage report found:

- Discharge from the Subject Land eventually enters Manjedal Brook and ultimately Folly River further downstream.
- Several stormwater models have been completed over the area since 2007, in support of various stormwater management documents. These include the Mundijong Floodplain Management Strategy (SKM, 2007), Mundijong-Whitby DWMS (GHD, 2010) and the Whitby LWMS (Cardno, 2011), none of which included Culverts A1, B1, B2 and C1.
- Calibre's proposed strategy will utilise results of the 2015 Birrega and Oaklands flood study, in conjunction with the Whitby LWMS.
- Blocking of the culvert increases the downstream Manjedal Brook flood elevation by 0.003m adjacent to the Soldiers Road culvert, dissipating shortly thereafter. This is considered a minimal to negligible effect to the Brook.
- Flows within the Brook have increased by 0.002m³/s, less than the increased flow generated by the Soldiers Road reserve catchment south of Keirnan Street and the blocking of Culvert A1. This minimal flow increase is due to the discharge from the culvert A1's catchment entering the Brook at 2hrs into the storm event, prior to the Brook peaking at 3.5hrs. It should be noted that the Whitby LWMS indicates flows within the Brook will reduce by approximately 3m³/s due to the detention of post-development flows within the Whitby development. This more than counters the effect of increased flows from these catchments.
- Stormwater ponding adjacent to Culvert A1 has increased by 0.03m, with 0.63m of freeboard still provided to the crest elevation of Soldiers Road.

Based on the above, the Drainage Report found that the effects of blocking Culvert A1 is negligible and localised (within a small range adjacent to the Soldiers Road culvert crossings), with no effect to the upstream town centre. It is recommended that the Shire of Serpentine Jarrahdale endorse the proposal to block Culvert A1, to facilitate the development of Lots 11 to 14 Keirnan St, Mundijong.

3.2 LWMS

The LWMS has been prepared by Calibre in March 2020 (Rev D) and includes a review of the prevailing groundwater conditions that contribute to the water flow across the development site.

The LWMS detailed the best management practices approach to water management that will be undertaken for this development, in accordance with Better Urban Water Management (WAPC, 2008). This includes managing, protecting and conserving the total water cycle of the local environment and the greater catchment. In addition, the report included managing, protecting and conserving the total water cycle of the local environment and the greater catchment by reviewing:

- Stormwater management that incorporates the latest water sensitive urban design practices;
- Groundwater resource management;
- Protection and enhancement of ecosystems dependent on water resources from the subject land;
- Sustainable water servicing.

A groundwater management strategy is included, with subsoil drainage proposed throughout the development. Connection will be directly into the internal drainage network.

3.3 Stormwater Collection and Management

3.3.1 Soil Permeability

Permeability test results taken during the geotechnical investigation works showed that there was good drainage characteristics in all areas (including the medium dense sand with traces of silt), except those containing the dense clayey sand. The investigation also found that the sites for the proposed drainage basins have good drainage characteristics. The in-situ sands contain moderate to low fines, zero plasticity and are free draining. The drainage condition within the sands prior to proof rolling is good. Permeability between $7 \times 10^{-4} \text{m/s}$ and $1 \times 10^{-3} \text{m/s}$ was recorded.

The geotechnical report has also cautioned that permeability and drainage conditions may be reduced during earthworks due to compaction of in-situ and imported sands and that over compaction during earthworks can seriously reduce soil permeability. The geotechnical report recommends that further permeability testing be carried out following earthworks to confirm parameters used during drainage design.

3.3.2 Surface Stormwater

A traditional pit and underground pipe system is proposed for the collection of all surface runoff within the road reserves throughout the development. This system will include all runoff from rainfall events up to and including the 20% AEP.

The stormwater will be conveyed via the pipe system to the drainage basins as shown in the figure below.

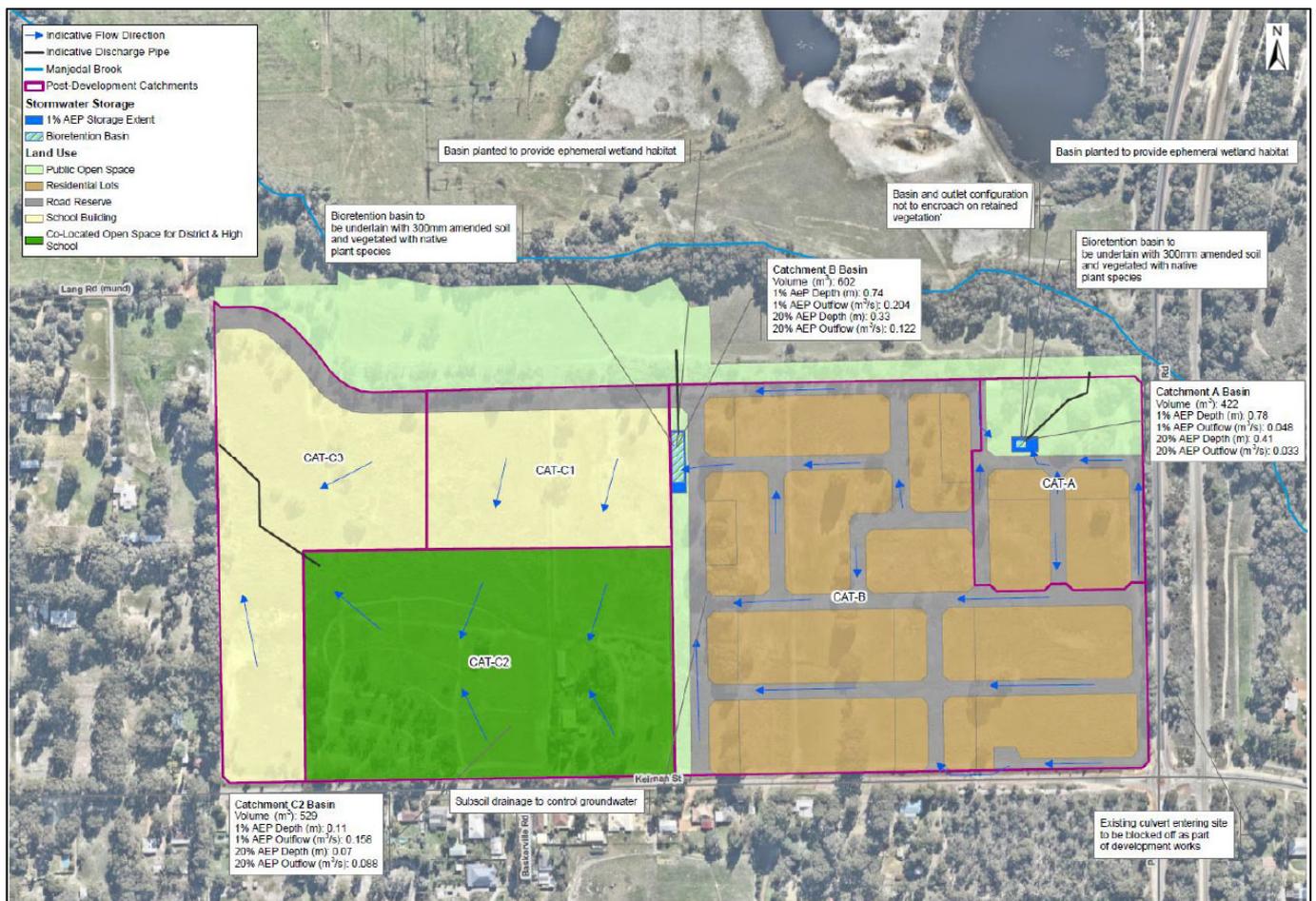


Figure 5 - Proposed Conveyance and Capture System

The road surface system will convey the stormwater for all rainfall events exceeding the 20% AEP to the Public Open Space and proposed drainage basins. Sufficient freeboard will need to be provided to the lots.

The key points relating to the surface drainage are:

- Lots and roads graded to direct overland flow to the low point of each catchment.
- Lots will retain and infiltrate the first 15mm of rainfall on site within soakwells, installed as per Shire standards.
- Peak outflow discharging into Manjedal Brook will be equal to or less than pre-development flows for respective AEP storm events.
- Water flowing off impervious surfaces not associated with lots, including roads, pathways and driveways and excess runoff from pervious areas will be directed to bioretention basins. The bioretention basins will be located at the base of the detention storages, sized to retain the first 15mm of rainfall or 2% of the effective impervious area. The bioretention basins will have vertical side slopes and a depth of 0.30m.
- Bioretention basins will be underlain with 0.3m of amended soil media, stormwater will infiltrate through the media before entering a subsoil drainage pipe, laid at the base of the amended soil media. Subsoil inverts will be at or above the estimated pre-development groundwater level. Amended soil media will be in accordance with the Facility for Advancing Water Biofiltration (FAWB) Adoption Guidelines for Filter Media in Biofiltration Systems and the Stormwater Management Manual of WA guidelines.
- Local native plants will be used throughout the POS and bio-retention basins. Non-local species used in the landscaping design will be chosen for drought tolerance.

- A GPT to be installed upstream of the detention basins, sized to treat the first 15mm of rainfall with capacity to bypass larger flows.
- It is anticipated that surface water quality will be improved through the introduction of the stormwater management system associated with the swales, basins and wetland systems.

3.3.3 Major Drainage System

The key points are:

- The finished floor levels are to be a minimum of 500 mm above the regional peak 1% AEP flood level. This varies across the site, with a floor level of 40 m AHD being relevant for the south eastern edge and 39 m for the north eastern edge. This drops to 32 m AHD on the south western edge and 33.5 m AHD in the north-west. The exact heights are to be refined as part of detailed design.
- The road drainage network to be sized to convey the peak 1% AEP storm event towards catchment detention storages at the low point of each catchment, in the POS.
- Finished floor levels will also be a minimum 300mm above the gutter line or the peak flood level of the internal stormwater system
- On-lot soakwells will overflow towards the road drainage network in events above 15mm.
- The eastern boundary culvert will be blocked as part of development works. As detailed in Section 5.1, this will not impact flood levels within Manjedal Brook.
- Peak outflow discharging into the Manjedal Brook will equal or be less than pre-development flows for respective AEP storm events.
- Outflow pipes from the detention basins will be set 150 mm above the top of the bioretention basins, with rock pitching installed at the downstream invert to prevent erosion.
- Detention basins to have a maximum side slope of 1:6 (V:H) and a maximum depth of 1.2m.
- Low kerbing to be provided at the low-point adjacent to catchment detention storage to allow overland flow to enter the storage from the road pavement.

3.3.4 Subsurface Water System

The groundwater levels will need to be managed via a subsoil drainage system which utilises and connects to the development's stormwater drainage pit system. The proposed subsoil drainage will reduce the groundwater levels, with the high points of the mounds (located between the subsoil lines due to the drawdown effect) providing a minimum 1.5m clearance to the finished lot levels. The subsurface water collected via the subsoil drainage system will also be conveyed to the same drainage basins as the surface stormwater.

The identified objectives are to:

- Where subsoils are installed, subsoils will discharge directly into the internal drainage network to be treated prior to discharging into the Manjedal Brook.
- Manage groundwater levels to protect infrastructure and assets.
- Maintain groundwater regimes for the protection of groundwater dependant ecosystems.
- Protect the value of groundwater resources.
- Adopt nutrient load reduction design objectives for discharges to groundwater.

The groundwater management requires the following:

- A minimum separation of 1.5m to the estimated pre-development groundwater levels or impermeable clay layer will be maintained post-development. Where this separation does not already exist, imported fill and a subsoil pipe network will be utilised.
- Subsoils will be set predominately at the estimated pre-development groundwater level. Subsoil pipes will be laid at a minimum 1:400 grade, will be a minimum pipe diameter of 225mm and will be located within the road reserve.
- Mounding will occur between the subsoil pipes, with a maximum of 500mm below houses after a 20% AEP event in the wettest month of the year. Mounded groundwater will rapidly drain to the subsoil system, reducing the mounding elevation below residential lots. The use of free draining fill and the distance between subsoil pipes throughout the development will assist in reducing mounding of groundwater. The permeability of all sand fill is to be a minimum of 5m/day.
- Road levels and building floor levels are to be set so that they are not negatively impacted by the recorded maximum groundwater elevation within the area in which they are located.
- All lot soak wells are to be shallow in nature (e.g. 900mm), so that their infiltration rate is not influenced by high groundwater levels.
- It is recommended that lot soakwells should at the front of the property, close to the road which contains the subsoil system to assist with drainage.
- Where possible water will be infiltrated on site to maintain similar overall infiltration volumes to the pre-development scenario. This is to be achieved through the use of pervious surfaces, bioretention basins and soakwells, which are designed to infiltrate water.

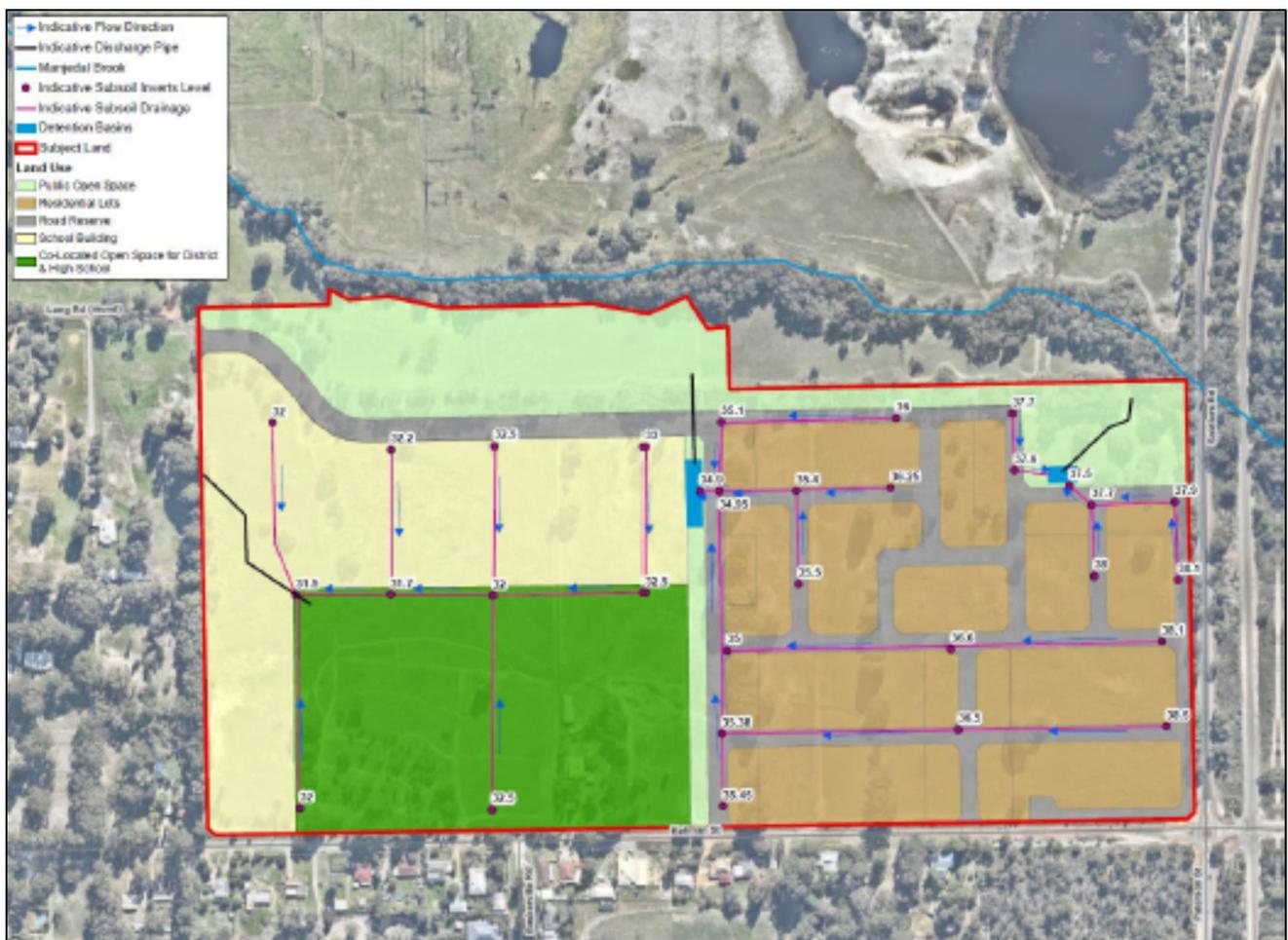


Figure 6 - Proposed Groundwater Management System

Note that the above plan is indicative only and will need to be confirmed by the various developers.

3.3.5 Drainage Basins

Two locations for drainage basins have been proposed as shown in Figure 5. The geotechnical investigation found that the sites for the proposed drainage basins as indicated have good drainage characteristics. These basins have been sized to contain the anticipated 1% AEP with a maximum depth of 1.2m. The basins are expected to be open, accessible and integrated into the landscape, with the sides of the basins graded at a maximum of 1 in 6. An infiltration rate of 1.5m/day has been assumed in the storage calculations.

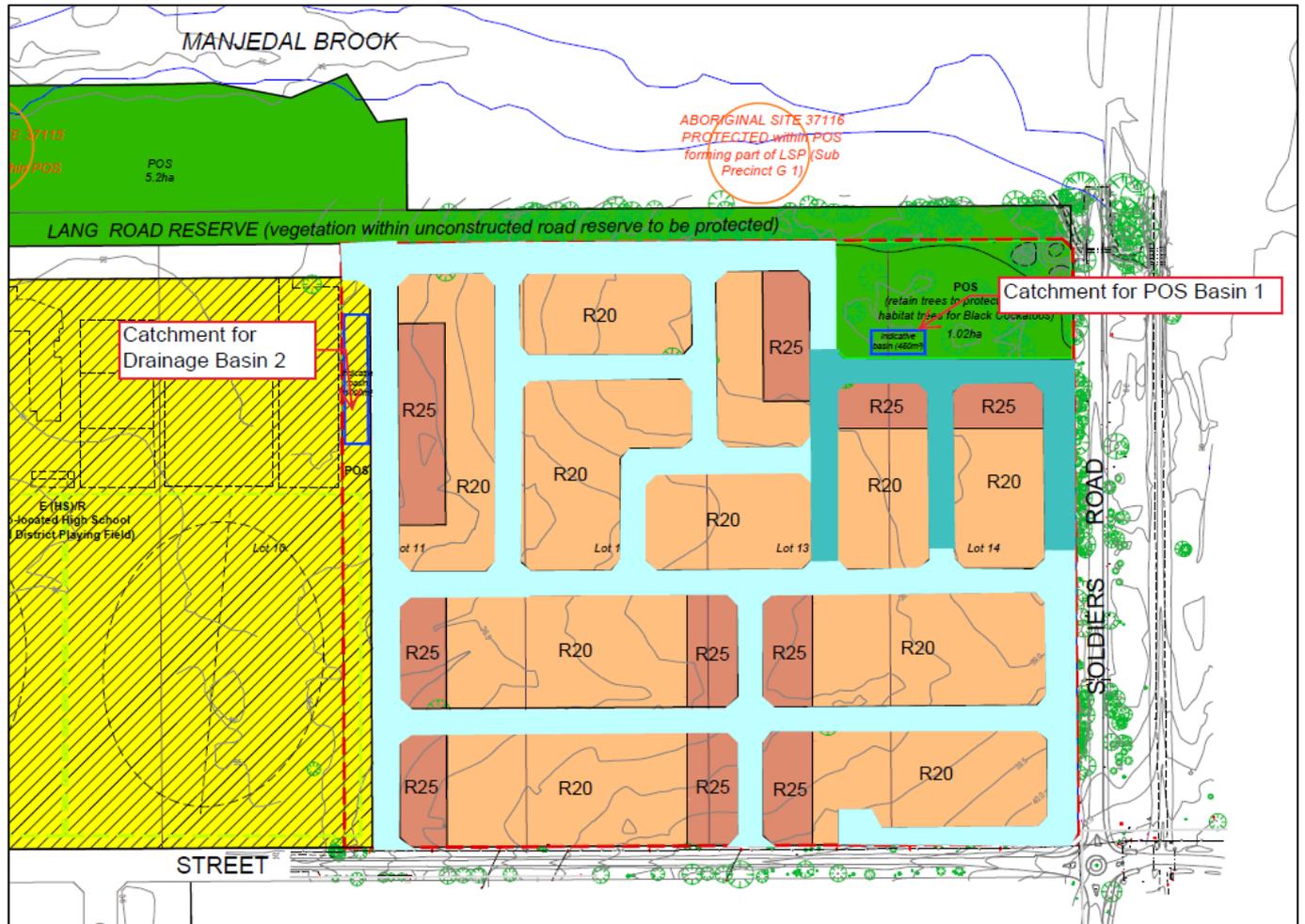


Figure 7 - Proposed Catchment Plan and Drainage Basin Locations

4 Roadworks

4.1 Proposed Road Hierarchy and Network

The proposed network of roads within the subdivisions' area consists of a combination of Access Street B (wider street) and Access Street D in Figure 6 below. These designations reflect the intended functions of the roads and typical cross sections are shown in Appendix B.

The engineering design of the roads, intersections and parking will comply with the Department for Planning Liveable Neighbourhoods recommendations, Transcore's Traffic Impact Assessment recommendations, Lush Fire and Planning's Bushfire Management plan recommendations, the Shire of Serpentine-Jarrahdale and Main Roads WA if applicable at the intersections of Keirnan Street.

The road cross sections will make provision (where applicable) for all utility services, parking, paths and drainage. It is envisaged that bollards will be installed in the verge to prevent vehicular access to the Lang Road reserve from the subdivision and between the laneway and Keirnan Street.



Figure 8 – Access Streets

5 Influence of the Traffic Impact Assessment

Transcore prepared a Traffic Impact Assessment (TIA) in April 2019 and a revised TIA in March 2020 which looked at the traffic generated throughout the whole LSP area, including Lots 10,50, 11-14. The assessment reviewed the resultant traffic patterns on the surrounding road network and provided an assessment of the proposed subdivision access system and key local intersections to establish the capacity of the road infrastructure to accommodate the anticipated traffic flows.

The key findings of the assessment are:

- The proposed external subdivision accesses comprise full-movement T-intersections on Keirnan Street (total of two) with links to the balance of LSP via Lang Road extension.
- The intersection capacity assessments undertaken for the external subdivision access intersections including intersection of Soldiers Road/Paterson Street/Keirnan Street indicate that these intersections will have sufficient capacity to accommodate the anticipated traffic from the proposed subdivision and the LSP.
- The proposed subdivision and LSP in general also provide for a comprehensive network of paths to facilitate non-motorised movements. The proposed path network also provides internal LSPG2 connectivity access to the future High School and District Recreational Playing Fields, makes provision for the interface with the future developments to the west of Taylor Road, as well as makes provisions for access to main future activity nodes such as future Neighbourhood and District Centres off Bishop Road to the northwest and northeast well as Mundijong Townsite to the south.
- The road reserve widths proposed in the LSP have been supported by the traffic volume, speed and usage assessments.
- Intersection within the development will be treated as suggested in the TIA.
- Wider lots with paired driveways and protected reversing areas in the parking lane are not required.

6 Influence of Bushfire Assessment

In an April 2019 and April 2020 revision, Lush Fire & Planning undertook a bushfire hazard level assessment over the LSP area and found that the area will have either a moderate or low bushfire hazard level. The moderate hazard levels relate to the 100m buffer from the external hazard vegetation.

The assessment notes that within the Lots 11-14 landholding, the principal bushfire hazard is the bushland on the Lang Road reserve, Soldiers Road, the railway line and also the Bella Cumming nature reserve. These are external to the site but require specific management of the hazard interface.

The key takeaways from the assessment that will be incorporated into the design and staging programme include:

- Provision of interim access or emergency access ways for individual stages during and after construction.
- Inclusion of firebreaks.
- Construction of subdivision roads to standards outlined in the Bushfire Management Plan to ensure safe access and egress.
- All constructed lots to be serviced with reticulated water.
- The development of the estate may have staged construction. In the event that the subdivision is staged then it is necessary to ensure that appropriate interim measures are provided. These may include:
 - Interim access or emergency access ways;
 - Creation of additional low fuel zones to ensure that the intended BAL ratings can be applied; or
 - The provision of boundary firebreaks especially on any balance lot.
- A plan demonstrating the location and capacity of fire the fire hydrants shall be submitted to the Shire and DFES prior to issue of titles.
- The BAL Contour Map indicates the majority of the site will have either a BAL-12.5 or Bal-Low rating. In some instance that there is a minor encroachment of BAL-40/FZ into the front setback of some lots on the periphery of the subdivision as shown in Figure 9 below (extract from BMP).

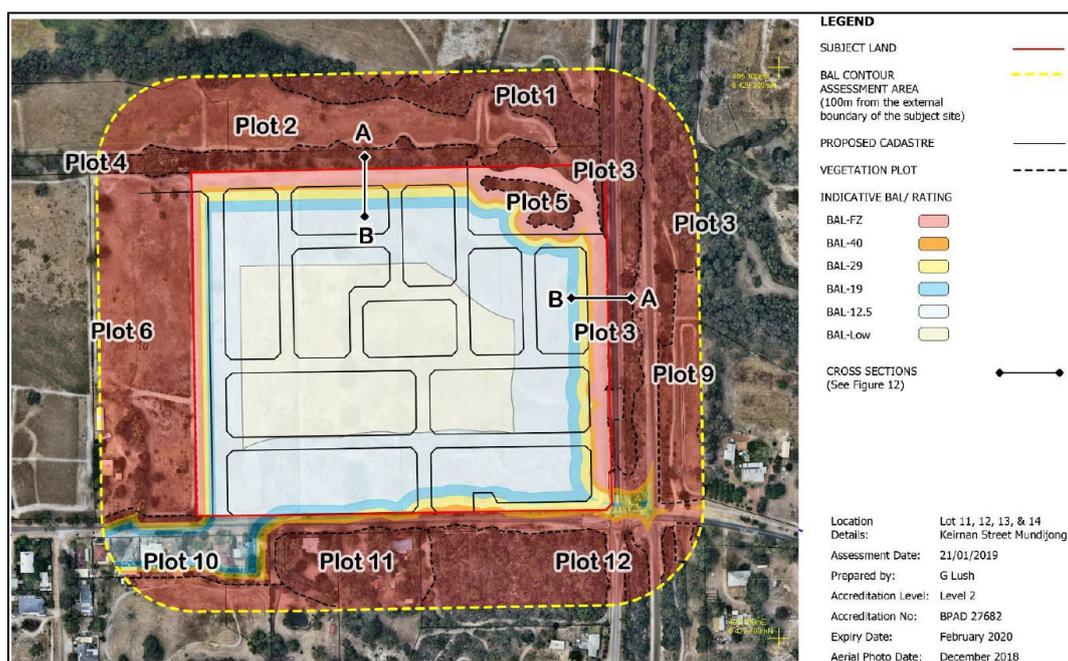


Figure 9 – BAL Contour Map (Lush Fire and Planning, 2020)

7 Influence of Archaeological Assessment

A preliminary archaeological assessment report was completed in April 2020 by Tomson Cultural Heritage Management. The assessment found:

- The previously recorded DPLH site 37115 (MJ-09) was relocated, one new Aboriginal archaeological place (Sam Woods' Camp [MJ20-01]) was located, and eighteen isolated archaeological artefacts were located during the assessment.
- One area was also identified by the Traditional Owners and archaeological team as having good potential for subsurface archaeological material.
- The archaeological assessment for Lots 10, 11, 12, 13, 14, 15 and 50 Keirnan Street, Lot 101 Lang Road and the Lang Road Reserve Mundijong is complete.
- One heritage site, Sam Woods' Camp (MJ20-01), was located within Lot 50 Keirnan Street.
- Previously recorded heritage place DPLH ID 37115 (MJ-09) was relocated and was noted to be in good condition.
- One area with moderate potential for subsurface archaeological material (PAD-01) was identified on Lot 50 Keirnan Street.
- Eighteen isolated artefacts were located during the archaeological survey.
- The Gnaala Karla Booja representatives participated in all aspects of the archaeological assessment and contributed to the results and recommendations outlined in this Preliminary Advice.

Given our understanding that the eighteen identified artefacts on Lots 11-14 are not considered to meet section 5 of the Aboriginal Heritage Act 1972, Calibre does not believe this will influence the design of the subdivision within Lots 11-14.

However, TCHM made further recommendation that:

- Heritage place DPLH ID 37115 and the newly recorded place, Sam Woods' Camp (MJ20-01) are likely to meet the requirements of sections 5 and 39(2) of the Aboriginal Heritage Act 1972 (AHA), and should be avoided and not impacted upon in any way without Ministerial consent under section 18 of the AHA.
- Further detailed recording and assessment of Sam Woods' Camp (MJ20-01) be undertaken, including the recording of oral histories, detailed surface recording, assessment of artefacts, and subsurface test excavations, prior to any section 18 application being made.
- A protective buffer of 30 m radius be applied around ID 37115 during any ground disturbing works so that its root system is not inadvertently affected.
- The area with potential archaeological subsurface deposit (PAD-01) be archaeologically tested and assessed prior to any section 18 application being submitted.
- If Sam Woods' Camp (MJ20-01) or ID 37115 cannot be avoided and will be impacted during future development, the proponent should consult further with Gnaala Karla Booja representatives about any proposed section 18 application, mitigation and salvage strategies and the management of salvaged materials, and comply with any other undertakings given in respect of the section 18 process.
- That the eighteen isolated stone artefacts recorded during survey do not, in TCHM's opinion, constitute Aboriginal archaeological sites according to sections 5 and 39 (2) of the AHA.
- The proponent implements suitable controls to prevent any impacts on ID 37115 and Sam Woods' Camp (MJ20-01) during earthworks, including adequate physical demarcation of site boundaries and effective management processes such as ground disturbance permits and operator inductions.



Figure 10 – Archaeological survey area and findings (TCHM, 2020)

8 Influence of Ethnographical Survey Assessment

A preliminary ethnographical survey assessment report was completed in April 2020 by Edward M. McDonald.

The desktop assessment found:

- A search of the AHIS revealed that there no ethnographic Aboriginal sites or Other Heritage Places (OHP) listed within Lots 50, 10, 11, 12, 13, 14 Keirnan Street, Mundijong. Previously recorded DPLH ID 37115 (MJ-09), a scarred or modified tree and OHP is located on Lot 101 (see Thomson 2020 for discussion).
- A review of previous heritage reports and the ethnohistorical literature also indicated that there were no earlier recorded heritage values that might reasonably be considered (ethnographic) Aboriginal sites on the land. However, as noted above Blockley & Greenfeld (1995) & Blockley et al. (1996) Aboriginal consultants had recommended a 30m buffer zone along Manjedal Brook in order to accommodate Nyungar concerns about protecting the quality of the water and its flow.

The ethnographic survey found:

- One ethnographic site, which also has archaeological components, was reported on Lot 50: Sam Woods' Camp (MJ20-01). The Aboriginal consultants requested that the campsite is preserved on the planned school ground and used for educational purposes or at minimum commemorated with interpretive signage, for example.

Impact on Engineering Design

The ethnographical survey assessment report recommends:

- That ground disturbance associated with the proposed development is monitored;
- Where possible, mature native trees are retained in the development, including those in the Lang Road Reserve;
- Runoff into Manjedal Brook is treated appropriately, and that nutrients and other pollutants are stripped prior to entering the Brook.
- That DJMM's proposed development of Lots 50, 10, 11, 12, 13 and 14 Keirnan Street, the eastern portion of Lot 101 and the undeveloped Lang Road reserve Mundijong, proceed on the basis that the concept plans presented to Bilya and Winjan in March 2020 are implemented.
- That scarred tree ID 37115 (MJ-09) is preserved in foreshore reserve along Manjedal Brook.
- That Sam Woods' Camp (MJ20-01) is preserved and its heritage values commemorated.
- That where the original ground surface is disturbed by earthworks that that disturbance is monitored.
- That where possible mature native trees, including those in the Lang Road Reserve, are retained in the development.
- That in accordance with best practice, nutrients and other pollutants are stripped from runoff and treated prior to entering Manjedal Brook.

The above concurs with the proposed design, monitoring, investigative and other measures recommended within this report.

9 Wastewater

9.1 Wastewater Collection

A reticulated network of DN150 gravity sewer mains will provide every lot with a single connection. The fall of the gravity sewer will be from the south-east to the north-west and will be designed in accordance with Water Corporation standard DS50. The subdivision’s sewer will connect to the designated connection point within the Lang Road reserve at proposed invert level 33.0m AHD.

Whilst lot size has not yet been confirmed, it is expected that a yield of 230 lots at a maximum size of 450m² will result in an area of 10.35ha contributing to the gravity sewer design flow (GSDF) calculation. A maximum calculated GSDF of 3.3L/s is expected to enter the downstream access chamber in the Lang Road reserve.

It is possible that there may need to be a designated tankering point for the development until the WWPS and gravity sewer mains to the pump station are constructed.

The staging of the sewer reticulation will be dependent on the expected sales focus areas.

9.2 Wastewater Treatment

A temporary Type 10 pump station in the Whitby development, east of Soldiers Road was considered but has been deemed to currently be near its capacity at 8L/s GSDF. Connection to this pump station was not considered suitable.

The ultimate scheme is for the development’s wastewater to be conveyed to the future Mundijong wastewater pump station (WWPS), located west of the LSP area on Scott Road, east of Tonkin Highway. This Type 90 WWPS has been designed to cater for the ultimate flows from a catchment that extends east of Soldiers Road. In March 2019, the Water Corporation provided an extract of the catchment plan (refer Figure 11) for reference and understanding of the development’s flows and eventual conveyance to the WWPS.

A DN450 gravity sewer main will be constructed within the Lang Road reserve connecting to a DN600 gravity sewer main on Scott Road before discharging to the proposed Mundijong WWPS. The pump station catchment’s Developer east of Soldiers Road will liaise with the Water Corporation for construction of the DN450 gravity sewer main which will be constructed along Lang Road to service their development and provide a connection point for this subdivision to the north-west of Lots 11-14 Keirnan Street (refer Figure 7).

The Water Corporation has advised that the WWPS is expected to be commissioned in 2020, although this is fully dependant on the surrounding Developers’ requirements. It is possible that DJM Mundijong Pty Ltd may choose to construct a portion of the DN450 gravity sewer main (west of the access chamber IL 33.0 on Lang Road) as part of a Developer Constructed Works Agreement (DCWA) for this subdivision’s works to service the Lot 11-14 development, depending on the timing of the contributing catchment developments. It is understood that this major headworks infrastructure is within the Water Corporation’s 5-year Capital Infrastructure Programme (CIP) and will be reimbursable.

If the other contributing catchment developers do not proceed with the construction of the Mundijong WWPS, and tankering from this development is not considered an option, then it is possible that the WWPS and the DN600 gravity sewer main will be required to be built to take the flows from this subdivision.

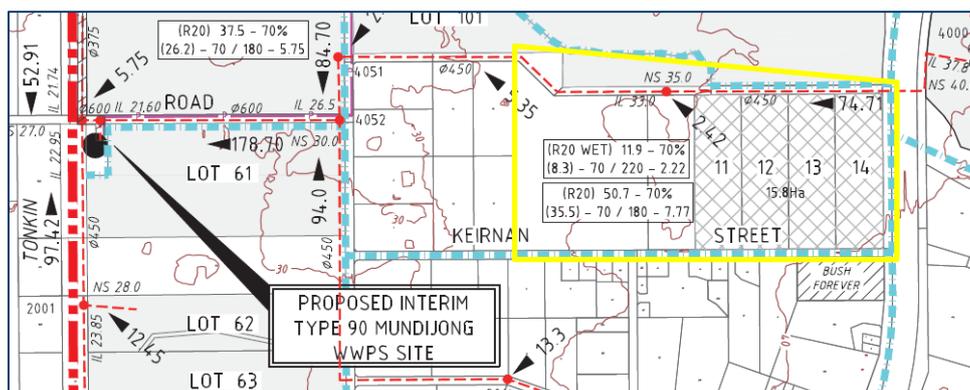


Figure 11 - Extract from Scott Road WWPS Scoping Report, 2018

10 Water Supply

The Water Corporation’s Esinet website shows that there is potable water supply available via the existing 315PE water main on Soldiers Road and the existing 150PVC water main (with a 100CI) on the south side of Keirnan Street (refer Figure 12). Water Corporation’s forward planning shows the proposed extension of a DN375 water main along the western side of Soldiers Road (refer Figure 13).

Water supply for the Lots 10 and 50 are expected to be from the existing 315PE potable water main on Keirnan Street.

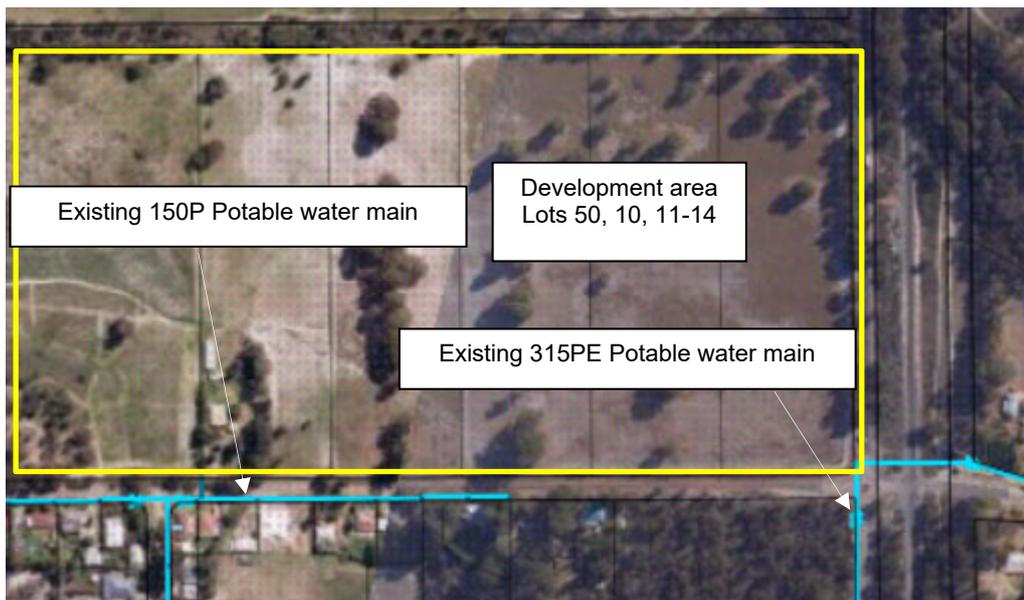


Figure 12 - Extract from Water Corporation Esinet, 2018

The water reticulation through the site will be via a reticulated 150PVC network. All design will be in accordance with Water Corporation Design Standard DS63.

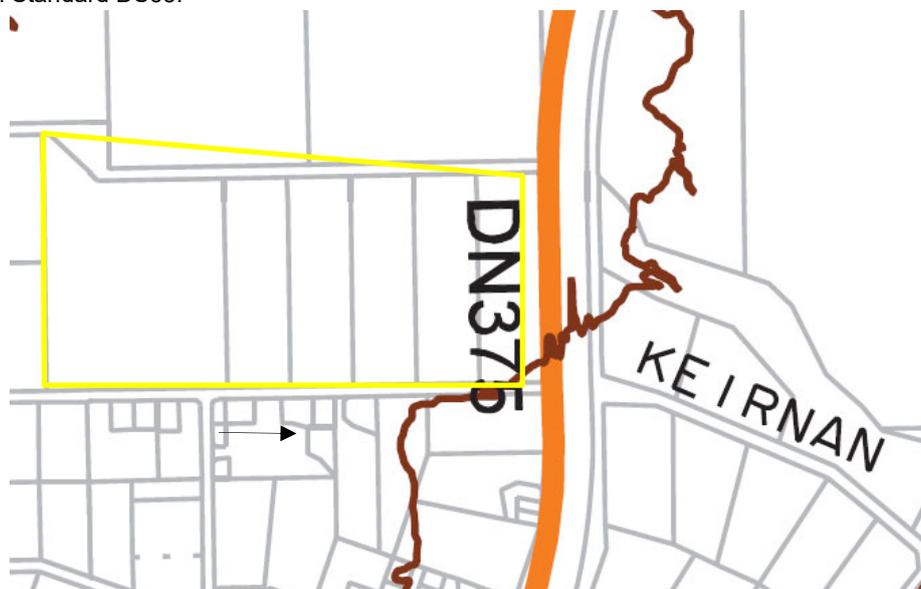


Figure 13 - Extract from Water Corporation Planning Map, 2018

11 Electrical Power Supply

There is existing low voltage (<1kV) distribution overhead power lines which run along Keirnan Street and high voltage distribution cables (1kV-33kV) that cross externally at the Keirnan Street/Soldiers Road intersection to the south-eastern area of the site. A high voltage termination exists in the same location (refer Figure 14).



Figure 14 - Extract from Western Power DBYD Map, 2018

The intention is to service the subdivision with underground power. Padmount sites for a switchgear and up to two transformers will most likely be required to provide network requirements within the subdivision.

Power capacity in the area is less than 5MVA.

Servicing of the subdivision will be confirmed by the Electrical Consultant who will need to liaise with Western Power. It is expected that Western Power will need to be commissioned to undertake a feasibility study so that upgrades and reinforcement to the surrounding existing network can be determined. The Developer will need to fund the cost of the feasibility study.

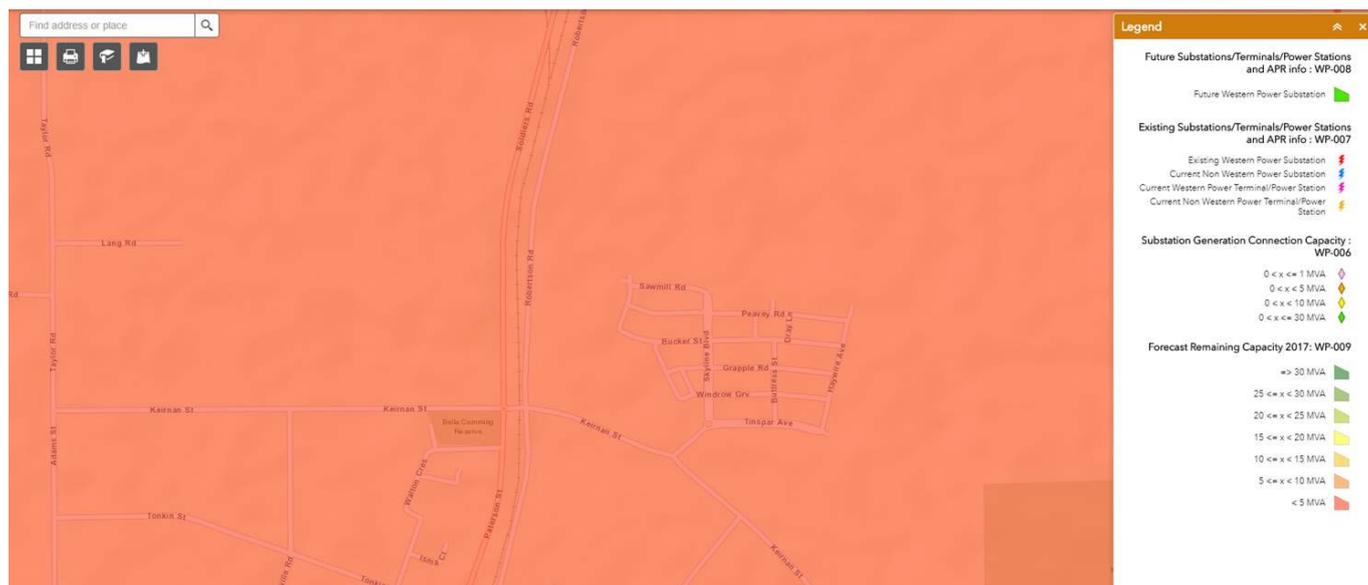


Figure 15 - Extract from Western Power Network Planning Map, 2018

Streetlights in the 10m road reserve are intended to be located on the southern side of the reserve.

12 Telecommunications

Both Telstra and NBN supply service to the area and it is expected that these services can extend to service the subdivision.

12.1 Telstra

Underground pit and pipe runs along the southern side of Keirnan Street, ending near the boundary of Lots 12/13. Further pipework is located in the western verge of Soldiers Road.

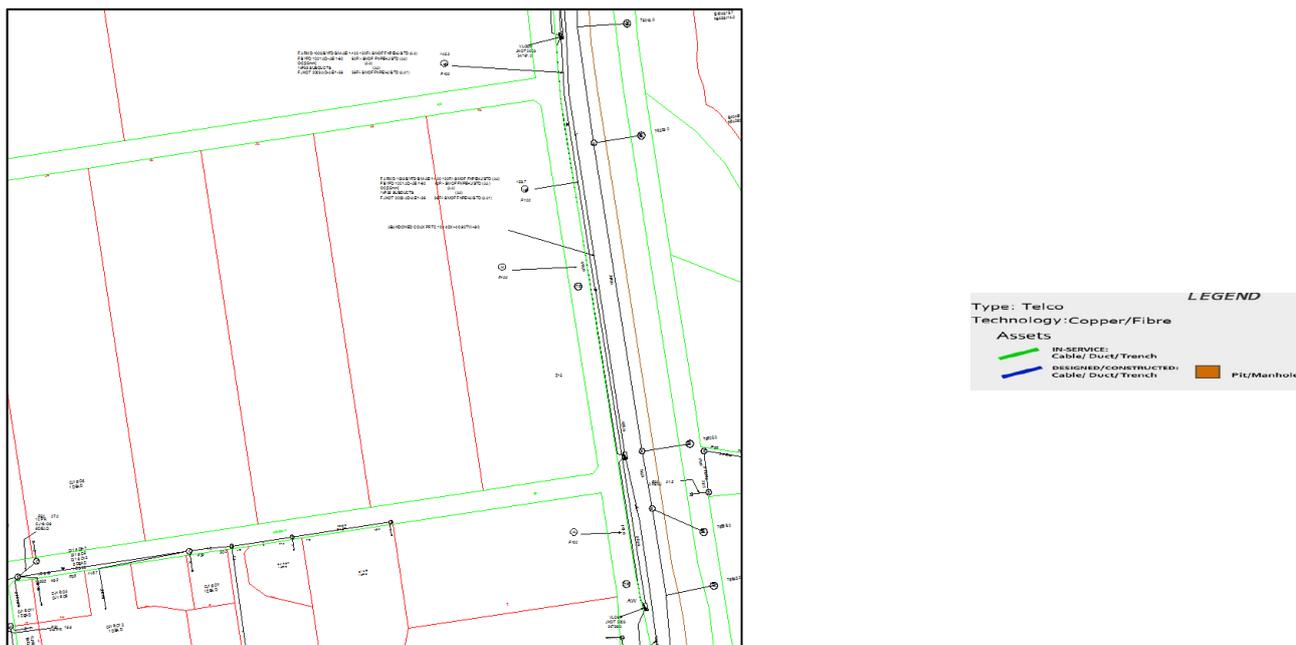


Figure 16 - Extract from Telstra Network Planning Map, 2018

12.2 NBN

Both Soldiers Road and Keirnan Street contain NBN copper/fibre, in-service cabling, with a connection pit located external to the south-western corner of the subdivision (refer Figure 17).



Figure 17 - Extract from NBN Network Map, 2018

13 Gas

An existing 160PE 1.5HP 700kPa gas main runs along Soldiers Road.

It is expected that ATCO Gas's network has sufficient capacity to provide gas to this subdivision.

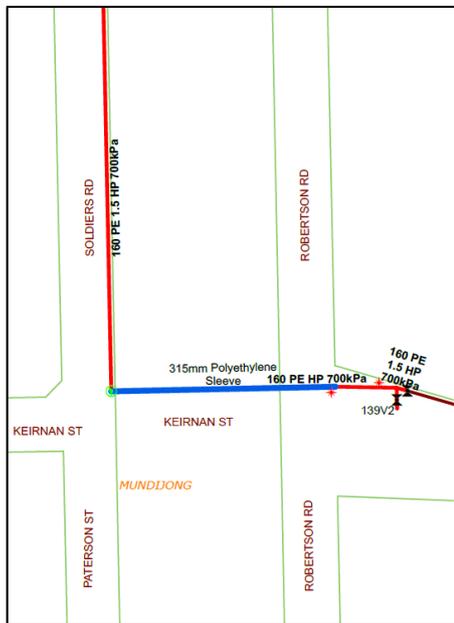
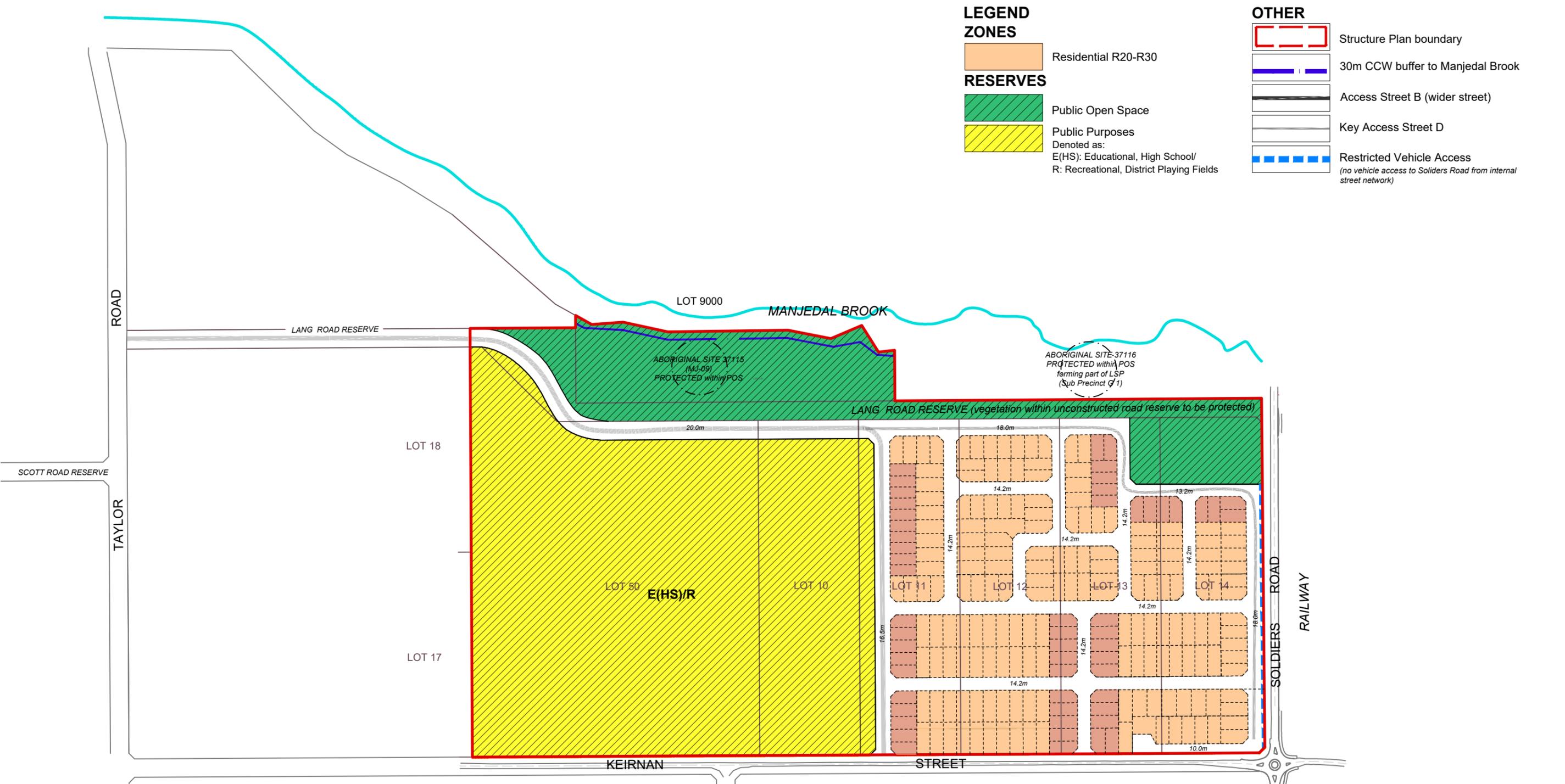


Figure 18 - Extract from ATCO Gas DBYD Map, 2018

LOTS 50, 10, 11-14 KEIRNAN ST, MUNDIJONG

Appendix A Local Structure Plan

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Notes

1. The High School site and the District Playing Field facilities are proposed as a co-located public purpose reservation, as preferred by the Shire of Serpentine-Jarrahdale (SP) and recommended in *Liveable Neighbourhoods*. The co-located facility is subject to further detailed design and a management arrangement being agreed between the Department of Education and the Shire of SJ, at the appropriate time in the future.
2. Public Open Space areas are indicative only and subject to detailed design and drainage considerations, at subdivision stage.
3. The key access streets are indicative only and subject to further detailed design at subdivision stage.
4. Any four-way intersections are to be designed to operate as priority-controlled intersections, subject to further design at subdivision stage.
5. The section of Lang Road Reserve to be transferred to public open space is required in order to retain the existing mature vegetation within that reservation, which may provide suitable habitat for the black cockatoo species.
6. No direct vehicle access from the internal road network is permitted to Soldiers Road, due to the need to protect the significant vegetation existing within the road reservation.
7. Acoustic noise mitigation is required to portion of the land to be developed within the LSP Area adjacent to Soldiers Road, to reduce the impact of noise exposure from the railway transportation to the east of Soldiers Road. The affected lots and the specific details of the dwelling treatment requirements are to be addressed at subdivision stage.

CONCEPT DESIGN - SUBDIVISION

Lots 11, 12, 13 and 14 Keirnan Street, Mundijong (LSP Area G2)
DJM MUNDIJONG PTY LTD

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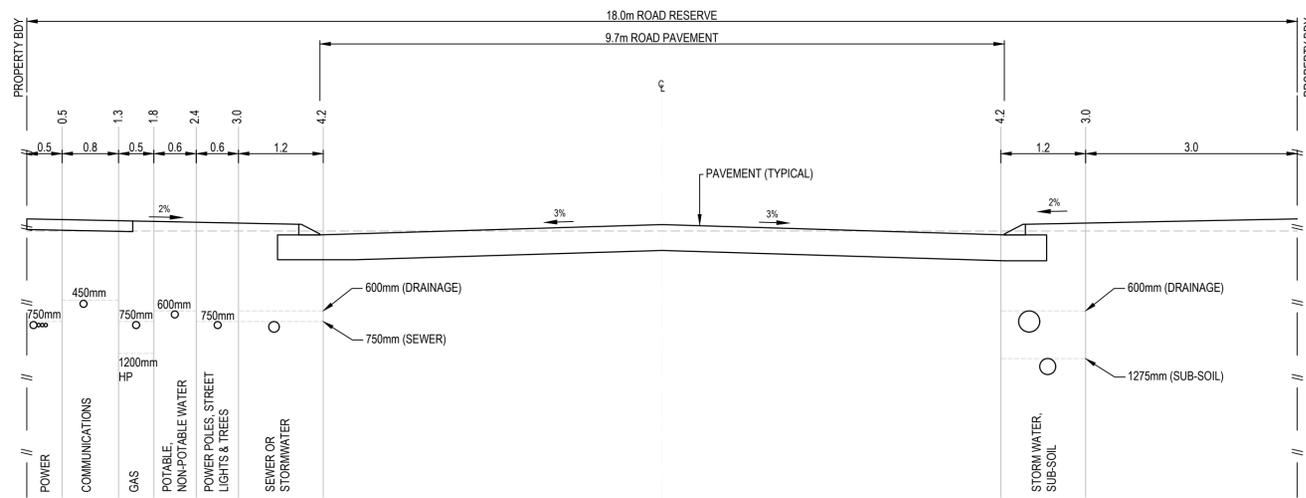


PETER WEBB AND ASSOCIATES
CONSULTANTS IN TOWN PLANNING & URBAN DESIGN

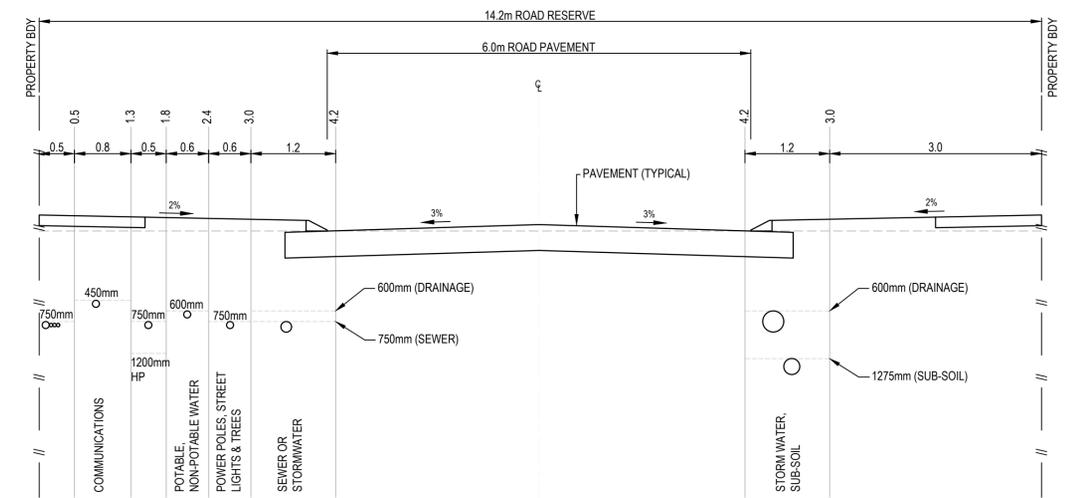
LOTS 50, 10, 11-14 KEIRNAN ST, MUNDIJONG

Appendix B Proposed Street Cross Sections

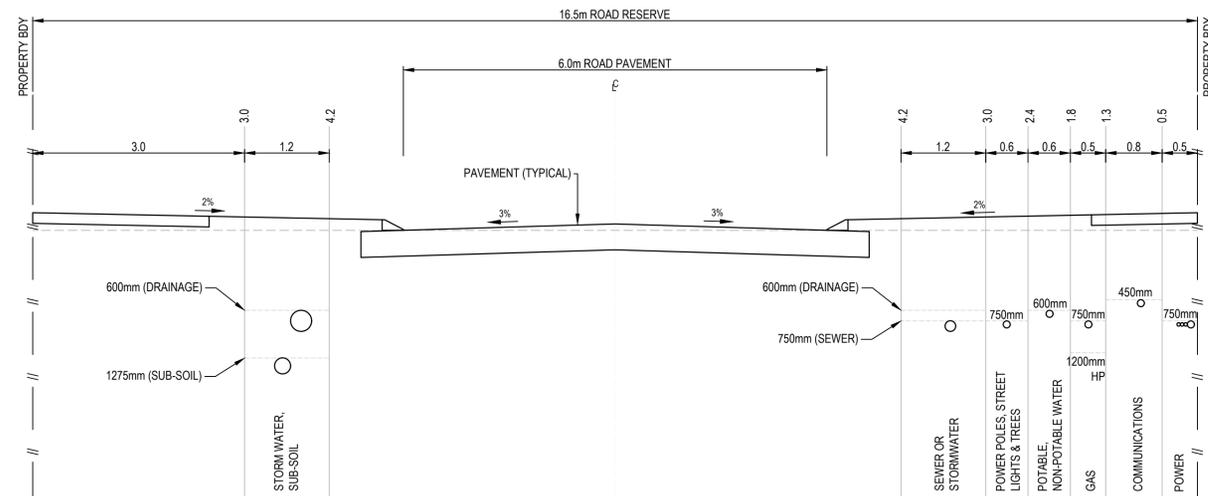
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TYPICAL CROSS SECTION (18.0m ROAD RESERVE)



TYPICAL CROSS SECTION (14.2m ROAD RESERVE)



TYPICAL CROSS SECTION (16.5m ROAD RESERVE)



REV	DATE	ISSUE DESCRIPTION	DRAWN	DESIGN	CHECK
A	29.04.19	ISSUED FOR INCLUSION IN LSP SUBMISSION	P.W		N.A

STATUS	PRELIMINARY NOT FOR CONSTRUCTION
APPROVED	

SCALE
0 0.5 1.0 1.5 2.0 2.5
SCALE 1:50

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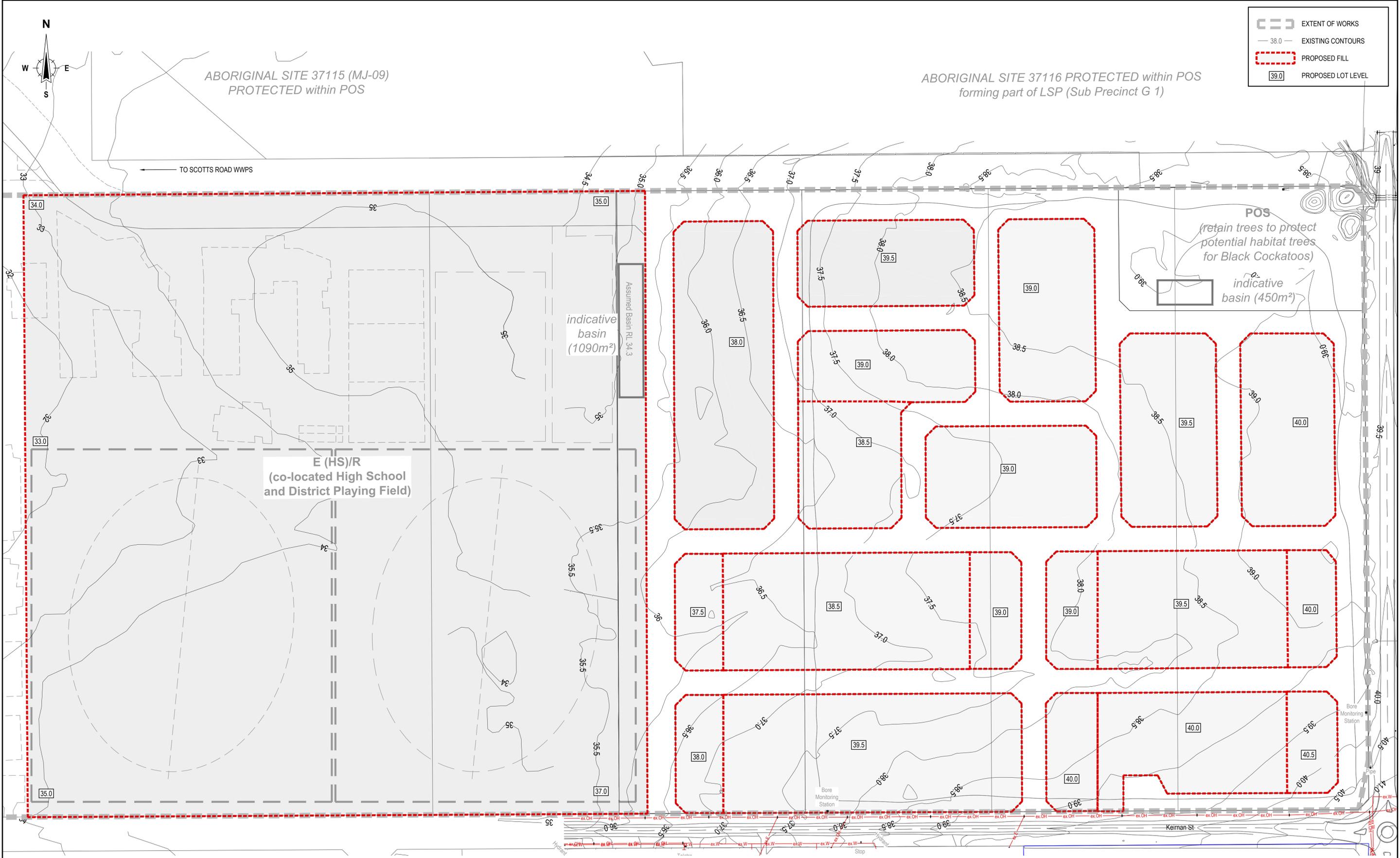
PROJECT
PROPOSED SUBDIVISION
LOTS 11-14 KEIRNAN STREET
MUNDIJONG

DRAWING TITLE TYPICAL ROAD CROSS SECTIONS		
PROJECT No. 18-000798	DRAWING No. SK03	REVISION A

LOTS 50, 10, 11-14 KEIRNAN ST, MUNDIJONG

Appendix C Proposed Finished Levels

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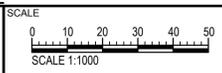


EXTENT OF WORKS
 --- 38.0 --- EXISTING CONTOURS
 [Red dashed box] PROPOSED FILL
 [Box with 39.0] PROPOSED LOT LEVEL



**PRELIMINARY
NOT FOR CONSTRUCTION**

REV	DATE	ISSUE DESCRIPTION	DRAWN	DESIGN	CHECK
B	27/02/20	EXTENT OF WORK AMENDED AND LEVELS ADDED	P.W.		N.A.
A	15.05.19	ISSUED FOR INCLUSION IN LSP SUBMISSION	J.H.		N.A.



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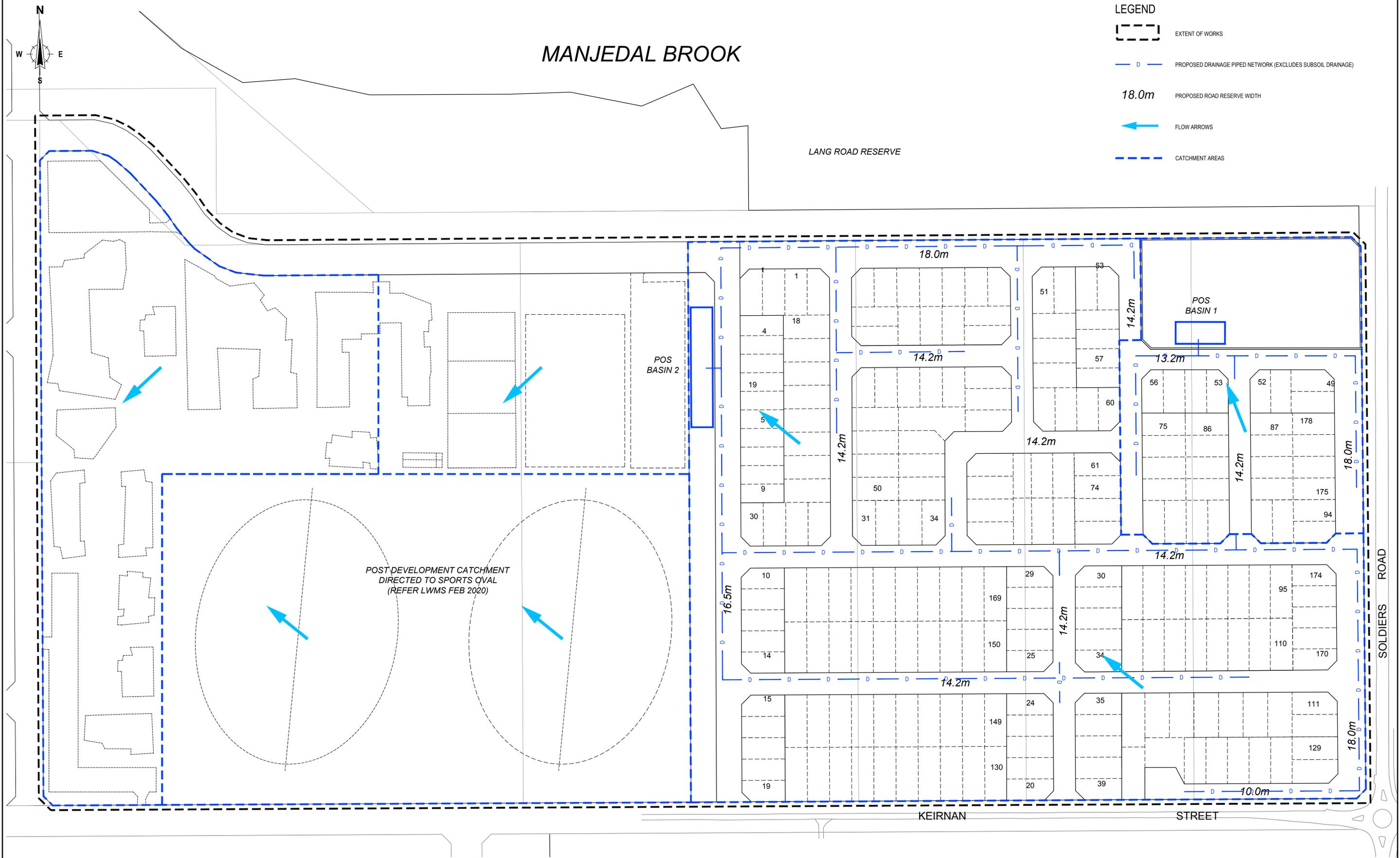
PROJECT
 PROPOSED SUBDIVISION
 LOTS 11-14 KEIRNAN STREET
 MUNDIJONG

DRAWING TITLE PROPOSED FILL LEVELS PLAN		
PROJECT No. 18-000798	DRAWING No. SK06	REVISION B

LOTS 50, 10, 11-14 KEIRNAN ST, MUNDIJONG

Appendix D Proposed Drainage Layout for
Lots 11-14 (Subdivision)
Refer LWMS for Overall Drainage Layout

DJM MUNDIJONG PTY LTD



LEGEND

- EXTENT OF WORKS
- PROPOSED DRAINAGE PIPED NETWORK (EXCLUDES SUBSOIL DRAINAGE)
- 18.0m** PROPOSED ROAD RESERVE WIDTH
- FLOW ARROWS
- CATCHMENT AREAS



REV	DATE	ISSUE DESCRIPTION	DRAWN	DESIGN	CHECK
C	27/02/20	EXTENT OF WORKS AMENDED		P.W	N.A
B	10/05/19	ISSUED FOR INCLUSION IN LSP SUBMISSION		P.W	N.A
A	29.04.19	ISSUED FOR INCLUSION IN LSP SUBMISSION		P.W	N.A

STATUS
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PROJECT
PROPOSED SUBDIVISION
LOTS 11-14 KEIRNAN STREET
MUNDIJONG

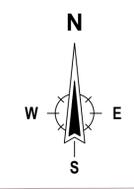
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PROPOSED DRAINAGE LAYOUT		
PROJECT No.	DRAWING No.	REVISION
18-000798	SK01	C

LOTS 50, 10, 11-14 KEIRNAN ST, MUNDIJONG

Appendix E Proposed Sewer Layout

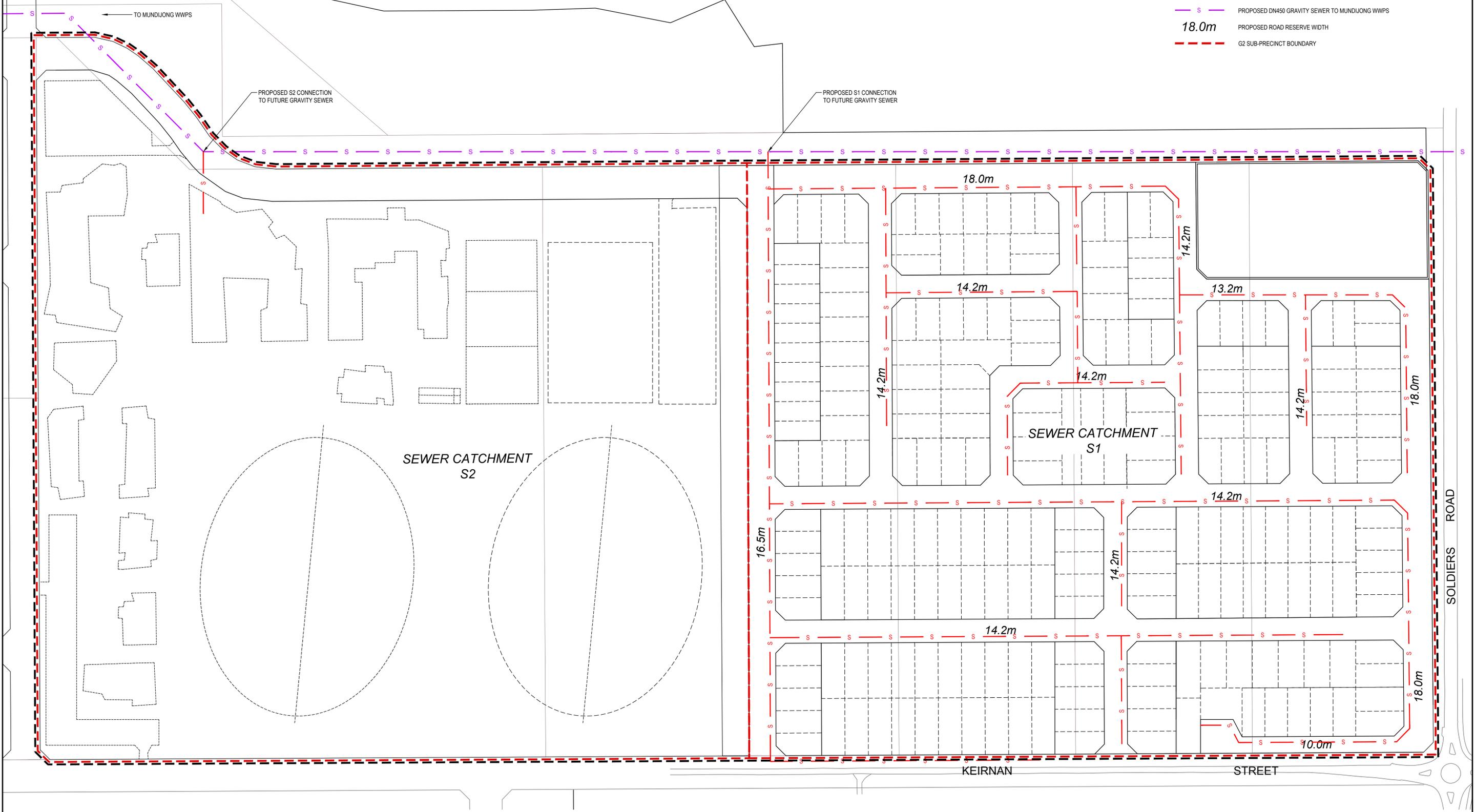
DJM MUNDIJONG PTY LTD

MANJEDAL BROOK



LEGEND

- EXTENT OF WORKS
- PROPOSED DN150 SEWER RETICULATION
- PROPOSED DN450 GRAVITY SEWER TO MUNDIJONG WWPS
- 18.0m PROPOSED ROAD RESERVE WIDTH
- G2 SUB-PRECINCT BOUNDARY



REV	DATE	ISSUE DESCRIPTION	DRAWN	DESIGN	CHECK
B	27/02/20	EXTENT OF WORKS AMENDED		P.W	N.A
A	29.04.19	ISSUED FOR INCLUSION IN LSP SUBMISSION		P.W	N.A

STATUS
**PRELIMINARY
NOT FOR CONSTRUCTION**

APPROVED

SCALE
0 10 20 30 40 50
SCALE 1:1000

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CLIENT
DJM Mundijong Pty Ltd

DISCLAIMER
ALL DIMENSIONS TO BE CHECKED ON SITE BY CONTRACTOR PRIOR TO CONSTRUCTION. USE WRITTEN DIMENSIONS ONLY. DO NOT SCALE. NOT FOR CONSTRUCTION UNLESS STAMPED BY CERTIFYING AUTHORITY



PROJECT
PROPOSED SUBDIVISION
LOTS 11-14 KEIRNAN STREET
MUNDIJONG

DRAWING TITLE PROPOSED SEWER LAYOUT		
PROJECT No.	DRAWING No.	REVISION
18-000798	SK02	B



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