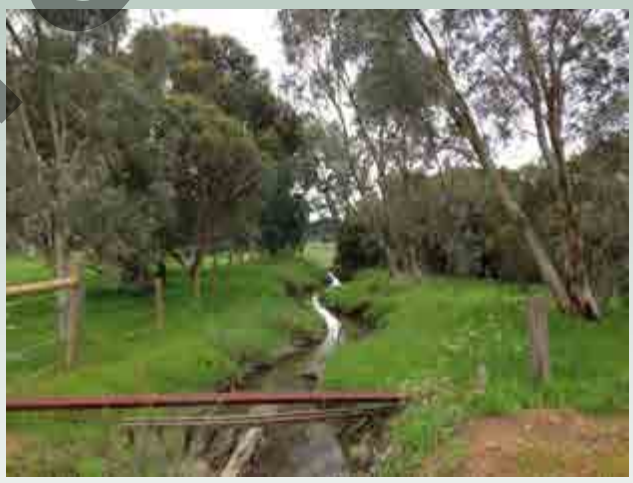
Serpentine Townsite

Local Structure Plan



January 2014

Shire of Serpentine Jarrahdale
Sustainable. Connected. Thriving!

Department of Planning
GOVERNMENT OF WESTERN AUSTRALIA

Western Australian Planning Commission

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Part 1 Statutory Section

1.0 Structure Plan Area

This part applies to the Serpentine Townsite Local Structure Plan (LSP) shown on **Figure 1** and is located within the Shire of Serpentine Jarrahdale (the Shire).

2.0 Structure Plan Content

This Structure Plan comprises the:

- Statutory Section (Part 1);
- Explanatory Section (Part 2); and
- Appendices – Detailed Technical Reports.

3.0 Interpretation and Use Class Permissibility

The words and expressions used in this LSP shall have the same respective meanings as given to them in the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 (the Scheme).

4.0 Relationship with the Scheme

4.1 In accordance with clause 5.18 of the Scheme, the provisions, standards and requirements specified under Part 1 of this Structure Plan have the same force and effect as if it were a provision, standard or requirement of the Scheme. Part 2 of this LSP is for explanatory purposes only, in order to provide a descriptive analysis of the LSP.

4.2 In the event of there being any inconsistencies or conflict between the provisions, standards or requirements of the Scheme and the provisions, standards or requirements of this LSP, then the provisions, standards or requirements of the Scheme shall prevail to the extent of any inconsistency.

5.0 Operation Date

In accordance with sub-clause 5.18.6 of the Scheme, this LSP shall come into operation when it is adopted by the Shire pursuant to sub-clause 5.18.6.1.

6.0 Zones, Reserves and Residential Density Codes

The LSP delineates and depicts the zones, reserves and residential density codes applicable to the LSP area according to the legend thereon.

The zones, reserves and residential density codes designated under this LSP apply to the land within it as if they were incorporated in the Scheme.

Subdivision and development shall generally be in accordance with the LSP or any variations as approved by the Shire and the Western Australian Planning Commission (WAPC).

An overlay plan will be required for all sites coded R5 at 'street block' level, demonstrating how the higher densities can be achieved in the future if and when reticulated sewerage becomes available.

7.0 Provisions

7.1 Local Development Plans (LDPs) (formerly referred to as Detailed Area Plans) shall be prepared for certain significantly located or irregularly shaped residential lots within the LSP area. Such lots requiring LDPs are identified under part 7.4.1 *Local Development Plans* of the LSP. Information detailed in a LDP may include, but is not limited to:

- Building Envelopes;
- Setbacks;
- Building Orientation;
- Vehicle and Pedestrian Access Arrangements;
- Retention of Vegetation;
- Fencing;
- Development Provisions; and
- Building protection/hazard reduction.

7.2 The implementation of the LSP will be facilitated through development and subdivision approvals which may be required to include wider contextual analysis. Where necessary, planning consideration should include elements of development outside of the LSP area.

7.3 Development proposals that comply with the provisions of this LSP or an approved LDP are exempt from obtaining Planning Approval under Clause 5.1.2. of the Scheme. Separate Planning Approval obtained through the lodgement of a Development Application shall only be required if variations to the proposed LDP are proposed.

7.4 The implementation of the LSP will be facilitated through development and subdivision approvals which shall generally conform to the LSP. Applications shall generally comply with the Character Statement and Development Principles listed in the following sub-section:

7.4.1 Local Development Plans (LDPs)

LDPs are required for but not limited to the following lots contained within the LSP:

- Richardson Street (Lot 84; Lot 1; Lot 82; part of Lot 14; part of Lot 12; part of Lot 10)
- Reason – Adjacent to Bush Forever, proximity to railway line and abuts public open space / drainage.

- Karnup Road (part of Lot 17; part of Lot 18)
- Reason – Irregular lot shape.

- Rudall Street (part of Lot 102)
- Reason – Abuts public open space / drainage.

- Arnold Road (Lot 98; part of Lot 106)
- Reason – Abuts public open space / drainage.

7.4.2 Character Statement

The development and subdivision of land within the LSP area will be undertaken over an extended timeframe during which the Townsite will evolve as a significant community, commercial and civic locality in the Shire. Whilst cognisant of the land's urban zoning which will facilitate the development of the area as a modern contemporary neighbourhood, it is equally important that the site's character and rural history is captured and reflected in the LSP.

7.4.3 Visual Amenity and View Corridors

The visual amenity and view corridors within the subject area have been considered in the context of the current landscape within the LSP area. The main view corridors are facing the Darling Scarp, Serpentine River and the Serpentine Sports Reserve which could all contribute to public amenity. In general, the study area has a gentle undulating topography with vegetation present along most of the boundaries.

7.4.4 Community Design Principles

The LSP is intended as a guide for future urban development with the objective of generally identifying appropriate locations for housing types and densities whilst permitting flexibility to ensure the delivery of a diverse range of dwelling styles.

7.4.5 Biodiversity Principles

The primary objective of the Shire's Local Biodiversity Strategy is to maintain and enhance natural vegetation, living streams and biodiversity throughout the Shire where possible. It specifies the aim of incorporating biodiversity conservation values as a guide to development assessment.

7.4.6 Solar Design and Resource Efficiency Principles

Lot layout through subdivision and the construction of dwellings and ancillary development needs to be orientated to maximise opportunities for solar passive design and energy efficient design.

The layout of subdivision also needs to respect existing landforms / drainage and where practicable, provide opportunities to retain the natural topography. The minimisation of cut and fill should be explored at all stages of subdivision and development.

8.0 Investigations and Management Plans

8.1 The following investigations and management plans may be required at the subdivision stage, where appropriate:

- Urban Water Management Plan/s (aligning with the Local Water Management Strategy);
- Environmental Management Plan/s;
- Public Open Space Management Plan/s;
- Fire Management Plan/s; and
- Acoustic Report (addressing noise impacts from the railway line).

Further studies may also be required by the Shire and/or the WAPC, as appropriate.

8.2 A separate Development Contribution Plan (DCP) will be prepared in accordance with the WAPC's State Planning Policy No. 3.6 - *Development Contributions for Infrastructure* (SPP 3.6) by the Shire. As described in SPP 3.6, DCPs seek to facilitate the orderly provision of infrastructure in Development Contribution Areas by prescribing cost contributions for developers of land in such areas.

DCPs can include 'standard' infrastructure (as specified in Appendix 1 of SPP 3.6) and 'community' infrastructure (comprising social and cultural facilities) and contributions may be made in the form of land, construction works or financial contributions, or a combination of the three.

8.3 Environmental management plans prior to subdivision and development must address the following where relevant:

- Contaminated soils
- Acid sulphate soils
- Hydrology
- Vegetation
- Flora
- Fauna

9.0 Local Structure Plan

A copy of the draft LSP Map appears as **Figure 1** below.

Figure 1: Local Structure Plan Map.

Part 2 Explanatory Section

1.0 Planning Background

1.1 Introduction and Purpose

The report has been prepared in support of a LSP in accordance with the Structure Plan related provisions of the Scheme and the Western Australian Planning Commission (WAPC) Structure Plan Guidelines.

The LSP aims to create an urban settlement which respects the historic environment of the Serpentine Townsite. The following main design principles have been established:

- To respect the heritage of Serpentine;
- To recognise the existing street layout pattern while providing guidance for future urban development;
- To provide for the growth of existing commercial, retail, civic and residential uses that have exposure to the existing and future movement network; and
- To capitalise upon views to the Darling Scarp and the Serpentine Sports Reserve.

This report provides a descriptive analysis of the LSP, including site description, the existing statutory planning framework, opportunities and constraints and the proposed implementation.

1.2 Land Description

1.2.1 Location

The subject land is located within the south-eastern corridor of the Perth metropolitan region, approximately 50 kilometres south-east of the Perth city centre in the Shire of Serpentine Jarrahdale (see **Figure 2**: Location Plan).

The subject area is bound by Arnold Road to the south, Richardson Street to the west, Summerfield Road to the north and Rudall Street to the east. Access to the subject area can be obtained from South Western Highway to the east, Karnup Road to the west which links to Mundijong to the north and Baldivis to the west.

Properties to the immediate north and east are zoned Rural under the Metropolitan Region Scheme (MRS) and are currently utilised for a variety of agricultural and conservation purposes.

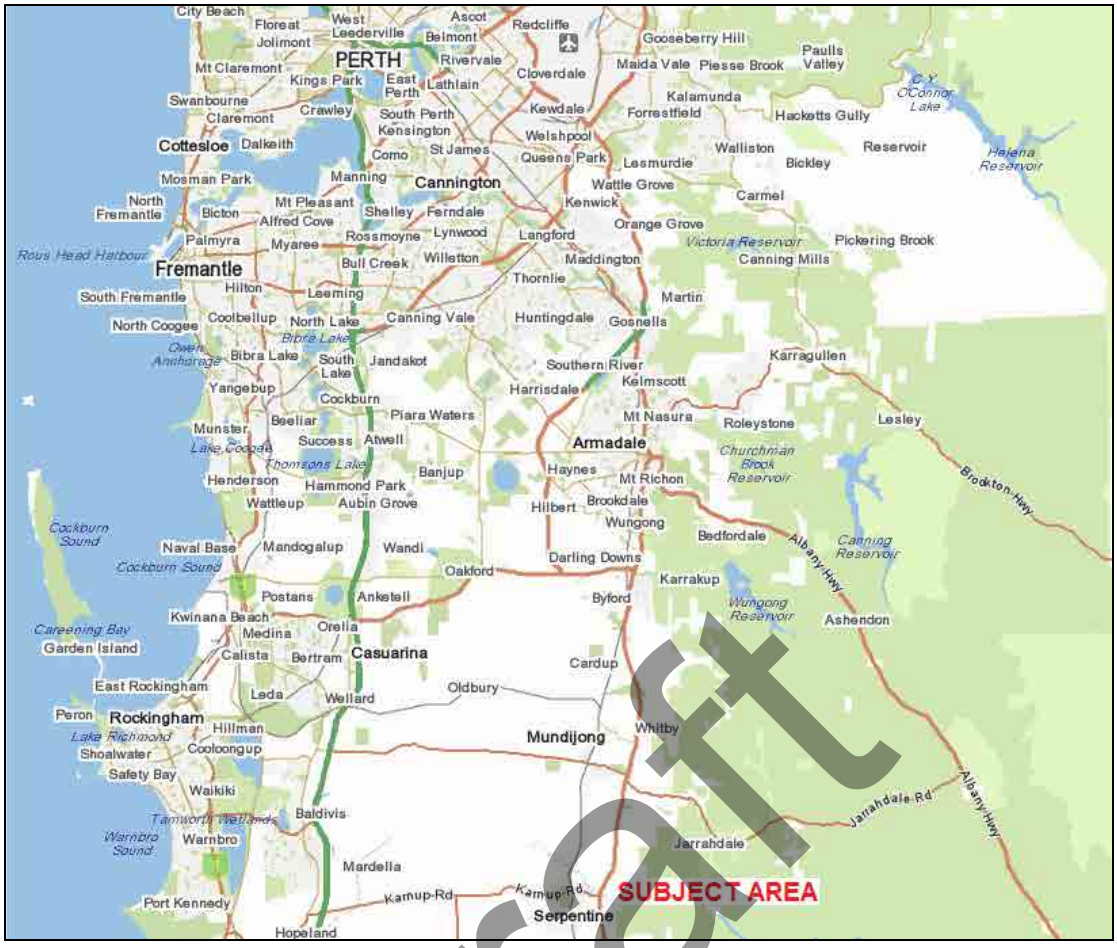


Figure 2: Location Plan.

South Western Highway, located to the east of the study area, carries a range of vehicles including buses and trucks between Perth and the south-west. A railway line is located directly west of the LSP area running parallel to Richardson Street and Hardey Road. An acoustic report should be prepared at subdivision stage for the northern part of the Serpentine Townsite to address the impact of noise from the railway line.

1.2.2 Area and Land Use

The study area is approximately 124 hectares in size and has the potential to provide approximately 47 new residential lots. Except for a small area of commercial land along Wellard Street and several existing public open spaces, the remainder of the Townsite is utilised for rural and residential purposes.

The Serpentine retail area comprises of a small number of local convenience retail and service outlets, focussed along Wellard Street and parts of Richardson Street.

Other areas of activity include the Clem Kentish Reserve containing the Clem Kentish Hall, an adjacent Tractor and Machinery Museum, tennis

courts, an oval with a cricket pitch and some bushland as well as the Serpentine Primary School along Lefroy Street.

1.3 Planning Framework

1.3.1 Zoning

Metropolitan Region Scheme (MRS)

All landholdings within the study area are zoned 'Urban' under the MRS (see **Figure 3**: MRS Zoning Plan).

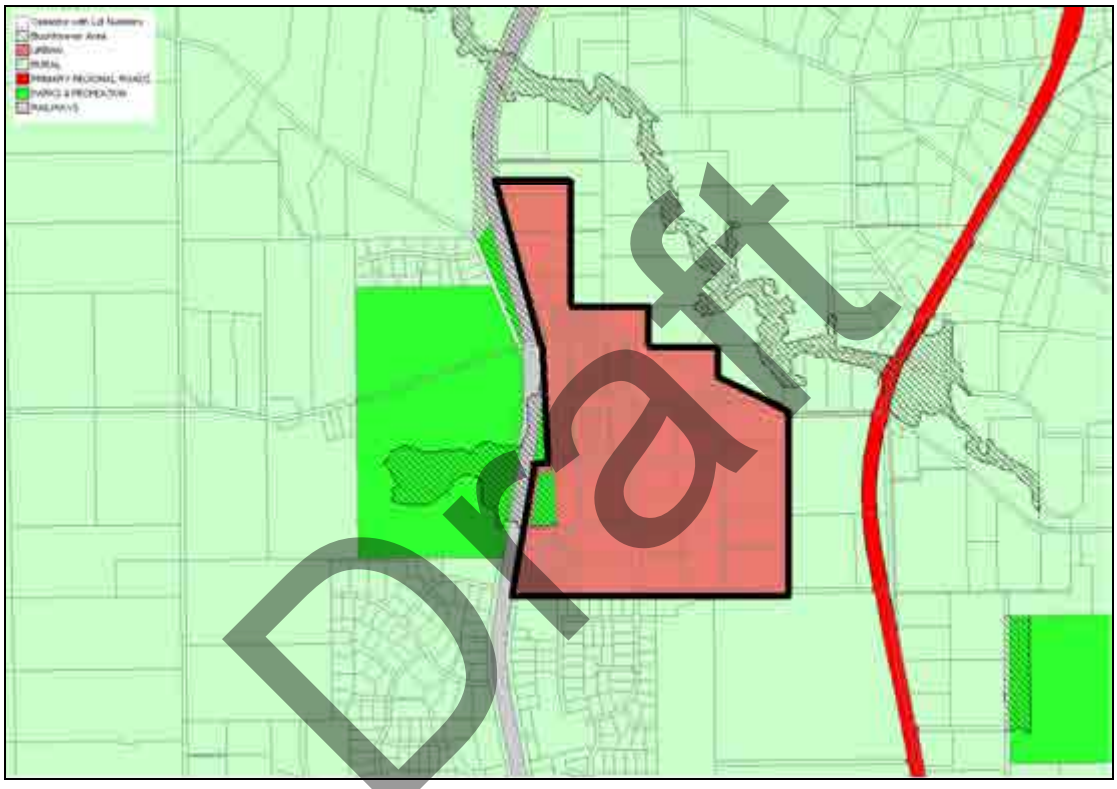


Figure 3: MRS Zoning Plan.

Town Planning Scheme No.2

The subject site is comprised of land zoned 'Urban Development' and reserved for 'Parks and Recreation', 'Public Purpose' and 'Public and Community Purpose' under the Scheme (see **Figure 4:** Town Planning Scheme No. 2 Zoning Plan).

The 'Urban Development' zone requires that a LSP be prepared to establish the pattern of development and zoning designations. The LSP aims to establish comprehensive structure planning mechanisms to limit continued ad hoc subdivision.

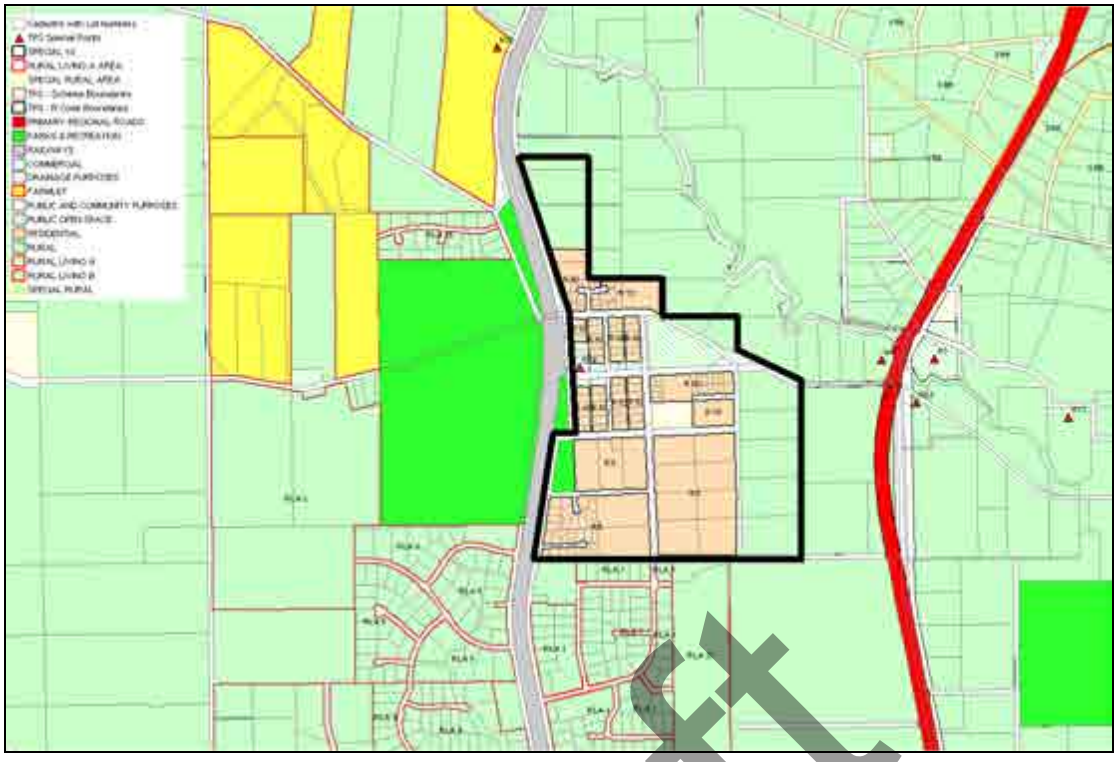


Figure 4: Town Planning Scheme No. 2 Zoning Plan.

1.3.2 Strategic Context

Directions 2031 and Beyond

Directions 2031 and Beyond (Directions 2031) is a strategic plan that establishes a vision for the metropolitan Perth and Peel region. Six sub-regions are identified. The Shire of Serpentine Jarrahdale is within the South East sub-region, which is guided by the draft *Outer Metropolitan Sub-regional Strategy.*

Directions 2031 focuses on a 'Compact Growth' strategy for accommodating and servicing future population growth. This assumes a yield of 15 dwellings per hectare and seeks to balance the need for increased densities within existing urban areas with outward urban expansion. Improving and supporting transport networks is a key objective of this growth scenario.

The LSP achieves a yield of 5-10 dwellings per hectare. This is considered appropriate for Serpentine, given that the town remains distant from established and planned growth areas and retains an individual character defined by its history and rural setting.

The objectives of Directions 2031 are reflected in the LSP and are addressed in Section 2 - *Site Conditions and Constraints* of this report.

Shire of Serpentine Jarrahdale Rural Strategy

The Shire's Rural Strategy was adopted in 1994 and provides a framework for the *"detailed forward planning of rural areas to allow for the development and growth, protect and appropriately use rural resources and preserve the character, heritage and natural features for the Shire".* Serpentine (along with Jarrahdale and Keysbrook) is identified as a *"development node focused on [its] existing urban centre...servicing the needs of their local communities and surrounded by rural land".* The need for structure planning of the Serpentine Townsite to guide its development in accordance with this objective was identified formally through the 2002 review of the Rural Strategy.

The Rural Strategy Review 2013 excludes the Serpentine LSP area from the Strategy and defers detail to this LSP.

1.3.3 State Policies and Guidelines

The LSP area and proposals are directly affected by the following State Planning Policies (SPPs). A summary of each policy and a short statement of relevance is provided.

SPP 2.1 - Peel Harvey Coastal Plain Catchment (SPP 2.1)

In general SPP 2.1 specifies land use and development controls for the Peel-Harvey Catchment to ensure the protection of wetlands and water resources. The policy contains provisions to ensure that proposals for urban and intensive agricultural development are assessed and undertaken in a manner that minimises its impact on local catchment areas.

SPP 2.1 seeks to minimise the export of nutrients (primarily phosphorous) from land use and development within the catchment to the drainage network. It deals in particular with phosphorous discharge arising from the subdivision and development of land and requires that this should not exceed pre-development levels. The pre-development monitoring establishes baseline water quality levels, against which future monitoring of drainage (post development) can be compared. Further to this, Public Open Space Management Plans will need to be prepared and implemented during the following subdivision process, in order to minimise nutrient export.

State Planning Policy 2.8 - Bushland Policy for the Perth Metropolitan Region (SPP 2.8)

Through the provision of a policy and implementation framework SPP 2.8 aims to ensure that bushland protection and management issues are addressed and considered in land use planning in the Perth Metropolitan Region. It seeks to establish a regional level conservation

system with the intention of protecting and managing significant bushland areas to preserve biodiversity and environmental values.

SPP 2.8 functions as a supplementary policy to State Planning Policy 2: Environment and Natural Resources Policy (SPP 2), specifically addressing in detail the protection and management of Bush Forever areas and local bushland. The LSP area contains or abuts Bush Forever sites.

State Planning Policy 2.9 - Water Resources (SPP 2.9)

SPP 2.9 provides clarification and guidance in relation to planning for water resources to ensure the existing and long term quality and quantity of available water resources.

Policy measures include:

- Protecting significant environmental, recreational and cultural values of water resources;
- Preventing or ameliorating potential impacts arising from adverse water quality, removal of riparian vegetation, prevent erosion and pollution; and
- Promoting environmental rehabilitation, improved nutrient levels and restoring flows of watercourses.

The policy deals with surface and groundwater resources, wetlands, rivers, estuaries and Total Water Cycle Management.

The LSP adheres to the principles of Water Sensitive Urban Design and seeks to maximise onsite infiltration and to minimise the export of nutrients from the site. The LWMS calculations and designs for the LSP area demonstrably ensure that stormwater during rainfall events up to 100 year storm event will be detained onsite for the prescribed period.

SPP 3.1 - Residential Design Codes (R-Codes)

Under the provisions of the R-Codes, all residential development is controlled so as to ensure adequate standards of access, amenity and housing choice.

The LSP generally proposes a base density of R5 with R10 densities to the north of Tonkin Street, and supports generally regular lot shapes to ensure that land is readily developable. Future development must comply with the R-Codes and the Scheme.

SPP 5.4 - Road and Rail Transport Noise and Freight Considerations in Land Use Planning (SPP 5.4)

SPP 5.4 is intended to ensure the minimisation of transport noise on nearby “noise sensitive premises” without imposing “unreasonable

restrictions" on nearby development or increasing costs associated with the provision of infrastructure.

The policy defines:

- Criteria to be used in the assessment of proposals involving noise sensitive development in the vicinity of major transport corridors;
- Measures that can be adopted to reduce road and rail traffic noise; and
- The circumstances when such measures are required.

The provisions of SPP 5.4 are applicable to the northern part of the LSP area which is likely to be impacted by noise from the railway line and will require an acoustic assessment to be undertaken at subdivision stage.

SPP 3.6 - Development Contributions for Infrastructure (SPP 3.6)

SPP 3.6 sets out development contribution provisions for standard infrastructure items as well as for community infrastructure items not included in the standard provisions through development contribution plans.

Liveable Neighbourhoods

Liveable Neighbourhoods (LN) has been adopted by the WAPC to guide structure planning and subdivision throughout Western Australia. Objectives of particular relevance to this LSP include the following:

- To ensure a site-responsive approach to urban development that supports and enhances the context in which it is located, strengthens local character and identity, integrates with its context and promotes a sense of community;
- To provide a safe, convenient and legible movement network, and to provide attractive streetscapes;
- To ensure that urban development lots have a suitable level of amenity, services and access;
- To provide a network of well-distributed parks and recreation areas that offer a variety of safe, appropriate and attractive public open spaces;
- To integrate appropriate water management measures in an efficient urban structure and range of parkland types.

This LSP has been prepared in accordance with these and other relevant principles identified in LN. Further reference is to be made to LN at the subdivision stage, which entails more detailed design work relating to, for example, lot layout, servicing and access, public open space and urban water management.

1.3.4 Local Planning Policies

Local Planning Policy No.4 - Revegetation (LPP 4)

LPP 4 seeks to facilitate the revegetation of cleared land, encouraging the use of local native flora. It emphasises the importance of revegetation as a planning consideration when determining planning proposals. The policy applies to all development and subdivision proposals in the Shire.

Local Planning Policy No. 6 - Water Sensitive Design (LPP 6)

LPP 6 seeks to ensure that best practice in water sensitive design is incorporated in structure planning, subdivision design and development. The implementation of this objective depends upon networks of Multiple Use Corridors, which serve an environmental function incorporating water quantity and quality management, nature conservation, ecological preservation, recreation, and education.

The LSP report demonstrates how future subdivision and development applications within Serpentine will comply with LPP 6. A Local Water Management Strategy (LWMS) for the LSP has been prepared by GHD and is included as **Appendix 1.**

Local Planning Policy No. 8 - Landscape Protection (LPP 8)

LPP 8 aims to maintain the integrity and preserve the amenity of landscape considered to be of high value, identifying a Landscape Protection Area. The policy outlines specific provisions for the development of land wholly or partially contained within the Landscape Protection Area. The LSP area contains or abuts land within the Landscape protection Area.

Local Planning Policy No. 9 - Multiple Use Trails within the Shire of Serpentine Jarrahdale (LPP 9)

LPP 9 seeks to *"implement the Shire's vision to provide a trails network that expands on the existing trails and interlinks suburbs and communities",* encouraging the incorporation of recreational trails within Multiple Use Corridors.

Recreational trails within the LSP area will be designed and constructed in accordance with the specifications of LPP 9 and in consultation with the Shire.

Local Planning Policy No. 22 - Water Sensitive Urban Design (LPP 22)

LPP 22 is intended to aid achieving total water cycle management outcomes consistent with State Planning Policy No. 2.9 - *Water Resources.* LPP 22 applies to the planning and development approvals

process to achieve land and water planning in a manner consistent with the intended outcomes for the Peel-Harvey Catchment.

Local Planning Policy No. 26 - Biodiversity Planning (LPP 26)

LPP 26 seeks to recognise the importance of biodiversity conservation as a consideration in the planning process. When a structure plan or changes to a structure plan is proposed, consideration must be given to the impact on local biodiversity targets which are outlined by LPP 26.

Local Planning Policy No. 67 - Landscape and Vegetation (LPP 67)

LPP 67 seeks to integrate landscape and vegetation with land use planning processes to ensure that the required information and detail is provided throughout the process. The policy also provides guidance regarding the Shire's expectations of landscaping.

Local Planning Policy No. 70 - Activity Centres (LPP 70)

LPP 70 seeks to guide the planning and development of activity centres in the Shire contributing to the planning objectives specified in State Planning Policy No 4.2 – Activity Centres for Perth and Peel. LPP 70 also seeks to implement the Shire's Activity Centres Strategy. Serpentine is identified as a local centre and has a total floor space allocation of approximately 4,500 square metres.

2.0 Site Conditions and Constraints

2.1 Geomorphic Wetlands

An Environmental Assessment of the LSP area prepared by PGV Environmental (**Appendix 3**) identifies seven wetlands occurring at the site. This includes three Multiple Use Wetlands, two Resource Enhancement Wetlands and two Conservation Category Wetlands (CCWs).

2.1.1 Multiple Use Wetlands

The Department of Environment and Conservation (DEC) considers Multiple Use Wetlands to be degraded wetlands mainly used for agricultural purposes. These wetlands serve hydrological functions such as groundwater recharge and flood mitigation but do not have specific management objectives. Much of the southern and eastern sections of the subject area is categorised as Multiple Use Wetlands. These wetlands have largely been developed or are Completely Degraded and could be used as detention basins or recharge areas.

2.1.2 Resource Enhancement Wetlands

DEC defines Resource Enhancement Wetlands as wetlands which may have been modified, but still support substantial ecological attributes and functions. Part of the north-eastern area of the LSP is classified as Resource Enhancement Wetlands. A smaller Resource Enhancement Wetland also occurs on the western side of the site. These wetlands have also largely been developed or are Completely Degraded and could be used as detention basins or recharge areas.

2.1.3 Conservation Category Wetlands (CCWs)

DEC classifies CCWs as the highest priority wetlands which support a high level of ecological attributes and functions. No development which may lead to further loss or degradation is permitted within a CCW or its buffer (typically 50 metres).

A Conservation Category Sumpland occurs in the area within and surrounding Lambkin Reserve to the west of the LSP area. Immediately adjacent is a Conservation Category Dampland. The LSP area is also adjacent to Conservation Category Palusplain and in proximity to Conservation Category Palusplain to the north.

The CCWs on the site are within existing Conservation Reserves and are within the existing developed areas. Increasing native vegetated buffers to these wetlands is not feasible. Therefore management of the wetlands will need to be active to ensure weeds and other deleterious impacts are managed appropriately. The Western Australian Planning Commission Guidelines for Determination of Wetland Buffer Requirements will guide the management of development to reduce potential impacts on wetland hydrologic regimes and attributes.

2.2 Landform

The site is generally flat to very gently undulating with elevations ranging from approximately 36m AHD to 30m AHD. The LSP area is situated against the backdrop of the Darling Scarp, which is the most significant topographical feature in the local area.

Figure 6: Typical views to the Darling Scarp.

The preservation of views to the Scarp will be a primary consideration in the assessment of development applications within the LSP area.

2.3 Soils

2.3.1 Geology

The LSP area corresponds to an area of Pinjarra Phase (P7). The Pinjarra Plain System consists of a broad low relief plain west of the foothills, comprising predominantly Pleistocene fluvial sediments and some Holocene alluvium associated with major current drainage systems. The Pinjarra Plain System is described as seasonally inundated swamps and depressions with very poor drained mottled yellow and sandy duplex soils.

The majority of the LSP area consists of fine to medium-grained sandy soils, with areas of gravelly sandy clay to the east and clayey peaty sands to the west. As some of the soil types occurring at the site are prone to waterlogging and ponding, surface water management will be required. It is recommended that to minimise the potential of soil erosion, ground disturbing activities should be kept to a minimum and the installation of temporary drop-out basins to capture and aid in the settling of clay fines should be considered.

The site does not contain any unique and topographical or geological formations and therefore these factors are not an impediment to development.

2.3.2 Contaminated Soils

There are no registered contaminated sites within the LSP area. Historical land use maps show the site has been primarily residential with some intensified farming land uses present. It is likely that long term fertiliser use has contributed to elevated nutrient levels in surface and groundwater. Due to the past rural land uses of the area, it is suggested that a preliminary site investigation may be required at subdivision stage to identify any potential contamination at the site.

2.3.3 Acid Sulphate Soils (ASS)

The majority of the soils in the LSP area have moderate to low risk of ASS disturbance within 3 metres of the surface. A small area to the west of the site associated with Lambkin Reserve (along Tonkin Street) is classified as having a high to moderate risk of ASS. Activities in this area will need to be conducted in accordance with an approved Acid Sulphate Soil Management Plan at subdivision stage.

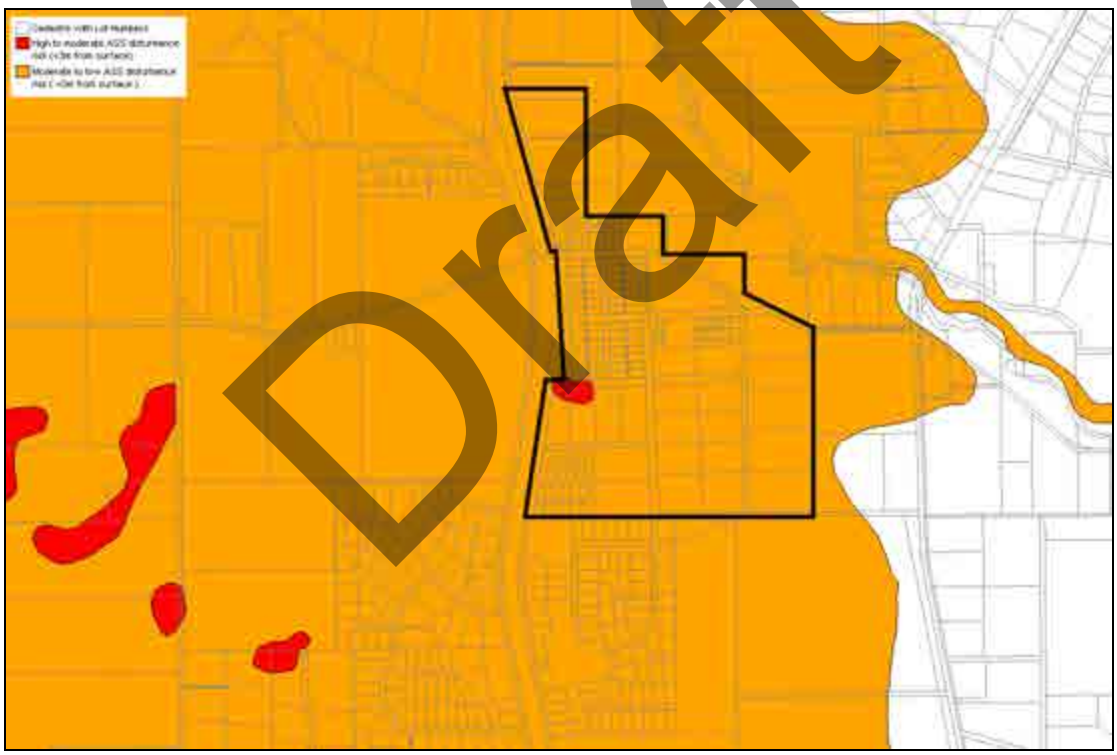


Figure 7: Acid Sulphate Soils.

2.4 Hydrology

The LWMS prepared by GHD is a key supporting document for the LSP. The purpose of the LWMS is to provide objectives, criteria and requirements for the protection and management of the water cycle as part of land use planning and development at all levels of the planning system in the Serpentine study area.

A number of high level studies within the LSP area have provided a regional environmental context for the LWMS. These have been reviewed in order to provide suitable background information for the LSP area and provide indication of the issues requiring further investigation. A number of site-specific investigations into various aspects of the subject site have also been conducted to inform the LSP preparation process.

The LWMS has identified stormwater management, groundwater management and water conservation design criteria based on overarching documents and the requirements of the Shire, DoW and similar developments in the district.

2.4.1 Surface Water

The LSP area is situated approximately 400 metres south of the Serpentine River, which is the primary waterway in the local area. Surface water in the LSP area drains to the Serpentine River which flows in a generally south westerly direction and ultimately discharges in to the Peel Harvey Estuary.

The LSP area is known to experience regular water logging in the lower-lying areas with inundation due to poor internal drainage of soils and persistent winter rainfall which elevates the shallow water table to the surface of poorly drained flat land.

There are some shallow drains (approximately 0.2 - 0.5m deep) which help to drain the site. Located in the eastern part of the site is Water Corporation Hardey's Creek Main Drain which drains a small area in the south-east of the development area near Arnold Rd. It intersects the eastern site boundary near Wellard St and conveys runoff north to the Serpentine River. Hardey's Creek Main Drain has a second branch to the west which drains water from the south west into the other branch of the Main Drain and then into the Serpentine River.

There is a potential to improve the ecological value of the degraded channels at the site through rehabilitation. This could involve the introduction of native vegetation and sedges to stabilise the banks and ensuring existing exotic vegetation is retained until native endemic species are established to provide bank stabilisation.

2.4.2 Groundwater

The LSP area is outside the Department of Water's groundwater contour area. The maximum Groundwater Level is defined as being the surface level. Provision is required to ensure that groundwater and geotechnical monitoring is undertaken prior to any development commencing in the area. The LSP area is not within a Department of Water public drinking water supply area.

2.5 Natural Areas, Biodiversity and Resource Efficiency

2.5.1 Vegetation

The environmental assessment undertaken by PGV Environmental identified potential impacts of the implementation of the LSP on biodiversity and natural areas within the Serpentine Townsite. The vegetation on the site has been largely historically cleared for the Townsite and rural purposes and is currently used as pasture for fodder conservation or grazing.

The LSP site falls within the Guildford Vegetation Complex. The structure of this complex is described as consisting of a mixture of Marri (Corymbia calophylla) and Jarrah (Eucalyptus marginata) open forest (in places tall open forest), with a small number of locations fringed by Eucalyptus rudis-Melaleuca rhaphiophylla woodlands along streams. Occasional areas of Eucalyptus lane-poolei are also found within the Guildford complex. The Guildford Complex is considered to be poorly reserved with 5% of the original extent of the vegetation remaining. Remnant vegetation occurs in the following locations within the LSP area:

- Lambkin Reserve north of Leslie Street;
- Part of Bush Forever Site 375 to the north of Tonkin Street;
- Road reserve in Turner Street;
- In the east of the site to the south of Karnup Road (Shire Reserve R 9157); and
- Railway Reserve to the west of the LSP area.

The remnant vegetation is representative of the poorly reserved Guildford Complex and contains threatened ecological communities and several conservation significant plant species. The remnant vegetation areas are considered to be in Very Good to Excellent Condition and are of regional significance.

Bushland vegetation on the LSP site is considered to be in Excellent to Very Good condition. The majority of vegetation within the LSP area is Completely Degraded and in some small areas it is Degraded to Completely Degraded. Bush Forever Site 375 which includes Lambkin Reserve is located within the LSP area. Bush Forever Site 365 is adjacent to the western boundary of the LSP area and Bush Forever Site 371 is in close proximity to the northern boundary of the LSP area.

It is recommended that any trees be retained where possible in landscaped areas, parking areas and in road/entry areas. There should be minimal disturbance to vegetation resulting from construction activities undertaken in development areas adjacent to bushland areas and it should be in accordance with the Australian Standards for Protection of Trees on Development Sites.

All trees should be located on a site plan that shows canopy and trunk diameters and the natural ground level at the base of each trunk.

2.5.2 Flora

Declared Rare Flora and priority species are present within small pockets of bushland in the LSP area. It is highly unlikely that such species will be present on the remainder of the LSP area. It is recommended that all areas of remnant vegetation which are subject to development are surveyed for significant flora and vegetation.

2.5.3 *Fauna*

The LSP area contains five habitat types:

- Completely cleared pasture;
- Parkland cleared Marri;
- Parkland cleared creeklines with exotic *Eucalyptus* Species;
- Native Woodland over Low Heath; and
- Low Heath and Weeds (Railway Reserve).

Completely cleared pasture dominates the LSP area in parts which are not developed. These areas are considered to be Highly Degraded Fauna Habitat. Parkland Cleared Corymbia Calophylla (marri) occurs in scattered areas within the LSP area, with a larger stand located to the south east. The parkland cleared stands are considered to be Disturbed Fauna Habitat. Lambkin Reserve is considered to be a Very Good Fauna Habitat. The low heath and weeds present in the Railway Reserve is considered to be Good Fauna Habitat for bandicoots, reptiles and a suite of insects. The remaining pockets of native woodland over low heath are more fragmented and considered to be Good Fauna Habitat.

Forest Red-tailed Black Cockatoo, Baudin's Cockatoo and Carnaby's Cockatoo are likely to be present on the site at some times of the year. The Cattle Egret may also be an irregular visitor to the area and the Southern Brown Bandicoot may be present in the bushland areas of the LSP.

Forest Red-tailed Black Cockatoo and possibly Baudin's Cockatoo and Carnaby's Black Cockatoo could be impacted by the development of the site if mature trees are cleared. These three black cockatoo species are listed under Section 18 of the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). Black Cockatoos require a habitat which enables foraging, roosting and breeding. The bushland areas contain the best quality habitat for the Black Cockatoos and should therefore be retained. To mitigate any potential impacts it is recommended that Marri and Flooded Gum trees and other significant trees are retained wherever possible. There is potential to improve the Black Cockatoo habitat by planting appropriate species in drainage

corridors, open space and road reserves. Assessment should be undertaken at subdivision stage to determine the implications of proposed development under the EPBC Act.

2.5.4 Resource Efficiency Principles

The housing design in the LSP area shall draw upon the natural setting, rural history and urban context of Serpentine to provide a unique residential character for the development.

The Townsite design provides opportunities for passive surveillance, community engagement and a mix of lot sizes which promotes diversity, walkability and supports transport use.

2.6 Heritage

The historic nature of Serpentine is reflected by the number of properties which are listed on the State Heritage Register. The listed properties within the LSP area include the Old Serpentine Inn (corner of Richardson and Wellard Streets), the Serpentine Butcher Shop (19 Richardson Street), Serpentine General Store (6 Wellard Street) and Saint Kevin's Church (Richardson Street).

Serpentine is also of Aboriginal significance with Aboriginal Heritage Site 3582 Serpentine River mapped over much of the area. The Site extends along the Serpentine River and floodplain and intersects the LSP area. It is a registered Heritage Site with the Department of Aboriginal Affairs and as such, advice on the implications of the Site under the Aboriginal Heritage Act 1972 will need to be investigated.

Figure 8: Serpentine General Store.

The significant presence of heritage listed properties and the general sense of heritage present within the Local Structure Plan area offers an opportunity to define and protect the rural amenity of the area. Elements which define the rural character and historic nature of the area can be used to develop development criteria which respond to these aspects.

3.0 Land Use and Subdivision Requirements

The urban design principles applied in the preparation of this LSP have emerged from the character of the site and the requirements of LN, as discussed above. These include:

- An overall layout that is site-sensitive and which integrates with its surrounds, recognising the Darling Scarp as the backdrop;
- An interconnected modified grid layout, affording the site strong legibility and a link to its natural amenities;
- Providing a variety of lot sizes that can accommodate a variety of housing product;
- Providing a high-quality, walkable urban environment;
- Providing a water sensitive design that is responsive to the existing site conditions;
- Providing high-quality POS for both passive and active recreation purposes.

3.1 Main Land Uses

Figure 9: Land Use Plan.

The main land uses proposed in the Local Structure Plan are:

- Residential R5 and R10
- Local Centre
- Public Open Space
- Community Facility
- Education/Institution

A summary of the proposed land use areas is provided below:

Land Use Summary (LSP Area)	
Land Use	**Area (ha)**
Residential – R5	47.83
Residential – R10	18.80
Local Centre	1.89
Public Open Space	16.97
Drainage	1.79
Bush Forever	5.32
Community Facility	1.56
Educational	1.92
Local Roads	28.38
Total	**124.46**

Table 1: Proposed land use areas.

3.1.1 Residential

The LSP proposes the creation of approximately 190 lots in total (including 47 new residential lots)

Opportunities are available for substantial freehold subdivision to lot sizes of 1,000m² (existing Residential R10 lots) and 2,000m² (existing and proposed R5 lots) with the majority of the lots approximately 2,000m² in area.

A range of lot types provide for diversity in built and housing type and maintain the rural character of the Townsite.

3.1.2 Activity Centres and Employment

Serpentine is not identified as an Activity Centre under SPP 4.2 however it is identified as a local centre in the Shire's Activity Centre Strategy. As a designated local centre, retail development will be able to occur to service growing demand. Its role as a retailing centre is limited to the sale of lower-order convenience goods to local residents.

Typically, local and neighbourhood retailing absorbs about 25-30% of annual retail expenditure with total annual expenditure equating to demand per household supporting about 2.2m² per capita.

Serpentine accommodates approximately 2000m² in commercial and retail floor space at present servicing the localities of Serpentine, Hopeland and Keysbrook.

Serpentine is expected to experience moderate growth within a fairly limited urban area. It would be reasonable to expect this area to accommodate a local centre catering for up to 4,400 residents.

3.1.3 Education Facilities

The Serpentine Primary School is identified by the Department of Education as a medium sized Primary School catering for the needs of the Serpentine community and the surrounding area.

3.1.4 Public Open Space

Public Open Space will accommodate quality areas suitable for active and passive recreation purposes and are located within a short walk of most residents.

Public Open Spaces proposed in the LSP comprise:

- POS within Conservation Category Wetland (CCW) buffers which gain partial credit and are considered "restricted POS" under LN; and
- POS outside the CCW buffers, which may be:
    - Excluded from POS calculations (if within 1:1 year drainage basins)
    - Considered restricted POS (if within 1:5 year drainage basins but not within 1:1 year drainage basins), or
    - Considered unrestricted POS (if not within 1:5 year drainage basins)

The public open space provided within the LSP is greater than the 10% required under LN. Variations to public open space provision during the detailed subdivision design will have regard to the passive recreation spaces, active recreation spaces, drainage, vegetation retention and other functions of public open spaces. Tables 2 and 3 below outlines the Public Open Space Schedule.

Land Parcels	Area (ha)
Total Townsite Area	**119.13**
Lambkin Reserve CCW	1.704

Richardson POS	1.13
Total Net Site Area	**116.30**
Other Deductions	
Primary School site	1.93
Public Purpose	1.94
Commercial Lots Richardson St	0.41
Wellard St Shops	0.83
Other Commercial, Public Purpose, Community Facility	0.81
Total Deductions	**5.92**
Gross Subdivisible Area (GSA)	**110.39**
Total POS Required (10% GSA)*	11.04

Table 2: Public Open Space Schedule.

POS (Unrestricted)	Area (ha)
Hardeys Creek POS	0.37
Hardeys Creek POS	8.08
Karnup Road	4.55
Lefroy Street POS	0.80
North Park	0.29
Spencer Park	0.89
Total Unrestricted POS	**14.99**
80% Credit	11.99

Table 3: Unrestricted POS provision.

POS (Restricted)	Area (ha)
Hardeys Creek Basin	1.01
Hardeys Creek Drain	0.31
Lefroy Street Drain	0.34
North Park Basin	0.07

Richardson Street POS	1.05
Total Restricted POS	**2.78**
Max 20% credit	0.56
Unrestricted POS Component	11.99
Restricted POS Component	0.56
Total POS Required	11.04
Total POS Contribution	12.55
POS Oversupply	**1.51**

Table 4: Restricted POS provision.

3.1.5 Drainage

A comprehensive drainage strategy is included in the Local Water Management Strategy **(Appendix 1).**

The existence of poorly draining soils and a high groundwater table results in the site becoming seasonally waterlogged. Therefore, infrastructure and buildings must be constructed with adequate separation from groundwater to safeguard against flooding:

- Finished floor levels shall be at least 1.2 metre above the maximum groundwater level (MGL);
- Where the predicted MGL is at or within 1.2 metre of the finished surface, adequate separation from groundwater must be provided by the importation of clean fill; and
- Imported fill is to incorporate a band of material that will reduce phosphorous export via leaching, while meeting the soil permeability and compaction criteria required by the Shire.

The proposed LSP incorporates water sensitive design principles for urban stormwater management, consistent with the WAPC's *Better Urban Water Management, 2008.*

3.2 Movement Networks

The traffic study undertaken by OPUS indicated that additional development within the Townsite in the short term is unlikely to impact on the surrounding road network. The anticipated longer term traffic generated from 2021 onwards is expected to increase traffic volumes on local access road network.

It is expected that the Karnup Road / Wellard Street intersection will consist of a roundabout, with a final design to be confirmed at such time as improvement of this intersection is deemed necessary.

3.2.1 Road, Walking and Cycling Network

The LSP structure is based on the existing street pattern in the Townsite. The Townsite pattern is based on a traditional grid formation and is direct, interconnected and highly legible with north-south, east-west building orientation. This pattern allows pedestrians and cyclists as well as vehicle users, access to key destinations within the urban area. This pattern has however been disrupted in some areas of the urban development zone by the approval of cul-de-sac subdivisions.

The movement network will be supported by conceptual design and drainage information.

Further expansion and development of the remaining portions of the Local Structure Plan area will benefit from duplicating the existing road layout. The grid road layout promotes a high degree of permeability, visibility and accessibility.

The traffic analysis prepared by OPUS (**Appendix 2**) confirms the above objectives in terms of traffic volumes.

No cycle routes are proposed within the structure plan, however, the Shire of Serpentine Jarrahdale is proposing cycle routes to link Karnup Road to Richardson Street, Lefroy Street and Wellard Street. This will provide good cycle linkages to the local centre, school and community facilities as well as the proposed residential lots to the north of the local centre and should be incorporated into the structure plan.

The crash data in the traffic analysis noted that a number of crashes occurred at the intersection of Karnup Road and South Western Highway. The crash patterns at this intersection appear to be related to slow moving traffic exiting Karnup Road crashing with the higher speed traffic passing through along the South Western Highway. Due to the likely increase in the use of this intersection as traffic volume increases, the intersection would benefit from a Road Safety Audit to establish possible casualties to the recorded crashes and recommend safety improvements.

An assessment of Arnold Road has recommended that Arnold Road either becomes a sealed road on approach to South Western Highway, along with an upgrade of the intersection to improve visibility, or, Arnold Road is closed to through traffic.

Appropriate pedestrian infrastructure should be provided to enable all residents within the structure plan to easily and safely access the local centre and primary school. Specific safe crossing facilities to

complement this would need to be assessed at a later stage of the development process.

An extension of the proposed cycle network to incorporate the new proposed road network to the south of the structure plan should be included to ensure a complete and connected cycle network for the town.

Improvements and proposed modifications to the existing road hierarchy are based on LN classifications and are shown on the LSP. The improvements to existing and proposed new road layouts are indicative only and are subject to planning at the time of subdivision and further development of the Townsite.

The main east-west neighbourhood connector (Karnup Road) links Serpentine to its hinterland and to the regional road network.

Proposed roads, parking bays and footpaths will be sited and designed in accordance with the specifications of Liveable Neighbourhoods and the Shire's requirements.

A noise assessment will need to be undertaken especially towards the northern extent of the Townsite to address the impact the railway line will have on this development. The noise assessment will be undertaken in accordance with SPP 5.4 and prior to further subdivision within the Townsite.

The Shire's Local Planning Policy No. 9 - Multiple Use Trails (LPP 9) requires that at subdivision and rezoning stages multiple use trails are identified. It is recommended that the proposed network of footpaths within the LSP connects to existing trails linking to the Byford area and also to the walking/cycling infrastructure proposed within the Byford Town Centre. The Healthy by Design document prepared by the Heart Foundation recommends designing walking and cycling routes to and around local landmarks and points of interest.

3.2.2 Public Transport

The TransWA Australind service stops at Serpentine four times daily (twice Perth-bound; twice Bunbury-bound). There are no localised public transport services current in the area.

3.3 Infrastructure Co-ordination, Servicing and Staging

3.3.1 Power

The existing Serpentine LSP area has underground power installed which can be extended as development occurs.

3.3.2 Water Supply

A large part of the LSP area is currently connected to scheme water and all domestic water will be sourced from rainwater.

3.3.3 Sewerage Treatment

The LSP area is not currently connected to a reticulated sewerage system. Domestic wastewater will be treated through on-site Aerobic Treatment Unit (ATU) effluent disposal systems, where the effluent can be recycled via irrigation of vegetated disposal areas. The new draft Government Sewerage Policy – Consultative Draft, Department of Health 2012 (the GSP 2012) will be referenced in determining the suitability of onsite systems for all lots. The GSP 2012 requires developers to demonstrate that the proposed lots and soil profile can accommodate on site disposal and ATU's.

3.3.4 Gas

Gas services are available in the LSP area and can be extended as development throughout Serpentine occurs.

3.4 Development Contribution Arrangements

Clause 5.19 of the Scheme states that developers are required to enter into an agreement that will provide for equitable distribution of costs associated with future development and subdivision.

A Development Contribution Plan needs to be prepared to conclude the above agreement. The Shire needs to prepare a Development Contribution Plan for the LSP area. This process has not been finalised and implemented at the time of writing the LSP. The contribution arrangement also needs to be processed through a scheme amendment.

Contribution items shall include but will not be limited to:

- Provision of adequate land for, and construction of, any drainage and water management infrastructure determined necessary by the Local Water Management Strategy;
- Provision of adequate land for and construction of significant transport infrastructure items, including Karnup Road to Rudall Street and the intersection with Wellard Street.
- Ongoing costs associated with preparation and maintenance of the contributions scheme, including associated studies or design; and
- Design and treatment of Hardey's Creek.

The Shire will in due course prepare a Development Contribution Plan. Until such time as a DCP has been adopted, Clause 5.19.1.5 of the Scheme provides the opportunity for the Shire to enter into negotiated

agreements with developers in respect to contributions as part of the LSP.

4.0 Implementation

4.1 Adoption of the LSP

All development shall be determined in accordance with the LSP once it is approved by the Shire in terms of Clause 5.18.3 of the Scheme.

4.2 Modifications to the LSP

There may be circumstances under which the LSP may warrant modification, either through a Shire initiative or upon a request from a landowner or the community. Any proposed modification to the LSP must be undertaken in accordance with the relevant provisions of the Shire's Scheme, Local Planning Policy No. 61 Local Structure Plans and the WAPC's Structure Plan Preparation Guidelines, August 2012.

The Shire may consider modifications to the LSP on condition that the modifications do not:

- Compromise the overall function or integrity of the LSP;
- Prejudice adjoining landowners in terms of amenity, interface or integration; and
- The modification must be able to demonstrate an improvement to the overall design and function of the LSP area.

5.0 Conclusion

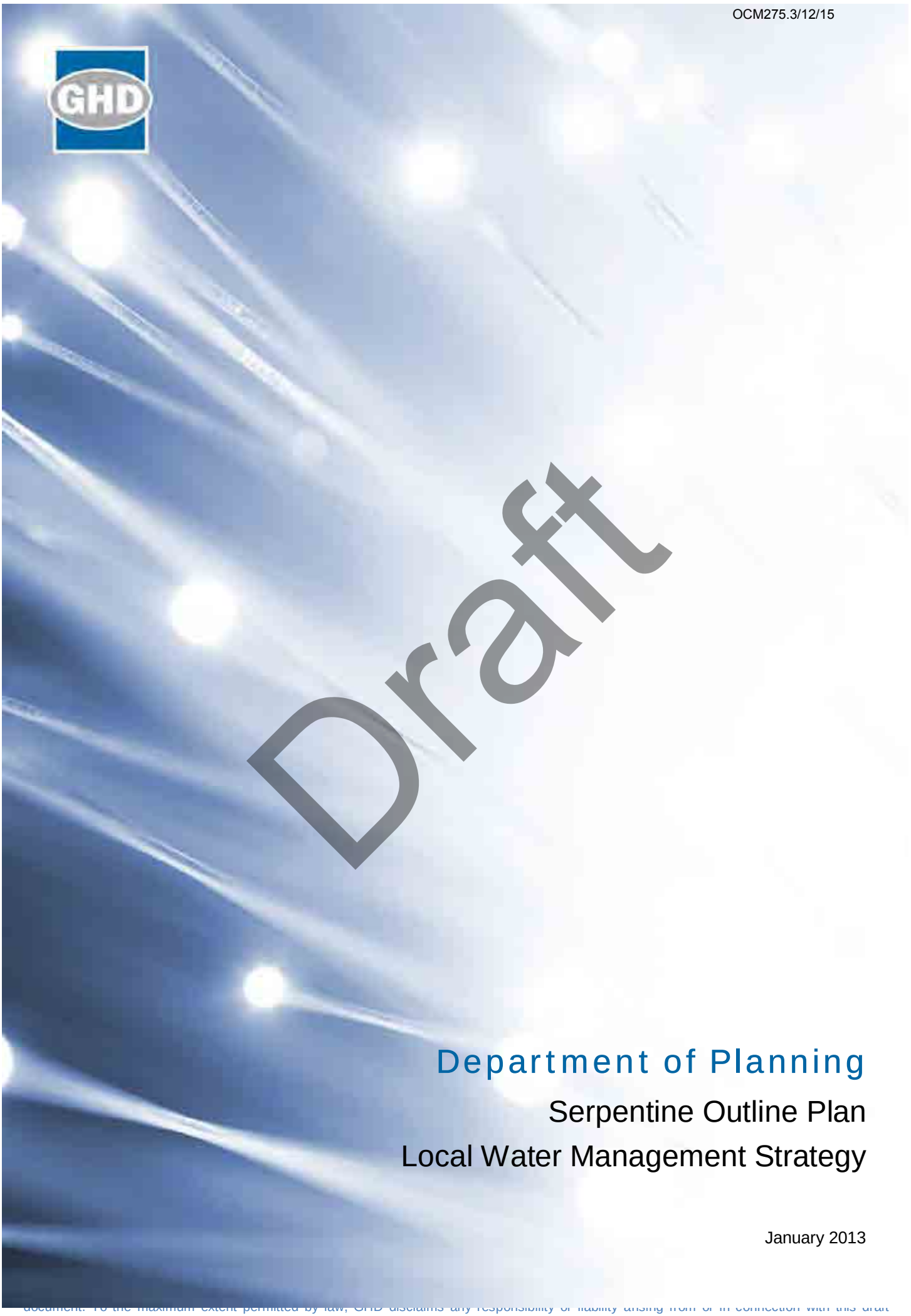
The LSP seeks to provide a planning framework to guide urban development in Serpentine. The proposed land uses and subdivision layout are consistent with the planning context provided under the MRS and the Scheme. The LSP design has been guided by the principles of WAPC and Shire policies which provide strategic direction for the future development of the metropolitan area.

The information provided demonstrates that the subject site is capable of being further developed for urban purposes. Suitable provision of Public Open Space sites has been made. These facilities are connected to the surrounding areas through an integrated road layout. Servicing requirements including roads and utilities have been adequately addressed.

The LSP retains a strong link to the history of the area, the character of the existing Townsite and the natural topography of the land while also adapting these elements to an urban context and complying with district, regional and strategic objectives.

Appendix 1

Local Water Management Plan (GHD, 2013)



Department of Planning

Serpentine Outline Plan

Local Water Management Strategy

January 2013

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Executive summary

This Local Water Management Strategy (LWMS) has been prepared by GHD Pty Ltd (GHD) for the Department of Planning in accordance with Better Urban Water Management (Western Australian Planning Commission, 2008). The purpose of the LWMS is to provide objectives, criteria and requirements for the protection and management of the water cycle as part of land use planning and development at all levels of the planning system for the Serpentine Outline Plan area.

The proposed Serpentine Outline Plan Area is located in the suburb of Serpentine within the Shire of Serpentine-Jarrahdale, approximately 50 km south of Perth CBD. The site covers approximately 90 hectares in area.

Water Use Strategy

To make the development area a leading example of water efficiency, the following measures will be implemented:

- Water efficient appliances: The development will have full compliance with the Building Code of Australia (BCA) and WA's "5-Star Plus Stage 1" supplement;
- In-house water use: The development will not be connected to scheme water and all in-house water will be sourced from rainwater. The self-sufficient nature of rainwater supply strongly encourages water conservation initiatives within households;
- Wastewater: The development will not be connected to a reticulated sewerage system. Domestic wastewater will be treated through on-site Aerobic Treatment Unit (ATU) effluent disposal systems, where the effluent can be recycled via irrigation of vegetated disposal areas; and
- Landscape irrigation: Public Open Space (POS) areas will be irrigated using local groundwater. Domestic gardens can be irrigated with effluent from the ATU systems. Any additional irrigation requirements can be sourced from rainwater or the installation of garden bores (subject to quality and quantity of groundwater within the area).

Stormwater Quantity Management Strategy

The proposed stormwater management strategy employs the following principles for the following events:

1 year ARI event

- Roofs will be connected to soakwells or rainwater tanks.
- Road runoff will be infiltrated as close to source as practical using water sensitive urban design (WSUD) measures such as infiltration devices such as bioretention basins/swales, soakwells and Atlantis cells.

5 year ARI event

- Will be collected and conveyed by swales. The swales will discharge directly to the Hardey's Creek Main Drain or will discharge to dry, shallow detention basins.
- Where swales and drains discharge to waterways and basins, the banks of the waterway or basin will be stabilised to prevent scouring.

100 year ARI event

- Events greater than the 5-year ARI event will be conveyed away from the development along roads and POS, discharging to Hardey's Creek Main Drain or Serpentine River. Basins have been sized to compensate major events up to the 100-year ARI event to the pre-development flow.

Groundwater Management Strategy

The existence of poorly draining soils and a high groundwater table results in the site becoming seasonally waterlogged. Therefore, infrastructure and buildings must be constructed with adequate separation from the groundwater to safeguard against flooding:

- Finished floor levels shall be at least 1.2 m above the maximum groundwater level (MGL). Where the predicted MGL is at or within 1.2 m of the finished surface, adequate separation from groundwater will be provided by the importation of clean fill; and
- Imported fill is to incorporate a band of material that will reduce phosphorous export via leaching, while meeting the soil permeability and compaction criteria required by the Shire of Serpentine-Jarrahdale.

Water Quality Management Strategy

Surface water from the development mostly discharges to the Hardey's Creek Main Drain and the Serpentine Drain which ultimately discharge into the Peel-Harvey Estuary system via the Serpentine River. Discharge from the development will meet the target water quality objectives identified in the Peel-Harvey Water Quality Improvement Plan (EPA, 2007).

It is proposed to adopt Water Sensitive Urban Design (WSUD) and Best Management Practices (BMPs) promoting retention, infiltration and treatment of events up to the 1-year ARI events, in accordance with the *Stormwater Management Manual for Western Australia* (DoW, 2004-2007). Structural measure will include a bioretention system which represents 2% of the total impervious area.

The key WSUD elements for the bioretention system incorporated into the design of subdivisions within the study area are:

- Biofiltration pockets: Wherever practical, these small biofiltration and infiltration systems will be incorporated into non-frontage verges (where they will not obstruct driveway crossovers) and road nibs.
- Vegetated median swales: Wherever practical, biofiltration and infiltration systems in the form of vegetated swales will be incorporated into median strips.

Implementation

The next stage for water management is to obtain subdivisional approvals supported by an Urban Water Management Plan (UWMP). The UWMP is to be consistent with the design criteria and strategies outlined in this LWMS and include site-specific detail design of the drainage system in consideration of other aspects of the overall design concept.

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1. Introduction

GHD Pty Ltd (GHD) was commissioned by the Department of Planning to prepare a Local Water Management Strategy (LWMS) for the Serpentine Outline Plan area (the Site). The proposed development is located in the suburb of Serpentine within the Shire of Serpentine-Jarrahdale, approximately 50 kilometres (km) south of Perth CBD (Figure 2). The site covers approximately 90 hectares (ha) in area.

The purpose of this LWMS is to:

- Provide objectives, criteria and requirements for the protection and management of the water cycle as part of land use planning and development at all levels of the planning system for the Serpentine Outline Plan area;
- Identify key water environments and management issues across the Serpentine Outline Plan area;
- Provide guidance for the protection of significant water resource assets and the management of water resources, including waterway and catchment health; water (re)use and efficiency; and flooding and stormwater management, as part of future land use planning and development in the Outline Plan area, at all levels of the planning system; and
- Incorporate applicable principles from Better Urban Water Management (Western Australian Planning Commission, 2008).

This LWMS has been prepared in consultation with the Western Australian Planning Commission (WAPC) Departments of Environment and Conservation and Water (DEC and DOW, respectively), Water Corporation and the Shire of Serpentine-Jarrahdale. This LWMS has been prepared in accordance with the principals outlined in Better Urban Water Management framework (WAPC, 2008), which provides a model for developers to address water related management issues at the various stages of planning and presents interim water related design objectives for water conservation, groundwater and stormwater.

1.1 Total water cycle management - principles and objectives

Total water cycle management, also referred to as integrated water cycle management, 'recognises that water supply, stormwater and sewage services are interrelated components of catchment systems and therefore must be dealt with using a holistic water management approach that reflects the principles of ecological sustainability' (DoW 2004-07, *Stormwater management manual for Western Australia*).

The *State Planning Policy 2.9: Water Resources* (WAPC, 2004) outlines the key principles of integrated water cycle management as:

- Consideration of all water resources, including wastewater in water planning;
- Integration of water and land use planning;
- The sustainable and equitable use of all water sources, having consideration of the needs of all water users, including the community, industry and the environment;
- Integration of human water use and natural water processes; and
- A whole of catchment integration of natural resource use and management.

The principles and objectives for managing urban water as stated in *the Stormwater Manual for Western Australia* (DoW, 2004) are as follows:

- Water Quality: to maintain or improve the surface and groundwater quality within the Development Areas relative to predevelopment conditions.
- Water Quantity: to maintain the total water cycle balance within the Outline Plan area relative to the pre-development conditions.
- Water Conservation: to maximise the reuse of stormwater.
- Ecosystem Health: to retain natural drainage systems and protect ecosystem health.
- Economic Viability: to implement stormwater management systems that are economically viable in the long term.
- Public Health: to minimise the public risk, including risk from injury or loss of life, to the community.
- Protection of Property: to protect the built environment from flooding and waterlogging.
- Social Values: to ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.
- Development: to ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

1.2 Planning background

The Serpentine Outline Plan is being prepared by the Western Australian Planning Commission (WAPC) to provide guidelines for the subdivision of urban zoned land in the Serpentine town site area, to ensure that the impact of environment and heritage are considered in the planning process. The Serpentine Outline Plan will provide a statutory plan and design criteria that aim to provide logical planning outcomes, while deterring subdivision applications that do not meet the requirements. The LWMS will investigate how water resources can be effectively managed by addressing all aspects of the water cycle, to ensure that key water issues are incorporated in the planning process at the local stage.

The planning framework for land and water planning is illustrated in Figure 1. The LWMS demonstrates how water resources can be considered in the land use planning system and to ensure consistency with *State Planning Policy 2.9: Water Resources* (WAPC, 2004).

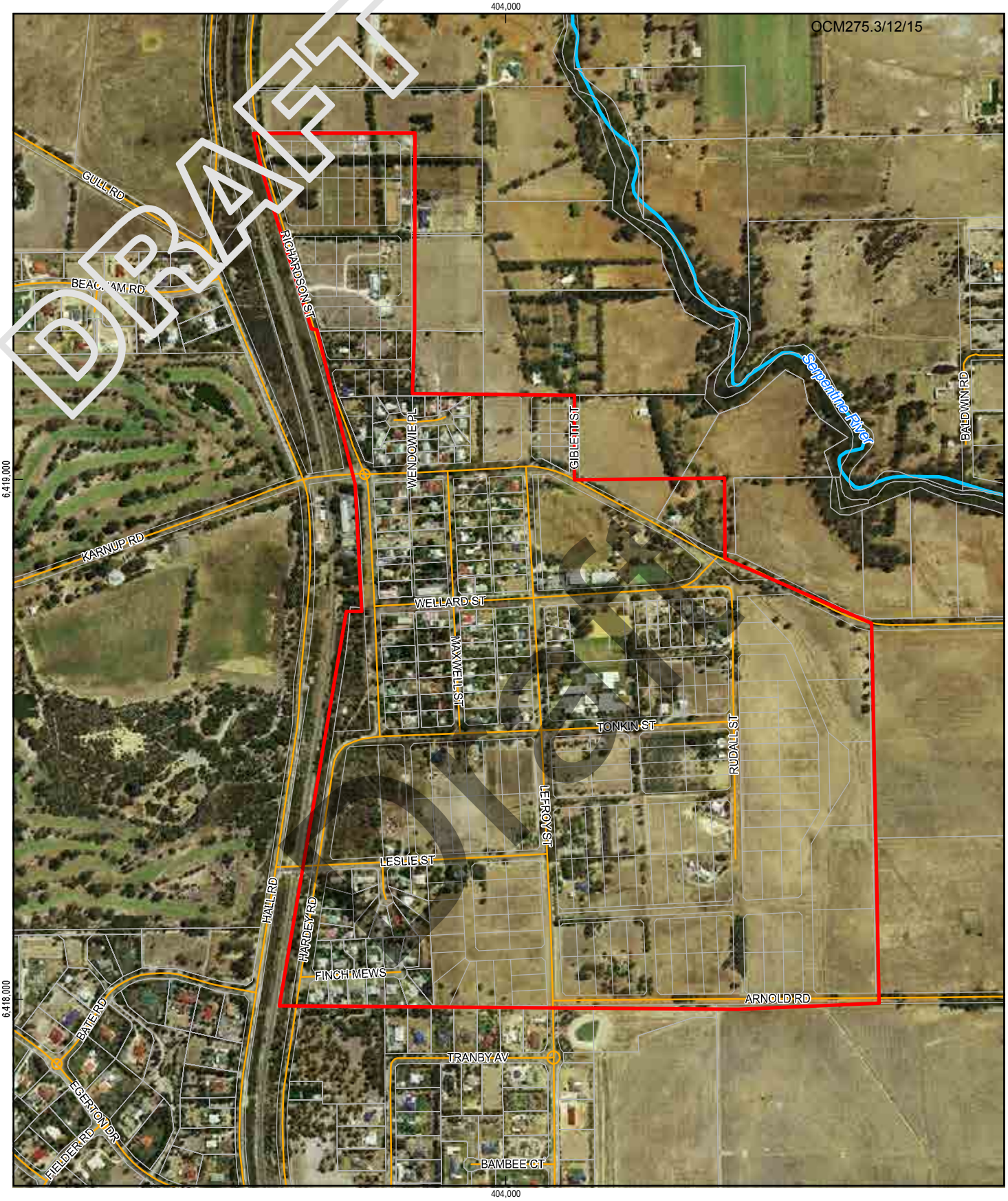
Figure 1 Planning framework for integrating the drainage planning with land planning

SOURCE: *Better Urban Water Management* (WAPC, 2008)

1.3 Previous studies

Information presented in a number of studies has been drawn upon in the developemnt of this LWMS and they are briefly summarised below:

- Murray Drainage and Water Management Plan (DoW, 2011) – presents a drainage and water management plan for a 375 km^2 study area extending from Nambeelup catchment in the north, the lower Serpentine River and Peel-Harvey estuary in the west, the Fauntleroy Drain catchment in south, and the darling ranges and foothills to the east. The DWMP area is predominantly within the Shire of Murray; however, 10% of the study area is located with the Shire of Serpentine-Jarrahdale, where the northern boundary is approximately 10 km south of this LWMS study area. The DWMP provides design principles for surface water and groundwater management, including drainage and flood control and water conservation and re-use measures.
- Serpentine River Floodplain Management Study (SKM, 2010) – presents a floodplain management strategy for the Serpentine, Baldivis, Karnup and Keralup areas, which conducted detailed hydrologic and hydraulic flood modelling of the catchment. The floodplain model incorporates this LWMS study area; and indicates that the study area is not subject to inundation for a 1:100 year ARI flood event.
- State Planning Policy (SPP) 2.1 Peel Harvey Catchment (WAPC, 2003) – sets down land use and development controls for the Peel Harvey catchment for the protection of wetlands and water resources. The policy contains provisions designed to ensure that proposals for urban and intensive agricultural development are carefully assessed and undertaken in a manner that minimises impact to the receiving water ways.



LEGEND

- Study Area
- Rivers
- Cadastre
- Roads

1: 10,000 (at A4)

0 40 80 160 240 320 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

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Department of Planning
Serpentine Outline Plan LWMS

Locality Plan

Job Number	61-28174
Revision	B
Date	18 Dec 2012

Figure 2

239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

G:\61\28174\GIS\Maps\MXD\6128174_G001_Fig2_RevB.mxd

Data source: Landgate: Roads - 20120510; DoP: Serpentine Aerial - 20120517, Cadastre - 20120517; DoW: Rivers - 20120510; GHD: Study Area - 20120510. Created by: bflorczak

2. Proposed development

2.1 Key elements in the Serpentine Outline Plan

The Serpentine Outline Plan is being prepared by the WAPC to provide guidelines for the subdivision of urban zoned land in the Serpentine townsite area, to ensure that the impact of environment and heritage are considered in the planning process.

The existing rural residential zoning (R5 – R10) will remain with no increase in the residential density within the study area; however, it is likely that the lot boundaries, drainage infrastructure and POS will be relocated according to future subdivision proposals. It is possible that a number of the larger, rural-style lots, may be subdivided in the future. Gross subdivisible area for the development is approximately 78.3 ha.

2.1.1 Land uses

The Town Planning Scheme Map for Serpentine contained in the Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2 (Department of Planning, 2011) summarises the current landuse of the development area (Appendix A). The area predominantly consists of residential lots and contains a combination of R10 and R5 residential zoned lots. The development area also contains a number of commercial lots and public and community lots, and public open space and recreation areas.

The proposed outline plan is shown in Appendix B.

2.1.2 Public open space

There is an allowance of 10% of Public Open Space (POS) within the development area in accordance with Liveable Neighbourhoods (2007). The POS will be collocated to align with the water management strategy and most efficiently incorporated into drainage design and flood management and is shown in Figure 3.

The existing drainage basin and finch Mews and Blue Wren Close may be relocated at a future date in accordance with the Shire of Serpentine Jarrahdale requests.

Unrestricted POS within the development is comprised of approximately 15 ha in the north-east corner of the development (Memorial Gardens) and the created Lot 15 Giblett St POS. The existing park adjacent to the school will remain and new POS co located with drainage features will be created along Leslie Street, Lefroy Street and Rudall Street as shown in Figure 3.

Table 1 Unrestricted Public Open Space

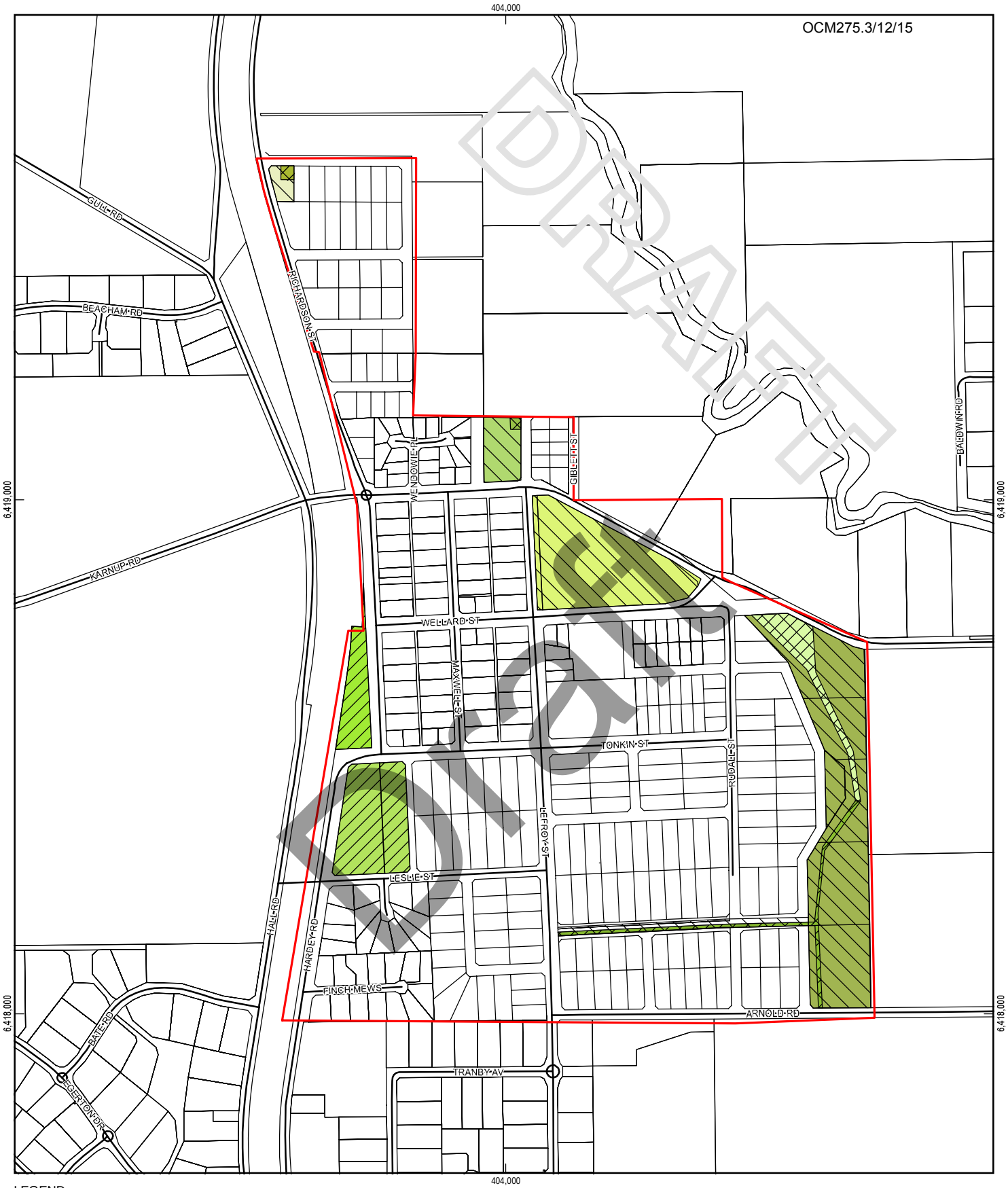
Unrestricted POS components	Area (m2)
Hardeys Creek POS 1	3699
Hardeys Creek POS 2	80788
Karnup Road POS	45529
Lefroy Street POS	8029
North Park	2902
Spencer Park	8982
Total Unrestricted POS	**149930**
80% Credit	**119943**

Restricted POS where usability is limited is to the drainage features (basins and living stream) where 5 year flows or storage is provided.

Table 2 Restricted Public Open Space

Restricted POS sites	Area (m2)
Hardeys Creek Basin	10140
Hardeys Creek Drain	3065
Lefroy Street Drain	3436
North Park Basin	673
Richardson Street POS	10500
Total Restricted POS	**27815**
20% Credit	**5563**

Detailed POS schedule and areas is provided in Appendix C.



LEGEND

Study Area	Lefroy_Street_Drain	Hardy_Creek_Drain	North_Park_Basin	Spencer_Park
Cadastre	Hardeys_Creek_POS	Karnup_Road	Richardson_Road_North	Spencer_Park_Basin
Restricted	Hardy_Creek_Basin	North_Park	Richardson_Road_South	
Unrestricted				

1: 10,000 (at A4)

0 40 80 160 240 320 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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Department of Planning
Serpentine Outline Plan LWMS

Public Open Space

Job Number	61-28174
Revision	C
Date	18 Dec 2012

Figure 3

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

G:\61\28174\GIS\Maps\MXD\6128174_G007_Fig9_RevC.mxd

Data source: DoP: Serpentine Aerial - 20120517, New Cadastre - 20120517, Bush Forever Sites - 20120510; DEC: Geomorphic Wetlands - 20120510, Environmentally Sensitive Areas - 20120510; DIA: Aboriginal Heritage Sites - 20120510; GHD: Study Area - 20120510. Created by: bflorczak

3. Design criteria

The design criteria adopted for this LWMS have been based on the design objectives outlined in *Better Urban Water Management* (WAPC, 2008),the Urban Water Management design objectives outlined in the Shire of Serpentine-Jarrahdale Urban Water Management Draft Planning Policy No 62 (Shire Serpentine-Jarrahdale, 2011) and State Planning Policy 2.1 for the Peel Harvey Catchment (WAPC, 2003).

3.1 Water Conservation

The overall intention of the LWMS is to achieve the sustainable management of all aspects of the water cycle within the development with the use of potable water to be as efficient as possible. Specifically the objectives for integrated urban water management for the development are:

- Mandatory use of rainwater harvesting on the lot-scale as the primary potable water. The *State Water Strategy* (Government of Western Australia, 2003) sets a target of 20% reuse by 2012. The development aims to reduce the use of scheme water by providing an alternative fit for purpose water supply for drinking water use.

3.2 Water Quantity Management

The post development annual discharge volumes and peak flows are to be maintained relative to pre-development conditions, unless otherwise established through determination of ecological water requirements for sensitive environments. To achieve the above principle the following criteria will be applied:

- Ecological protection - For the critical one year average recurrence interval (ARI) event, the post development discharge volume and peak flow rates shall be maintained relative to pre-development conditions in all parts of the catchment. Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles as agreed by DEC and DoW.
- Flood Management - Manage the catchment runoff for up to the 1 in 100 year ARI event in the development area to pre-development peak flows, unless otherwise indicated in an approved strategy or as negotiated with the relevant drainage service provider.
- Protect infrastructure and assets from inundation and flooding - Urban development usually results in the removal of significant areas of vegetation and replacement of permeable areas with buildings, roads and paved areas. This results in increased volumes and flows of surface runoff, which has the potential to cause flooding and inundation. Floor levels of all habitable buildings shall be a minimum of 1.2 m above groundwater level.

3.3 Water Quality Management

Maintain surface and groundwater quality at pre-development levels (winter concentrations) and if possible, improve the quality of water leaving the development area to maintain and restore ecological systems in the sub catchment in which the development is located. To achieve the above principle the following criteria will be applied:

- If the pollutant outputs of development (measured or modeled concentrations) exceed catchment ambient conditions, the proponent shall achieve water quality improvements in

the development area or, alternatively, arrange equivalent water quality improvement offsets inside the catchment. If these conditions have not been determined, the development should meet relevant water quality guidelines stipulated in the *National Water Quality Management Strategy* (ANZECC & ARMCANZ, 2000).

- Ensure that all runoff contained in the drainage infrastructure network receives treatment prior to discharge to a receiving environment consistent with the *Stormwater Management Manual* (DoW, 2004-2007) using structural controls representing 2% of connected impervious catchment
- Where implemented all outflows from sub soils will receive treatment prior to discharge to the stormwater system.
- Protect groundwater as a resource.

3.4 Commitment to best management practice

In order to meet the design criteria of reductions in total phosphorus, total nitrogen, total suspended solids and gross pollutants as compared to developments in which water treatment is not undertaken, it is necessary to use a combination of best management practice strategies. In addition, best management practice strategies reduce risks of flooding on housing and infrastructure while maximising the potential for stormwater to be treated as a resource.

The hierarchy of best management practice principles is as follows:

- Implement controls at or near the source to prevent pollutants entering the system and/or treat stormwater.
- Install in-transit measures to treat stormwater and mitigate pollutants that have entered the conveyance system.

Implement end-of-pipe controls to treat stormwater, addressing any remaining pollutants prior to discharging to receiving environments.

3.5 Objectives and strategy

A summary of the objectives for this LWMS is shown in Table 3.

Table 3 Water Management Objectives and Strategy

	Objective	Strategy
Water Conservation	Maximise the reuse of stormwater. Limit potable water use outside of homes and buildings. Reduce the average per capita potable water consumption.	Minimise potable water use outside of homes and buildings by providing alternative supplies and reducing demand by mandating the use of rainwater harvesting as the primary potable water source
Water Quantity	Maintain the total water cycle balance for ecological protection Minimise potential surface water pollution by use of non-structural and structural controls, in accordance to WSUD and BMP's.	Stormwater runoff shall be retained for up to the 1 hr 1-year ARI event off line from major flow paths. Attenuation of peak 5 and 100-year ARI developed flows to pre-development flows. Provide for the 100-year overflow path. Floor levels of all habitable buildings pad levels 0.5 m above the 100-year event flood level. Floor levels

	Protect property and infrastructure within and downstream of the development, to the required level of protection.	of all habitable buildings shall be a minimum of 1.2 m above groundwater level.
Water Quality Management	Maintain or improve the surface and groundwater quality within the study area relative to pre-development conditions. Maintain groundwater levels within the natural regime.	Using structural controls such as swales representing 2% of the connected impervious catchment in combination with non-structural controls such as public education campaigns, use of low phosphorus fertilisers in POS areas, to minimise potential pollution of stormwater and groundwater. Preliminary water quality targets will be established for the study area and reviewed and refined based upon future monitoring. Existing drainage inverts shall be maintained where possible.

4. Existing environment

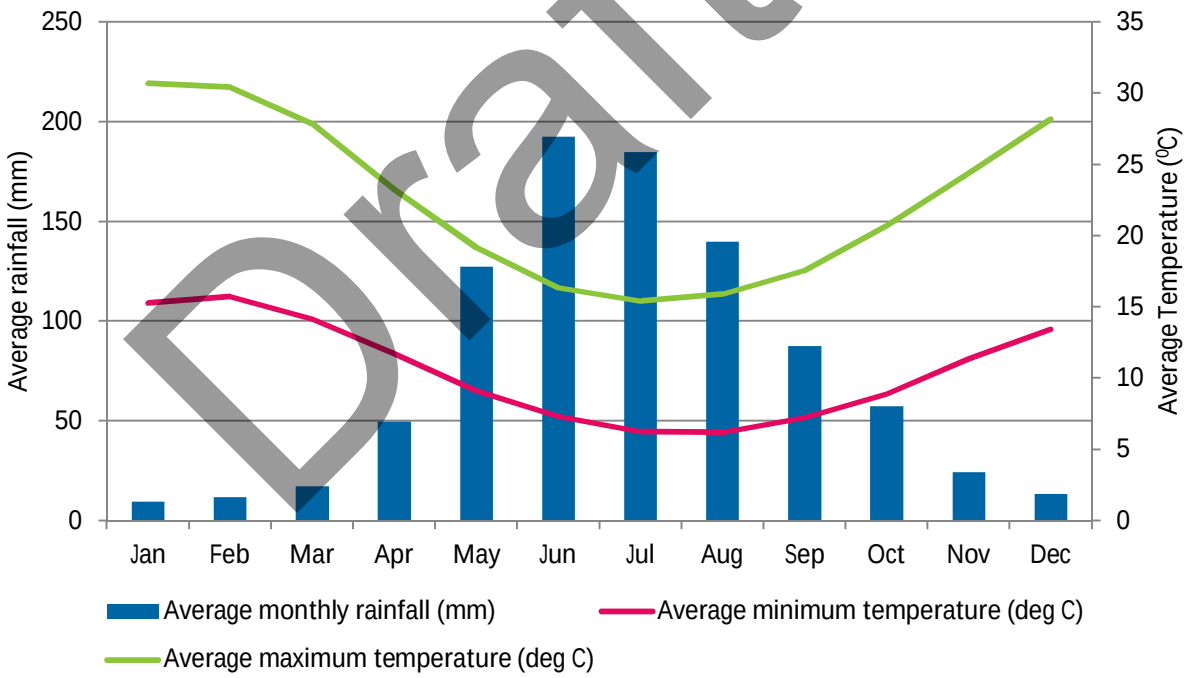
4.1 Location

The Serpentine Outline Plan development area is located in the suburb of Serpentine within the Shire of Serpentine-Jarrahdale approximately 50 km south of Perth as shown in Figure 2. The site is approximately 90 ha in area.

4.2 Climate

The climate in Serpentine is typically characterised by hot, dry summers, and cool wet winters. The nearest meteorological station which records rainfalls is the Serpentine gauge (station number 009039) which is approximately 2 km away from the development. The average annual rainfall at Serpentine from 1907 to 2011 is approximately 928 mm/annum. The nearest temperature station is at Karnet (station number 009111) which is approximately 10 km from the development. Figure 4 presents the monthly average rainfall at Serpentine and minimum and maximum temperature at Karnet, which indicates that on average 70% of the annual rainfall occurs over the months from May to August.

Figure 4 Monthly average temperature and rainfall



4.3 Topography

The site topography is characterised by a relatively flat palusplain (seasonally waterlogged land) varying between approximately 30 mAHD in the north-west corner to 35 mAHD in the middle of the site (Figure 5). As the site is not free-draining, it is important that drainage infrastructure is designed to convey runoff from the site in a controlled manner.

4.4 Land use

The current landuse within the development area is predominantly residential zoned R5 to R10, with a number of commercial and community lots and areas for POS and parks and recreation.

It is proposed that the landuse will remain largely residential a mixture of R5 and R10; however, the lot boundaries, POS and drainage network may be relocated, depending on future development plans.

4.5 Soils

4.5.1 Geology

The site corresponds to an area of Pinjarra Phase (P7). The Pinjarra Phase is described as seasonally inundated swamps and depressions with very poor drained acidic mottled yellow and sandy duplex soils.

The majority of the site consists of fine to medium-grained sandy soils, with areas of gravelly sandy clay to the east of the site and a pocket of clayey peaty sands in the west (Figure 7). The Geology Survey of Western Australia (1986) maps the site as Yilgran Craton (AYI(h)), described as granulite and migmatite, high grade metamorphic rock.

4.5.2 Contaminated soils

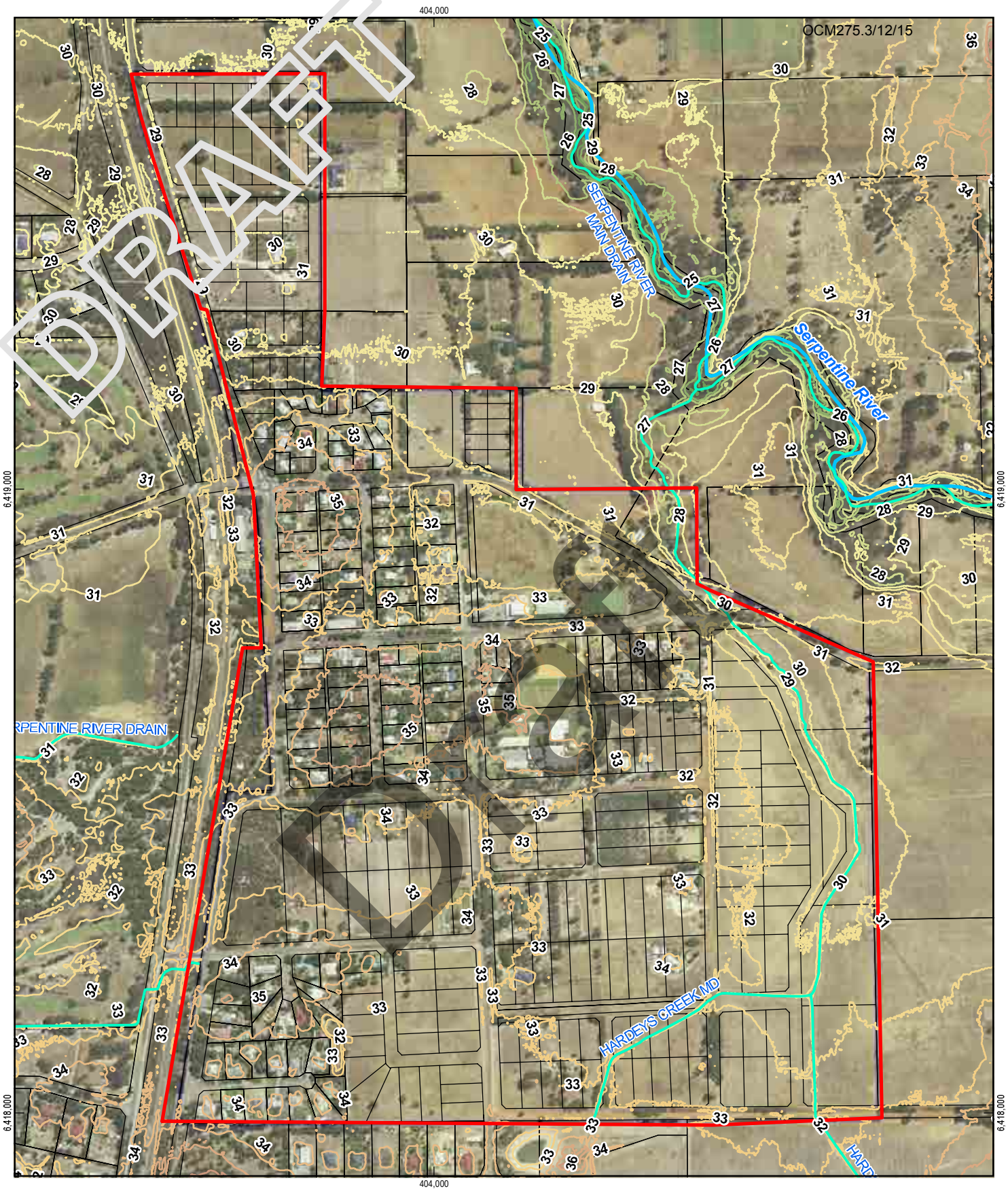
A search of the publically available DEC *Contaminated Sites Database* undertaken in May 2012 indicates that there are no registered contaminated sites within the development area. Historical landuse maps show the site has been primarily residential with some intensified farming land uses having previously been undertaken. It is likely long term fertilizer application has contributed to elevated nutrient levels in surface and groundwater.

4.5.3 Acid sulfate soils

Acid Sulfate Soils (ASS) are naturally occurring soils containing iron sulphides. These soils are typically benign within the anaerobic environment of their formation. However, when they become oxidised through various disturbances such as development, acidic soil, surface water and groundwater can result. Resultant sulphuric acid solubilises contaminants including heavy metals, potentially releasing lead, aluminium, iron, and arsenic into groundwater.

The main environmental indicator of ASS is shallow groundwater and/or waterlogging of laterites and sands, which may have generated sulphuric conditions, which lead to acid sulfate soils.

ASS risk mapping (Figure 6) indicates that the majority of the soils within the LWMS area have moderate to low risk of ASS. A small area to the west of the site (along Tonkin St) is classified as having a high to moderate risk of ASS occurring at depths less than 3 m from the surface. Works in this area will need to be conducted in accordance with an approved acid sulfate soil management plan.



LEGEND

Study Area	Cadastre	**LIDAR Contour 1m**	28	32	36	40
Open Drains	cadastre_cliped_ammend_Sep2012-	25	29	33	37	41
Rivers	CadastreOption2DashedLine-	26	30	34	38	
	cadastre_Option2-	27	31	35	39	

1: 551,311,233 (at A4)

0 30 60 120 180 240 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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Department of Planning
Serpentine Outline Plan LWMS

Topography and Drainage

Job Number 61-28174
Revision A
Date 18 Dec 2012

Figure 5

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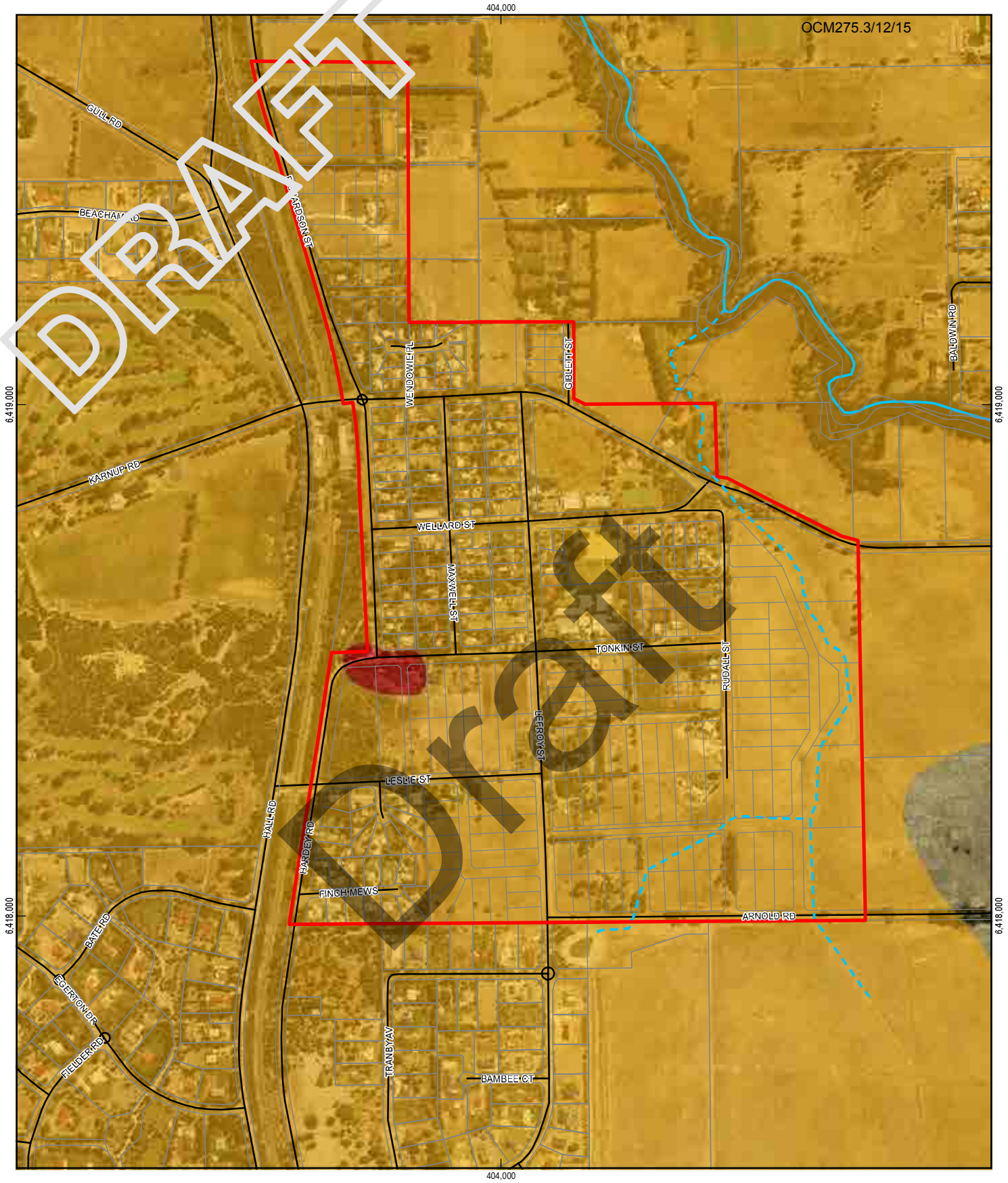
Data source: Water Corporation: Open Drains - 20120510; DoW: Rivers - 20120510, 100 year ARI Floodway and Flood Fringe Areas - 20120521; DoP: Serpentine Aerial - 20120517, Cadastre - 20120517, Contour 1m - 20120517; GHD: Study Area - 20120510. Created by: bflorczak



LEGEND

- Study Area
- Cadastre
- Roads

Acid Sulfate Soils

- High to moderate ASS disturbance risk (<3m from surface)
- Moderate to low ASS disturbance risk (<3m from surface)

1: 10,000 (at A4)

0 40 80 160 240 320 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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Department of Planning
Serpentine Outline Plan LWMS

Job Number 61-28174
Revision D
Date 18 Jan 2013

Acid Sulfate Soils

Figure 6

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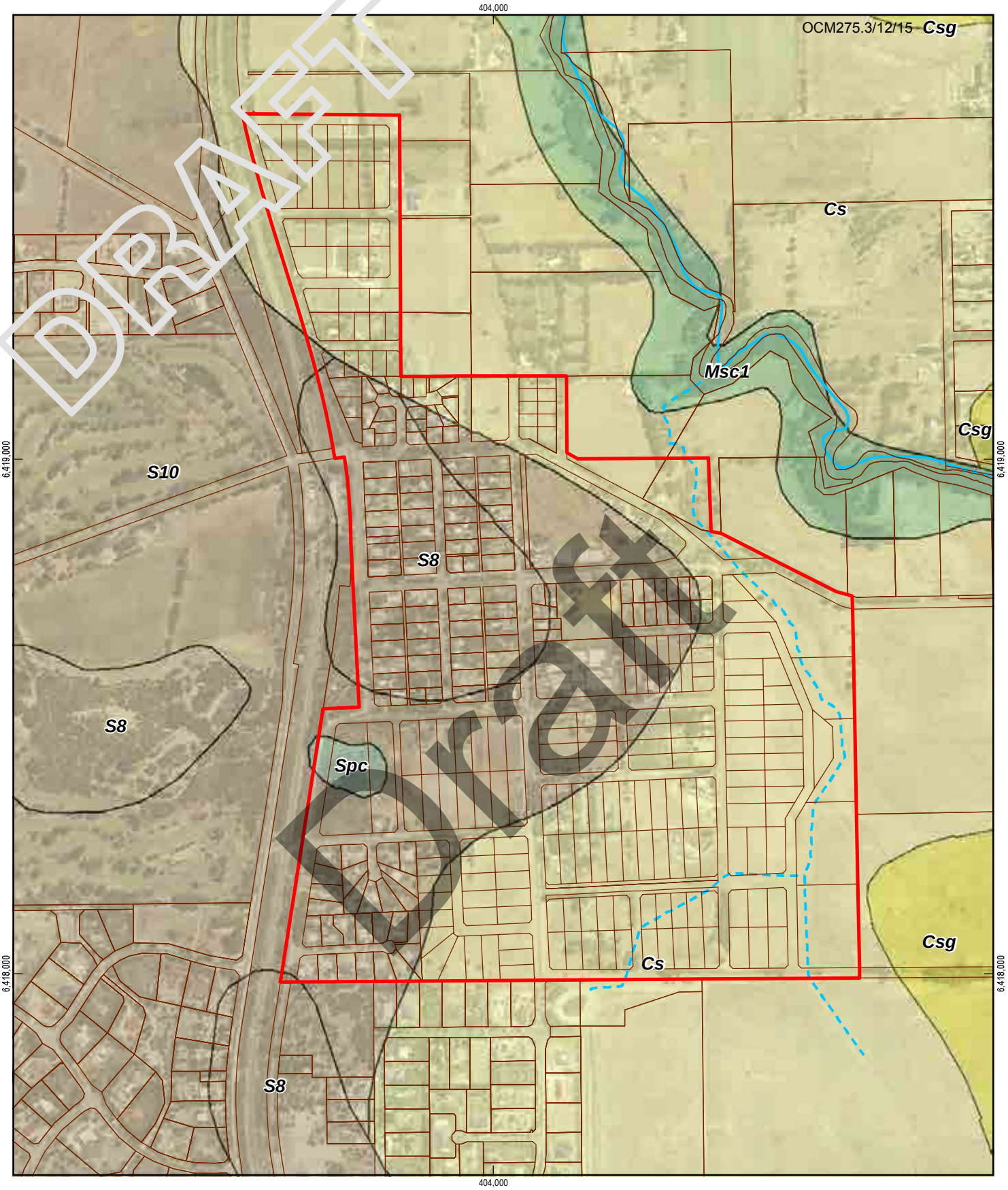
Data source: Landgate: Roads - 20120510; DoP: Serpentine Aerial - 20120517; DEC: Acid Sulfate Soils - 20120510; GHD: Study Area - 20120510. Created by: bflorczak



LEGEND

Study Area

LEVEL_NAME

Mainstream

Cadastre

Geology

Spc	*CLAYEY PEATY SAND - grey to black, quartz sand with variable organic content; minor clays, of lacustrine origin*
Msc1	*CLAYEY SANDY SILT - pale brown, sand angular to rounded, low cohesion, of alluvial origin*
Csg	*GRAVELLY SANDY CLAY - variable with lenses of silt and gravel, quartz sand sub-angular with eolian rounded component, heavy minerals common, gravel rounded, of colluvial origin*
S8	*SAND - white to pale grey at surface, yellow at depth; fine to medium-grained, moderately sorted sub-angular to sub-rounded minor heavy minerals, of eolian origin*
S10	*SAND - as S8 over sandy clay to clayey sand of the Guildford Formation, of eolian origin*
Cs	*SANDY CLAY - white, grey to brown, fine to coarse, sub-angular to rounded, clay of moderate plasticity; gravel and silt layers near scarp, of alluvial origin*

1: 10,000 (at A4)

0 40 80 160 240 320 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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Department of Planning
Serpentine Outline Plan LWMS

Job Number	61-28174
Revision	D
Date	18 Dec 2012

Geology

Figure 7

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G:\61\28174\GIS\Maps\MXD\6128174_G004_Fig7_RevD.mxd

Data source: DoP: Serpentine Aerial - 20120517, Cadastre - 20120517; DOIR:Geology 50k - 20120518; GHD: Study Area - 20120510. Created by: bflorczak

4.6 Reserves, conservation areas and environmentally sensitive areas

4.6.1 Bush forever

A small area to the west of the site is classified by the Department of Planning as a Bush Forever site (BFS), as indicated in Figure 8. The site BFS No 375 is co-located with a conservation category wetland bound by Hall Road and Richardson Street.

4.6.2 Aboriginal Heritage

The northern portion of the LWMS study area is classified as a ceremonial and mythological Aboriginal Heritage Site, as indicated in Figure 8. The classification is related to the Serpentine River (Site No. S02407) which extends along the Serpentine River and floodplain. The classification is not likely to impact development of the site.

4.6.3 Environmentally sensitive area

The majority of the LWMS area is classified by the DEC as an environmentally sensitive area, as indicated in Figure 8. These areas correspond to declared geomorphic wetlands and are discussed in Section 4.7.2.

4.6.4 Significant flora and fauna

No Declared Rare Flora or Fauna as classified by the DEC has been recorded in the study area.

4.7 Waterways, wetlands and drainage

4.7.1 Surface water

The Serpentine area is known to experience regular water logging in the low-lying area, with inundation due to a combination of persistent winter rainfall elevating the shallow water table, which rises to the surface and inundates areas of flat terrain, and poor drainage.

The Serpentine River is located approximately 400 m north of the northern site boundary (Figure 5). The Serpentine River flows south-westerly in a natural channel through Serpentine until it ultimately discharges into the Peel-Harvey Estuary system.

The Water Corporation open drains are shown in Figure 5. The Water Corporation Hardey's Creek Main Drain which conveys runoff north to the Serpentine River, intersects the eastern site boundary near Wellard St and drains a small area in the south-east of the development area near Arnold Rd. The Water Corporation Serpentine River Drain intersects the western boundary near Leslie St, and conveys runoff west, and discharges into the Serpentine River.

The site is included in the Serpentine Floodplain Management Study (SKM, 2011). The flood modelling indicated that the study area is not subject to inundation from overtopping of drains during the 100 year ARI flood events. However, Hardey's Main Drain upstream of Karnup Road (just north of the LWMS study area) was identified as being subject to between 1 – 2.5 m of inundation (classified as high to extreme flooding risk) during a 100 flood event, which could result in backwater effects upstream in the drain. Serpentine River flood map is provided in Appendix G.

4.7.2 Geomorphic wetlands

The DEC's *Swan coastal geomorphic wetland mapping* (date) (Figure 8) indicates the LWMS area contains Multiple Use, Resource Enhancement and Conservation Category wetlands within the study area. The following text provides further detail regarding these varyingly classified wetlands.

Multiple Use wetland areas

Much of the southern and eastern parts of the site are classified as Multiple Use wetland. The Multiple Use wetland areas are totally or mostly cleared, and are used for agricultural purposes. These wetlands still serve hydrological functions, such as groundwater recharge and flood mitigation, but they do not have any specific management objectives.

Resource Enhanced wetland areas

Smaller areas in the north and west of the site are classified as Resource Enhancement wetlands. The Resource Enhancement wetlands areas are wetlands which may have been partially modified, but still support substantial ecological attributes and functions.

Conservation Category wetlands

Conservation category wetlands occur in both the west and east of the site. Conservation category wetlands are the highest priority wetlands and support a high level of ecological attributes and functions. No development which may lead to further loss or degradation is permitted within Conservation category wetlands.

The Conservation category wetland, located at 51 Tonkin Street No. 14974 (refer to Figure 8), appears to have been cleared in the past and is unlikely to continue to support any values for which conservation classification was awarded. To support development of this area a request to reclassify the wetland to a less stringent management category, and an update to the *Geomorphic Wetlands Swan Coastal Plain* dataset was submitted to the DEC. This request contained:

- Visual justification
- Desktop study of wetland values
- Wetland vegetation condition assessment

DEC has advised the request to reclassify the Conservation category wetland, located at 51 Tonkin Street No. 14974, to a less stringent management category of multiple use has been approved. Department of Planning has provided the communications and approvals in Appendix F.

The proposed land use of the currently designated Conservation Category wetland No. 14974 will remain as the current R10 and R5 residential zoning. Upon subdivision, the stormwater drainage infrastructure and management measures will be implemented in line with the Stormwater Management Strategy discussed in Section 6 of this document.

The Conservation Category wetland located within the eastern sector of the Outline Plan (Lambkin Reserve) bound by Tonkin Street to the North, Leslie Street to the South and Hardey Road to the West will remain untouched, with the proposed land use identified as Restricted Public Open Space.

In order to protect this wetland a 50 m buffer is provided to the wetland from all future development in line with DEC requirements for wetland protection. An assessment of the wetlands hydrology indicates no external catchments will grade to the Conservation Category wetland, development is therefore unlikely to increase runoff to this wetland. As discussed in

Section 6 of this document, the development will ensure additional stormwater is directed along existing drainage path way away from the wetland.

4.8 Groundwater

4.8.1 Levels and flows

The LWMS development area is situated outside of the DoW's groundwater contour area. DoW's historic maximum groundwater contours, show the minimum groundwater level is 30 mAHD, approximately 0 m below the natural surface based on the existing topography. Based on site evidence, groundwater is generally perched at surface level in low lying areas during the winter months and flows in a westerly direction towards Serpentine River.

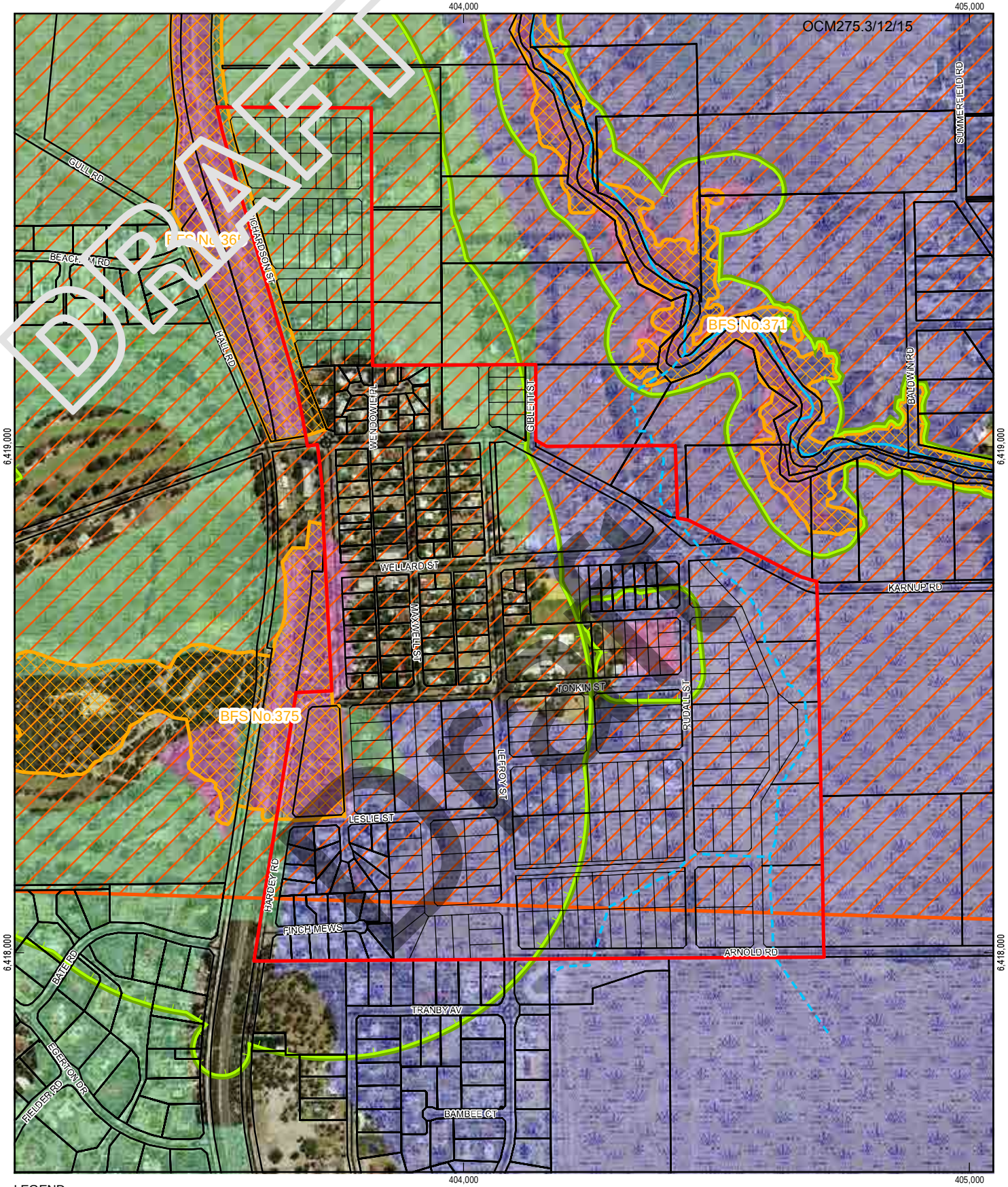
4.8.2 Groundwater quality

There is very limited groundwater quality data available for the study area. Based on previous land uses shallow groundwater quality is believed to have small concentrations of ortho-phosphorous in the groundwater. Total nitrogen (TN) concentrations are believed to be moderate, with moderate concentrations of nitrate and nitrite.

The site is classified by the DoW's as 'unsuitable for additional garden bores' due to the characteristics of the regional aquifer potentially resulting in poor groundwater quality and/or quantity (DoW, 2012). The geology of the site consists of clayey formations which could result in an unreliable water supply, and there is moderately high groundwater salinity level of between 1500 – 2000 mg/L, which could result in poor water quality (DoW, 2012). Garden bores can be installed and used to access groundwater for irrigation purposes; however, it is acknowledged that there are risks associated with the aquifer which could result in poor groundwater quality and/or quantity.

4.8.3 Future commitments

Due to the absence of further empirical data that could be used to characterise groundwater conditions in relation to depth and quality, a conservative design based on the Maximum Groundwater Level (MGL) defined as being ground level has been assumed in this LWMS. The requirement will be made to developers that both groundwater monitoring and a geotechnical assessment will be required, the data evaluated, and groundwater management measures identified prior to initiating development. The groundwater monitoring and geotechnical reports will be provided to DoW and the Shire of Serpentine Jarrahdale, as well as an updated groundwater management strategy, prior to development.



LEGEND

- Environmentally Sensitive Areas
- Bush Forever Sites
- Aboriginal Heritage Sites
- Cadastre

EVALUATION

- Conservation
- Resource Enhancement
- Multiple Use
- Not Assessed

- Roads

1: 10,153 (at A4)

0 40 80 160 240 320 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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Department of Planning
Serpentine Outline Plan LWMS

Environmental
and Heritage Constraints

Figure 8

Job Number	61-28174
Revision	A
Date	03 Dec 2012

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Data source: DoP: Serpentine Aerial - 20120517, New Cadastre - 20120517, Bush Forever Sites - 20120510; DEC: Geomorphic Wetlands - 20120510, Environmentally Sensitive Areas - 20120510; DIA: Aboriginal Heritage Sites - 20120510; GHD: Study Area - 20120510. Created by: bflorczak

5. Sustainable water use strategy

5.1 Water Efficient Fixtures and Fittings

It is proposed that the development permits only highly rated water efficient appliances and fittings. *The Water Use in Houses Code* Stage 1 requires that all tap fittings other than bath outlets and gardens taps must be minimum 4 stars Water Efficiency Labelling and Standards (WELS) rated, all showerhead must be a minimum 3 stars WELS rated and all sanitary flushing systems must be a minimum 4 stars WELS rated dual flush (Department of Housing and Works, 2007). This will be a requirement of the plumbing and design guidelines and be controlled though the inspection of houses when being connected to the non-drinking water supply. Further inspections will occur during change of ownership of properties by placing a condition on the title.

The water-using products covered by the WELS Scheme, are set out in Table 6. This table recommends WELS rating for these products.

Table 4 Specifications for Fixtures and Fittings

Product	Minimum WELS rating	Recommended WELS rating
Clothes washing machines	4	4.5
Dishwashers	4	4.5
Toilet (lavatory) equipment	4	4
Showers	3	4
Tap equipment	4	4
Urinal equipment	3	3

5.2 Efficient landscaping and irrigation measures

It is understood that POS areas within the LWMS study area are currently irrigated with groundwater abstracted from the local aquifer. Discussions with the Shire indicate that the intention is to continue to irrigate POS areas with groundwater in the short to medium term.

It is recommended that POS areas be designed to minimise irrigation requirements, with predominantly local native landscaping and keeping turf areas to a minimum. Innovative irrigation design methods and technologies will be used and the latest available documentation on irrigation in Western Australia will be followed, including:

- Urban Irrigation Best Management Practices (Irrigation Association of Australia, 2006);
- Waterwise Garden Irrigators Program – Design Principles, Specifications and Guidelines (Irrigation Association of Australia, 2007); and
- Waterwise Garden Irrigators Program – System Specifications, (Irrigation Australia, 2007).
- The following strategies will be applied to this development:

- Ensuring irrigation is installed according to Irrigation WA standards;
- Using rain sensors and soil moisture meters to turn irrigation off when not required;
- Using subsurface irrigation to reduce water lost to evaporation and wind displacement;
- Xeriscaping through use of plants with very little or no irrigation demand.

5.3 Fit-for-purpose water sources

5.3.1 In-house water demand

The subject land is not currently connected to the scheme water supply. The primary water supply to the residential development will be provided from rainwater harvesting from roof and shed runoff through the installation of rainwater tanks plumbed into houses.

The Shire of Serpentine Jarrahdale require a minimum rainwater tank storage of 109 kL (99 kL for domestic consumption and 10 kL storage for fire-fighting purposes) (personal communication, Shire Serpentine Jarrahdale, 2012). It is the responsibility of the landowner to maintain the upkeep of their rainwater tanks and any shortfall in water supply can be met by carting water.

5.3.2 External non-potable water demand

Household irrigation water demands can be met through re-use of effluent from the ATU systems. Additional irrigation requirements can be sourced from rainwater or the installation of garden bores. It is acknowledged that there are risks associated with the aquifer which could result in poor groundwater quality and/or quantity (Department of Water, 2011). The prospective purchases will be made aware of the risks of installing a garden bore on the subject lot at the point of sales, where of the associated risks will be included as part of the special provisions within the annexures of the sales contract.

Public open space irrigation can be met through existing groundwater allocation license holders transferring part or all of their licensed entitlement to new water users within the same subarea in accordance with Operations policy 5.13 – Water Entitlement Transactions for Western Australia (Department of Water, 2010). Applications for transfer will be assessed by Department of Water and relevant policies shall be complied with. Should additional non potable water be necessary groundwater allocation license are available within the Serpentine Area and an application for their use will be provided in future stages if required.

5.4 Rainwater harvesting water balance

5.4.1 Assumptions

The rainwater harvesting water balance was conducted to provide an indication of a suitable tank size for a variety of household occupancy rates (from 1 resident to 6 residents) and a variety of total harvestable roof areas (450 m^2, 500 m^2 and 700 m^2). The average lot sizes were estimated from the lot density in the updated cadastre plan provided by the WAPC. The maximum roof area was estimated from the minimum required open space per lot based on the zoning R codes from the Residential Zoning Codes.

Data from the Perth Residential Water Use Study 2008/2009 (Water Corporation, 2010) was used to provide an estimation of total in-house water demands, including both potable and non-potable water demands. The Perth Residential Water Use Study estimated an average annual usage of 56 kL/person/year, which incorporates savings from using water efficient appliances

and fittings. The annual demand was averaged over the year to generate a daily water demand (153 L/person/day), and multiplied by hourly demand factors to account for typical fluctuations in water demand over the course of the day. The water balance does not include demand for ex-house water usage such as irrigation.

Six minute rainfall data from the Jandakot rainfall gauging station (station number 009172) sourced from the Bureau of Meteorology was used to generate an hourly rainfall time series used in the rainwater harvesting water balance. The water balance was conducted for a typical high rainfall year, average rainfall year and low rainfall year (Table 5) to estimate a range of suitable rainwater tank volumes required to safeguard against prolonged dry periods.

It was assumed that rainfall in excess of 1 mm was required to generate roof runoff. The hourly water balance was conducted for the calendar year for the typical low, average and high rainfall years, beginning on the 1 January and ending 31 December. To establish an initial water volume in the tank, the water balance was run for an additional 7 month initialisation period using the average hourly rainfall data from 1 June to 31 December. Evaporation losses from the rainwater tank were not included in the water balance.

A minimum tank volume of 109 kL (where 99 kL is available for in-house water usage) was used in the calculations, based on requirements from the Shire of Serpentine Jarrahdale. A maximum tank size of 180 kL (where 170 kL is available for in-house water usage) was used in the calculations.

The results of the water balance are summarised in Table 6 to Table 8. The results indicate that for all lots with less than four residents, a 109 kL tank is sufficient to provide in-house water. Lots with a total roof area of 450 m^2 and between four to five residents require a larger tank of between 125 to 170 kL, and where there are six or more residents, the rainwater tank may require top-up. Lots with a total roof area of 500 m^2, and between four to five residents require a larger tank of between 125 to 155 kL, and where there are six or more residents, the rainwater tank may require top-up. Lots with a total roof area of 700 m^2, and between four to six residents require a tank of between 150 to 180 kL, and results indicate that these lots will not require top-up during dry rainfall years.

Table 5 Annual rainfall from Jandakot rainfall gauge (009172) for high, average and low rainfall years

Scenarios	Annual rainfall (mm)
High rainfall year (2000)	967
Average rainfall year (2002)	750
Low rainfall year (2004)	597

Table 6 Rainwater tank calculations for total roof area of 450 m^2

Number of residents	Annual demand (kL)	Low rainfall year			Average rainfall year			High rainfall year		
		Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)
1	56	217	109	0	281	109	0	383	109	0
2	112	217	109	0	281	109	0	383	109	0
3	168	217	109	0	281	109	0	383	109	0
4	224	217	125	0	281	109	0	383	109	0

Number of residents	Annual demand (kL)	Low rainfall year			Average rainfall year			High rainfall year		
		Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)
5	280	217	170	0	281	145	0	383	109	0
6	336	217	180	57	281	180	31	383	130	0

Table 7 Rainwater tank calculations for total roof area of 500 m^2

Number of residents	Annual demand (kL)	Low rainfall year			Average rainfall year			High rainfall year		
		Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)
1	56	241	109	0	312	109	0	425	109	0
2	112	241	109	0	312	109	0	425	109	0
3	168	241	109	0	312	109	0	425	109	0
4	224	241	125	0	312	109	0	425	109	0
5	280	241	155	0	312	140	0	425	109	0
6	336	241	180	25	312	180	5	425	115	0

Table 8 Rainwater tank calculations for total roof area of 700 m^2

Number of residents	Annual demand (kL)	Low rainfall year			Average rainfall year			High rainfall year		
		Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)
1	56	337	109	0	437	109	0	596	109	0
2	112	337	109	0	437	109	0	596	109	0
3	168	337	109	0	437	109	0	596	109	0
4	224	337	120	0	437	109	0	596	109	0
5	280	337	150	0	437	135	0	596	109	0
6	336	337	180	0	437	160	0	596	109	0

5.5 Wastewater

For the proposed R5 lots equal to or greater than 2000 m^2 there is no requirement by the Department of Health or the local authority for a connection to a sewerage system. No new R10 lots (lots equal to or greater than 1000 m^2) are proposed. Currently no sewer system is proposed for the Serpentine area.

Therefore individual lots within the rural residential development will be serviced by on-site Aerobic Treatment Unit (ATU) effluent disposal systems with the condition that use of an ATU meets the requirements outlined in Sections 5.1 and 5.7 of WAPC's Statement of Planning Policy No 2.1 *The Peel-Harvey Coastal Plain Catchment* (1992), and Section 5.2.2 of the WAPC Government Sewerage Policy: *Perth Metropolitan Region* (1995).

The selection of an appropriate ATU for the individual lots is the responsibility of the landowner, and the unit must comply with the Department of Health Code of Practice for the Design, Manufacture, Installation and Operation of ATUs (Department of Health, 2001).

The selection of an appropriate ATU for the individual lots is the responsibility of the landowner, and the unit must comply with the Department of Health Code of Practice for the Design, Manufacture, Installation and Operation of ATUs (Department of Health, 2001) and all additional requirements imposed by the Shire of Serpentine-Jarrahdale.

It is the responsibility of individual landowners to ensure that the wastewater treatment system adopted maintains adequate clearance to groundwater of 1.2 m and complies with Shire of Serpentine-Jarrahdale requirements (refer to Section 7 for indication fill requirements for groundwater separation). The building and effluent disposal envelope will be setback from drains located adjacent to the property boundary and from roadside table drains/swales to ensure sufficient horizontal separation. Shire of Serpentine-Jarrahdale requires effluent disposal areas to be defined early in the subdivision process for approval.

Effluent from ATU's is able to be disposed of via irrigation areas. Disposal to surface irrigation is not considered for a suitable option for this rural residential development due to high groundwater levels and other risks associated with surface disposal (public health risks, risk of runoff, risk of surface ponding, and disinfection).

Effluent will be disposed of via sub-surface irrigation (eg closely spaced and pressurised subsurface dripper pipework installed at a depth of 100 mm below the ground level) of a vegetated or landscaped disposal area. The sub-surface irrigation disposal area will be required to comply with setback requirements for buildings and other infrastructure.

The following measures are required to manage the risk nutrient runoff into the drains:

- Subsurface irrigation (closely spaced and pressurised subsurface dripper pipework installed at a depth of 100 mm below the ground level) is required to dispose of the effluent over a vegetated or landscaped disposal area;
- Construction of an irrigation disposal area with a minimum area of 150 m^2 which includes a layer of imported fill incorporating material that reduces phosphorus export (e.g. Spearwood Sands or a suitable clay mix);
- The irrigation pad requires a minimum 1.2 m of fill to provide sufficient vertical separation from the groundwater; and
- The irrigation disposal area is required to be located with a minimum separation distance of 30 m from the drainage network to increase the travel time and natural attenuation of nutrients prior to reaching the drains.

The following building pad criteria for each lot are required to ensure adequate clearance from groundwater levels:

- Aerobic Treatment Units: require a minimum 0.45 m separation to groundwater from the base of the tank;
- Alternative Treatment Units: require a minimum 0.6 m from the base of the unit to maximum groundwater levels.

It is the responsibility of the individual landowner and/or developer to receive approval from appropriate regulatory agencies to install an appropriate ATU system and ensure that quarterly servicing of the system is conducted by a contactor approved by the Department of Health.

6. Stormwater management strategy

6.1 Floodplain management

Recommendations for floodplain management are presented in the Serpentine River Floodplain management strategy (SKM, 2010). This study developed two-dimensional modelling of the Serpentine River catchment and resulted in the identification of floodway and flood fringe areas. The proposed Floodplain management plan (SKM, 2010) includes structural and non-structural measures for flood mitigation focused on managing potential flooding impacts on the site and to the immediate neighbouring land and drainage infrastructure.

6.1.1 Flood mitigation measures

Flood mitigation measures are focused on correct planning for appropriate land use in the structure plan areas and setting aside the land required for floodplain inundation depths. Existing and developed scenarios were presented within the Floodplain management strategy (SKM, 2010). The 'developed' case includes raised ground levels within subdivisions but no other modifications, such as waterway realignments or new or modified road crossings.

Planning measures recommended by the Flood plain management strategy (SKM, 2010) are:

- New dwellings in proposed and existing residential areas must have their floor levels elevated 500 mm above the 100 year annual recurrence interval flood level.
- New industrial or commercial premises should have their floor levels elevated 500 mm above the 100 year annual recurrence interval flood level.
- Major arterial roads with immunity to the 100-year annual recurrence interval flood level that access new residential areas and can provide egress to emergency services must be identified. Other residential streets should be designed to be serviceable up to the five-year annual recurrence interval flood event.

6.2 Pre development

The Serpentine area is known to experience regular water logging in the low-lying areas to the west of the study area. 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, and poor drainage.

Hardey's Creek drain runs south to north draining the adjacent agricultural and residential lots via 2 x 1200 mm culverts under Arnold Road. The drain also receives stormwater from the existing urban developed south of Tranby Avenue through an existing Water Corporation storage basin and overflow via a 1200 mm diameter culvert under Arnold Road. The combined flow runs through an unlined trapezoidal channel to Karnup Road where a series of 2 x 1200 mm culverts and 2 x 1500 mm culverts outlets to the Serpentine River.

The proposed subdivision was divided into 15 catchments, with delineation primarily based on the grades of the natural surface and existing drains with key flow rates identified in Table 9. Stormwater modelling confirmed the extensive flooding and water logging the south eastern portion of the proposed development.

Table 9 Predevelopment flow rates

Location	5 Year Predevelopment Flow (m^3/s)	100 Year Predevelopment Flow (m^3/s)
Arnold Road Basin	6.00	11.68
Hardey's Creek MD at Karnup Rd	8.17	17.90

6.3 Stormwater quantity

6.3.1 Proposed Stormwater Management Strategy

The drainage layout proposed in this LWMS refines the existing drainage in line with:

- The aspirations of the Serpentine Jarrahdale Shire for open drainage only;
- The proposed urban design concept for an integrated and rural feeling development; and
- Flood protection.
- This resulted in the following key components:
- Modification of the western section of Hardey's Creek Main Drain from Arnold Road to Rudall Street to enable conveyance of major flood flows through the study area in a linear public open space type corridor with the following benefits:
  - – No major drainage line along Arnold Road
  - – Useable public open space within the study area serving a flood protection function during major events
- Relocation of the existing retention basin from the rear of Finch Mews and Blue Wren Court as requested by Shire of Serpentine-Jarrahdale. The storage of this basin has been included in the future basins following development.
- Construction of three new retention basins (Figure 10) in order to service much of the remaining proposed development and ensure pre-development peak flows into Hardey's Creek Main Drain are maintained.

Based on the above reasoning the proposed stormwater management strategy employs the following measures for the following events:

1 year ARI event

- Roofs will be connected to soakwells or rainwater tanks.
- Road runoff will be infiltrated as close to source as practical using water sensitive urban design (WSUD) measures such as infiltration devices such as bioretention basins/swales, soakwells and Atlantis cells.

5 year ARI event

- Will be collected and conveyed swales. The swales will discharge directly to the Hardey's Creek Main Drain or will discharge to dry, shallow detention basins.
- Where swales and drains discharge to waterways and basins, the banks of the waterway or basin will be stabilised to prevent scouring.

100 year ARI event

- Events greater than the 5-year ARI event will be conveyed away from the development along roads and POS, discharging to Hardey's Creek Main Drain or Serpentine River. Basins have been sized to compensate major events up to the 100-year ARI event to the pre-development flow.
- Lots will be set a minimum of 0.5 m above 100 year ARI flood level

6.3.2 Stormwater rates and volumes

Urbanisation results in an increased impervious area. Increased rates and volumes of stormwater runoff must be managed to protect infrastructure and assets from flooding and inundation, while water quantity and quality must be managed to protect wetlands and waterways from risk of increased inundation and contaminant loads. Surface water management must ensure that urban development does not increase the peak flows discharging to receiving environments.

The 5 and 100 year storage volumes and flow rates required for each of the basins are presented in Table 10. The indicative locations and surface areas of basins are shown in Figure 10. The detention storages should be located outside of the floodway and landscaped into the surrounding public open space and should be designed with a maximum water depth in a 100 year ARI event of 1.5 m with side slopes between 1:6 and 1:8. It is important to note that the requirement to retain/detain the 1 year 1 hour ARI event and provide bio retention areas equivalent to 2% of the connected impervious area should be dealt with separately and therefore have not been incorporated into these storages.

Table 10 Basin Peak Flow Rates and Volumes

Location	5 year Flow (m^3/s)	100 Year Flow (m^3/s)	5 Year Volume (m^3)	100 Year Volume (m^3)	Estimated 5 Year Area (m^2)	Estimated 100 Year Area (m^2)
1Basin	0.45	0.87	950	2200	950	2500
2Basin	8.00	17.20	7700	39800	8750	23600
3Basin	0.40	0.85	250	550	250	630

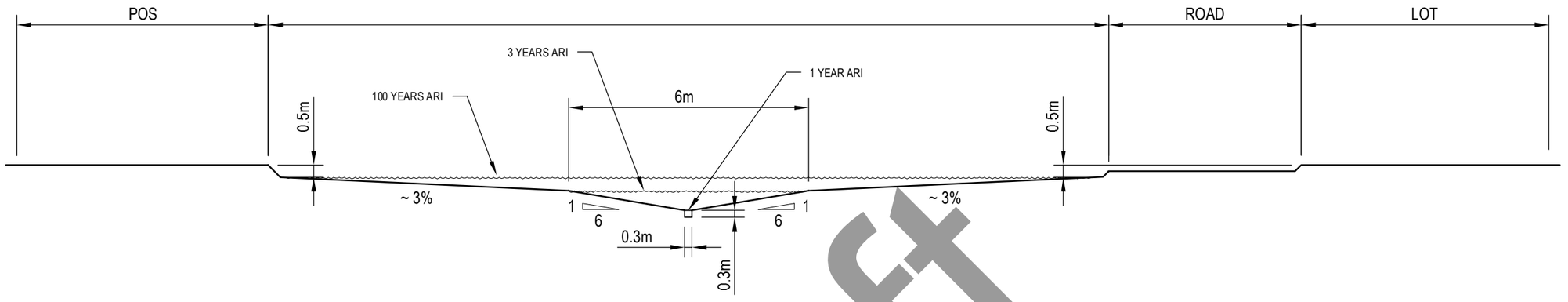
As described in Section 2.1.2 and shown in Figure 10 it is proposed to co-locate POS areas with drainage. Approximately 17.8 ha the site is identified as POS with 15 ha being unrestricted POS. A total of 1.732 ha the POS identified will be restricted POS be used for drainage. Basins are designed to drain within 3 days of a major storm event to limited POS inundation time.

Downstream discharge flow rates from development area follow and (incorporating upstream flows) do not exceed pre-development peak flow rates at Hardey's Creek Main Drain as shown in Table 11.

Table 11 Pre and Post Development Flow Rates

Location	5 Year Predevelopment Flow (m^3/s)	5 Year Post development Flow (m^3/s)	100 Year Predevelopment Flow (m^3/s)	100 Year Post Development Flow (m^3/s)
Hardey's Creek MD at Karnup Rd	8.17	7.80	17.90	17.40

Hardey's Creek Main Drain is proposed to be a 1 m deep with 13 m top width and 1:6 sides (5 year ARI event flow depth would approximately equal 350 mm) living stream incorporated into the POS..



HARDY'S CREEK MAIN DRAIN (MULTIPLE USE CORRIDOR)

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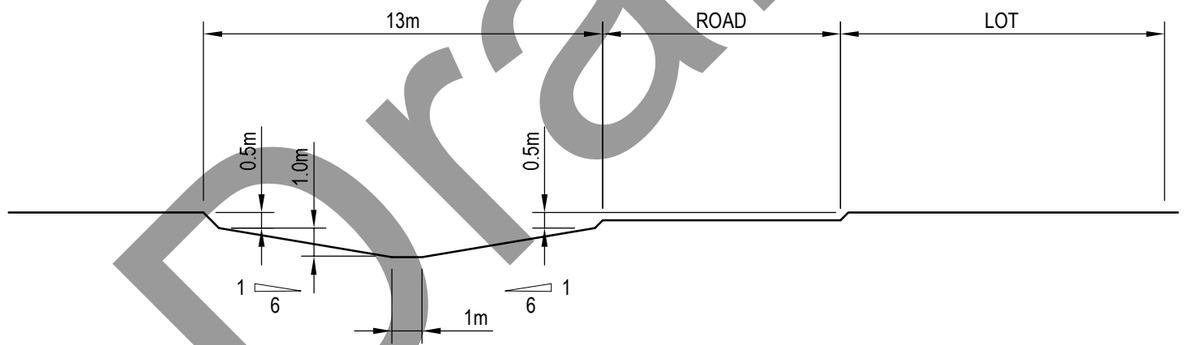

MINOR SWALE THROUGH ROAD RESERVE

NTS

0 2m 4m 6m

SCALE 1:200 AT ORINIGAL SIZE

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DEPARTMENT OF PLANNING
SERPENTINE OUTLINE PLAN LWMS

SWALE CROSS SECTION

job no. 6128174
rev no. A

scale 1:200 for A3 date DEC 2012

Figure 9

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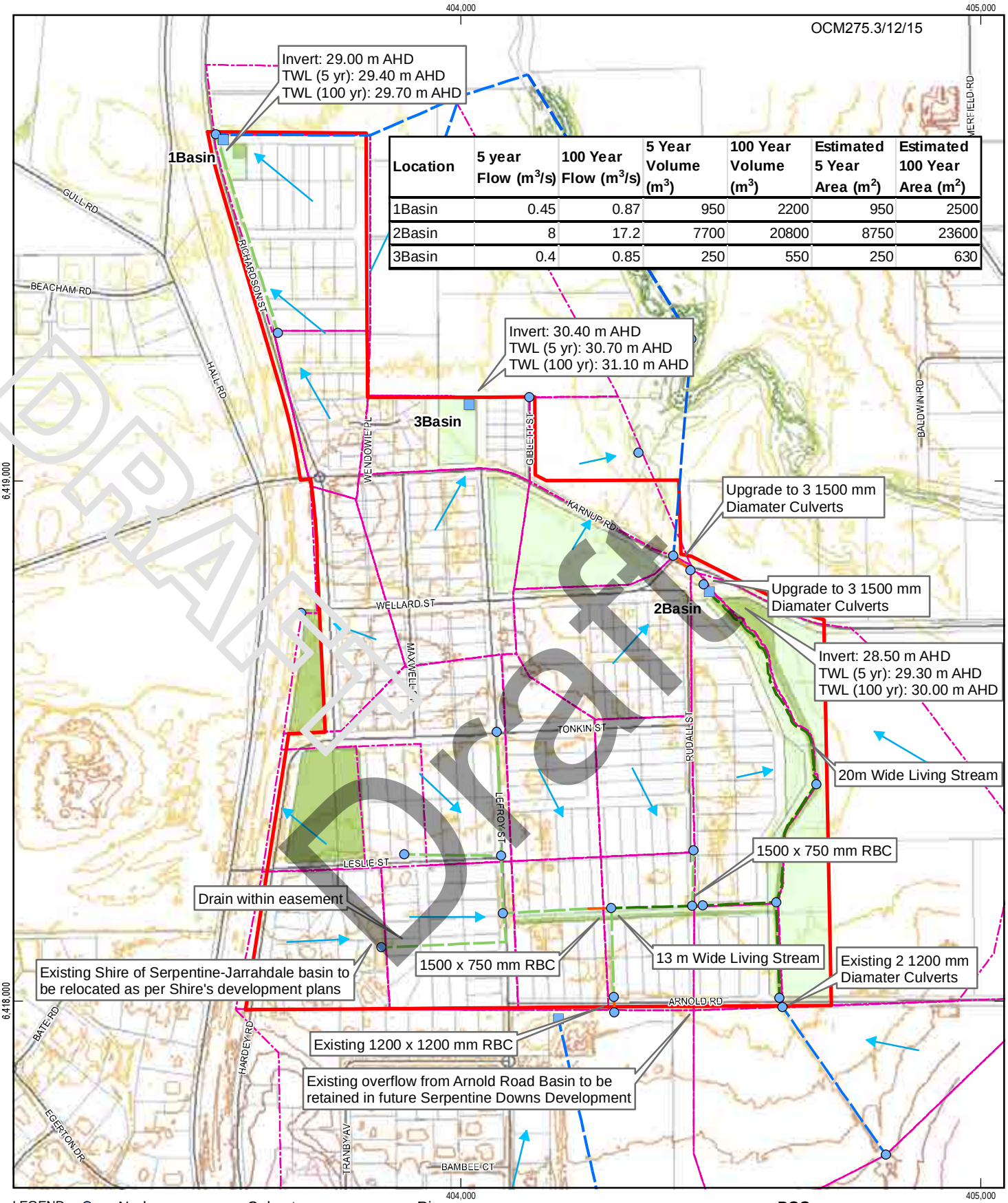

Location	5 year Flow (m^3/s)	100 Year Flow (m^3/s)	5 Year Volume (m^3)	100 Year Volume (m^3)	Estimated 5 Year Area (m^2)	Estimated 100 Year Area (m^2)
1Basin	0.45	0.87	950	2200	950	2500
2Basin	8	17.2	7700	20800	8750	23600
3Basin	0.4	0.85	250	550	250	630

LEGEND

- Node
- Storage
- Culverts
- Drain
- Living Stream
- River
- Swale
- Catchment Flow Direction
- Study Area
- Catchments
- Cadastre
- Roads
- POS
- Restricted
- Unrestricted

1: 10,000 (at A4)

0 40 80 160 240 320 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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Department of Planning
Serpentine Outline Plan LWMS

Job Number 61-28174
Revision D
Date 18 Jan 2013

Stormwater Management Strategy Figure 10

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6.4 Fill requirements

100 year ARI flood event modelling results are presented in longitudinal sections in Appendix E. Fill requirements adjacent to modelled waterways are estimated not to exceed 1.5 m.

No on site groundwater monitoring or investigations have been undertaken so it is not possible to accurately determine the amount of fill required as a result of groundwater levels at this stage. Fill requirements away from the waterways must be determined in conjunction with appropriate earthworks designs to achieve satisfactory surface and subsurface drainage grades and block levels appropriate to the nature and size of developed lots and may vary substantially from this estimate. Refer Section 7.2 for groundwater level management.

6.5 Stormwater quality

To address stormwater and flood management, the principles of the minor/major system of drainage will be employed. The minor drainage system accommodates the low frequency ARI event, typically less than 5 year ARI events. The major drainage system is a system swales, kerbs and roads to attenuate and infiltrate peak surface water flows.

It is proposed to adopt Water Sensitive Urban Design (WSUD) and Best Management Practices (BMPs) promoting retention, infiltration and treatment of events up to the 1-year ARI events, in accordance with the *Stormwater Management Manual for Western Australia* (DoW, 2004-2007).

Where development is associated with an ecosystem that is dependent on a particular hydrologic regime for survival, the water quality discharged to the groundwater must be in accordance with the requirements of DEC.

Where development is associated with any new or existing waterway or open drain that intersects the shallow water table, and that may discharge pollutants from the shallow groundwater to receiving environments, the following interim targets will be adopted until such time as appropriate site-specific targets are developed.

- As compared with a development that does not actively manage water quality, the following should be achieved:
  - – at least 60 per cent reduction of total phosphorous
  - – at least 45 per cent reduction of total nitrogen

It is anticipated that the site-specific targets will be developed after one year of monitoring which will allow for a preliminary understanding of baseline conditions. The site-specific targets will be adopted prior to any development activities.

Engineering drawings submitted to Council for approval must be supported by clear and auditable documentation, providing details of proposed staging and implementation of the surface and groundwater quantity and quality management strategy.

It is strongly recommended that developers meet with the Shire to discuss proposed surface and groundwater management strategies and to gain further guidance on site-specific requirements of the local authority at commencement of any urban water management plan.

6.5.1 Structural measures

The choice of structural treatment measures varies across the study area to suit streetscape and POS landscapes.

The proposed drainage plans uses multiple soak wells, Atlantis cells and basins to infiltrate the 1 year 1 hour ARI. The process of infiltration effectively filters the stormwater and is effective in the removal of particulate nutrients. To increase the potential of the infiltration device treatment media, such as Laterite is to be employed.

A bioretention system, which represents 2% of the total impervious area, will result in performance at the maximum possible reductions. The key WSUD elements to be incorporated into the design of subdivisions within the study area are:

- Biofiltration pockets: Wherever practical, these small biofiltration and infiltration systems will be incorporated into non-frontage verges (where they will not obstruct driveway crossovers) and road nibs.
- Vegetated median swales: Wherever practical, biofiltration and infiltration systems in the form of vegetated swales will be incorporated into median strips.

6.5.2 Non structural measures

Non-structural measures to control and reduce discharge of contaminants to the groundwater are based on source control of stormwater. Non-structural source control can include:

- Actions that aim to change behaviour such as public awareness campaigns and community education;
- Strata management operations and maintenance activities such as street sweeping, waste management, landscape maintenance and fertiliser use;
- Land use and management measures, such as sediment and erosion control during construction and permeable pavements;
- Develop landscaping guidelines for the proposed development area that recommend the use of appropriate native species in landscaping and provide advice on the responsible use of fertilisers and herbicides;
- Provide an effective waste-management plan for the area to ensure that litter and other waste does not collect in the drainage systems, including street sweeping; and
- Require all development construction projects, including road and infrastructure construction, to implement sediment and erosion control measures.
- Non-structural measures have been shown to be cost-effective long-term methods of improving water quality and reducing contamination.

6.6 Best Management Practices

Table 12 outlines the best management practices for maintaining a high level of surface water quality.

Table 12 Best management practices for surface water quality

Best management practices	Definition of recommended action
Residential fertiliser	Use low water soluble fertiliser applied to sandy textured soils, applied sparingly to gardens and turf.
	Minimise lawn areas or plant an alternative lawn.

	Fertilise only when symptoms of nutrient deficiency occur eg. Yellowing.
	Use a complete lawn fertiliser containing nitrogen, phosphorus and potassium, if fertiliser is required.
	Apply fertiliser at the maximum individual application rate, that is 25 g/m2 for couch and 12 g/m2 for kikuyu and buffalo grass.
	If fertiliser is required apply in spring or early autumn (Sept, Oct, Nov, Mar and Apr).
	Do not fertilise during summer or winter months.
	Do not over-water.
Soil remediation	Ensure all new urban developments in areas with sandy soils undergo soil remediation at the estate scale.
	At the lot scale blend or apply a layer of higher PRI soil 0-50 cm beneath the finished ground level to provide increased phosphorus retention.
	Use soil amendment materials such as yellow Spearwood sands, Karrakatta soils or brown loams.
	Remediate soil in accordance with Peel-Harvey coastal catchment water-sensitive urban design technical guidelines.
	Take care to maintain soil permeability.
Water and nutrient sensitive principles	Decision-making authorities should take a lead planning role in incorporating best management practices including water-sensitive urban design principles, criteria and outcomes in its strategic land use planning, policies structure plans and subdivision conditions.
Water-sensitive urban design	Compliancey with environmental quality criteria should be incorporated in local planning policy
	Ensure design complies with stormwater management policies
	Apply water-sensitive urban design treatment trains
	Prepare water management strategies
	Undertake soil amendment.
	Ensure total phosphorus and total nitrogen import and export criteria are met.
	Meet the minimum percentage area of deep-rooted perennial vegetation
	Impose building and landscaping covenants
	Ensure sound construction and building site management.
Drainage reform	Modify drainage management practices to reduce in-channel sediment movement as opportunities arise.

	Manage drainage as part of the total water cycle with the dual objectives of optimising stormwater runoff and reducing nutrient flows into the rivers and streams.

To ensure that WSUD features perform well, look attractive, require low maintenance, and to extend their design life, it is important to choose appropriate plant species for the construction of the WSUD feature. The choice of plant species for use is a function of:

- Size of WSUD feature;
- Location of WSUD feature in relation to roads and public open space;
- Prevailing soils and climate;
- Ability of the plant to absorb nutrients;
- Ability of the plant to meet hydraulic requirements;
- Ability of the plant to undergo periodic inundation, if required;
- Water/ irrigation demand of plant and ability to withstand drought;
- Prevailing salinity;
- Local representation of plant species;
- Root structure and behaviour;
- Plant size; and
- Visual appeal of plant.

Based on the above criteria Table 13 and Table 14, list the recommended species for use in the proposed WSUD features. Shire of Serpentine-Jarrahdale has provided a plant selection list based on accepted plant species for use in the Serpentine area. Refer to Appendix H for further details.

Table 13 Recommended plant species for infiltration/detention basins

Botanical Name		Common Name	Approved
Melaleuca	preissiana	Stout paperbark	Yes
Melaleuca	rhaphiophylla	Freshwater paperbark	Yes
Melaleuca	cuticularis	Saltwater paperbark	
Melaleuca	lateritia	Robin redbreast bush	
Banksia	littoralis	Swamp banksia	
Banksia	seminuda	River banksia	
Carex	appressa	Tall sedge	Yes
Carex	fascicularis	Tassel sedge	Yes
Carex	inversa	Knob sedge	
Dianella	caerulea	King Alfred	

Dianela	revoluta	Little Rev	
Lomandra	histrix	Tropic Belle	
Lomandra	longifolia	Lomandra	
Juncus	caespiticius	Grassy rush	
Juncus	holoschoenus	Jointleaf rush	
Juncus	kraussii	Sea rush	Yes
Juncus	pallidus	Pale rush	Yes
Juncus	pauciflorus	Loose flower rush	Yes
Juncus	subsecundus	Finger rush	Yes
Goodenia	pulchella	subsp. Coastal Plain	
Eucalyptus	occidentalis	Flat-topped-yate	Yes
Eucalyptus	rudis	Flooded gum	
Casuarina	cunninghamiana	Casuarina	
Ficinia	nodosa	Knotted club rush	Yes
Lepidosperma	gladiatum	Coastal sword-sedge	Yes

Table 14 Recommended plant species for bioretention swales/biofiltration pockets

Botanical Name		Common Name	Approved
Carex	appressa	Tall sedge	
Carex	appressa	Tassel sedge	
Carex	inversa	Knob sedge	
Juncus	caespiticius	Grassy rush	Yes
Juncus	holoschoenus	Jointleaf rush	Yes
Juncus	kraussii	Sea rush	Yes
Juncus	pallidus	Pale rush	Yes
Juncus	pauciflorus	Loose flower rush	
Juncus	subsecundus	Finger rush	
Ficinia	nodosa	Knotted club rush	Yes
Dianella	caerulea	King Alfred	Yes
Dianela	revoluta	Little Rev	

Lomandra	histrix	Tropic Belle	
Lomandra	longifolia	Lomandra	
Lepidosperma	gladiatum	Coastal sword-sedge	

6.7 Disease Vector Management

The drainage network has been designed to ensure that detained immobilised stormwater is fully infiltrated or conveyed within a 96 hour time period between the months of November and May, in compliance with the Shire of Serpentine-Jarrahdale's design criteria for Urban Water Management (Shire Serpentine-Jarrahdale, 2011).

Additionally, regular inspections and maintenance of the bioretention swales is recommended to control weed growth and minimise silt build-up to prevent clogging and reduce ponding after each storm event.

7. Groundwater management strategy

7.1 Glossary of terms

Controlled groundwater level

Controlled groundwater level (CGL) is a groundwater level endorsed by DoW and is the depth at which subsoil drains are installed. In the absence of groundwater monitoring, the GCL should be placed at the maximum groundwater level (MGL) which has been defined as being at the surface level. Sub-surface drainage may not be installed below the controlled groundwater level.

Maximum groundwater level

Maximum groundwater level is a groundwater level endorsed by the DoW. The actual level selected will vary according to availability of data and/or modelling results, but is commonly the maximum recorded groundwater level for a high rainfall condition. In the absence of data this level is assumed at groundwater level.

Developments will be required to make the development surface level 1.2 m above the maximum groundwater level, if subsurface drainage is not installed and meet all requirements for ATU separation.

Phreatic line

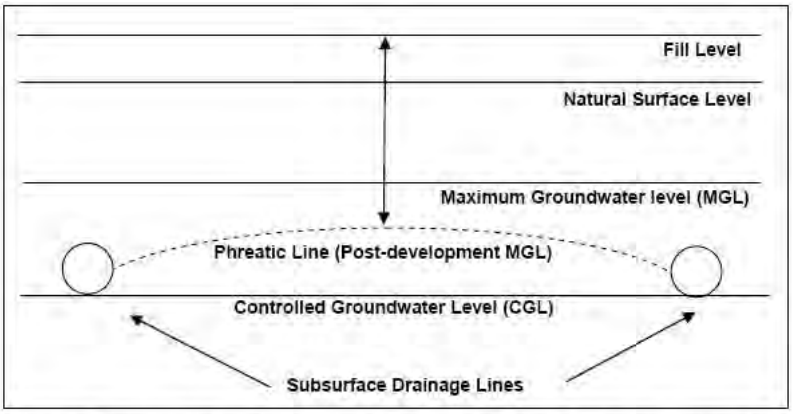
The phreatic line is the modified (post development) maximum groundwater level following the installation of subsurface drainage and is in fact an arc in between subsurface drainage lines, as indicated in Figure 11

When subsurface drainage is installed the phreatic line becomes the level from which building floor level clearance to groundwater is measured termed Design Groundwater Level (DGL).

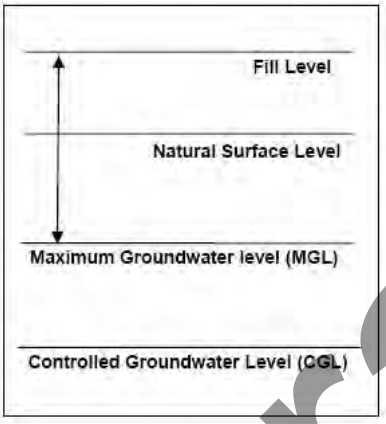
7.2 Groundwater Levels

The building finished floor levels and effluent disposal areas (reticulation pad) within each individual lot must maintain at least 1.2 m clearance from the MGL through the importation of clean fill, in compliance with the Shire's building requirements. This meets the requirements of groundwater clearance of more than 0.45 m and 0.6 m for the ATU systems. Imported fill is to incorporate a band of material that will reduce phosphorus export via leaching (e.g. Spearwood Sands), while meeting soil permeability and compaction criteria required by the Shire of Serpentine-Jarrahdale.

Examples of different ways in which the groundwater clearance and subsurface drainage criteria may be met under different conditions are presented below in Figure 11. Case 1: The natural surface is less than 1.2 m above maximum groundwater level. Subsurface drainage is installed at controlled groundwater level to control the maximum groundwater level. However, because the natural surface is less than 1.2 m above the resultant phreatic line, some additional fill has also been provided to meet the minimum clearance requirement.



Case 2: The natural surface is less than 1.2 m above maximum groundwater level. Fill is provided to meet the minimum clearance requirement.



Case 3: The natural surface is greater than 1.2 m above maximum groundwater level. No fill or subsurface drainage is required to meet the minimum clearance requirement.

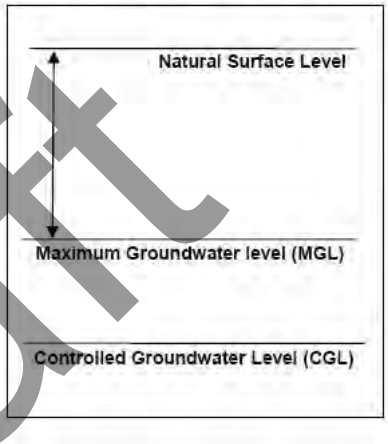


Figure 11 Meeting the groundwater clearance and subsurface drainage criteria.

To protect housing from flooding and damage from groundwater, the predicted maximum groundwater level must be determined, through modelling and/or measurement. As this information is not currently available, local studies shall be undertaken and endorsed by the DoW. Where the predicted maximum groundwater level is at or within 1.2 m of the surface the importation of clean fill and/or the provision of sub surface, drainage will be required to ensure that adequate separation of building floor slabs from groundwater is achieved. In such instances, the sub surface drainage will need to be placed at a DoW approved controlled groundwater level.

Further investigations will be required in the next stage of planning to determine local scale predicted maximum groundwater level for individual developments to determine whether subsurface drainage is required for protection of urban infrastructure.

Where a perched water table exists or the predicted maximum groundwater level is at or within 1.2 m of the natural ground level, the importation of clean fill and the provision of subsurface drainage will be required to ensure that adequate separation of building floor slabs from groundwater is achieved. In such instances, the sub surface drainage will need to be placed at or above the approved controlled groundwater level. The design of proposed subsurface drainage systems should determine the resulting phreatic line (or the line marking the upper surface of the zone of saturation in the soil) termed the Design Groundwater Level in between drainage lines and finished lot levels should be a minimum of 0.8 m above.

Any clean fill imported onto the site is to incorporate a band of material that will reduce phosphorus export via soil leaching, whilst also meeting soil permeability and soil compaction criteria specified by the local government authority. The bio-retention system and drainage inverts are set at or above controlled groundwater level although existing inverts below the level may remain. Sub surface drainage is to be installed at or above controlled groundwater level and must be designed with free-draining outlets.

Figure 12 illustrates those areas that will require subsoil drainage/fill to meet the required separation.

7.3 Groundwater Quality

The environmental values of groundwater within, and surrounding, the study area must be upheld.

To ensure that the existing groundwater quality is maintained, the quality of the stormwater infiltration to groundwater will be maximised through:

- Adopting a treatment train approach to runoff, through the use of WSUD and BMPs such as permeable pavements, buffer strips, bioretention swales, rain gardens, biofiltration pockets, median swales, gross pollutant traps, and infiltration basins;
- Xeriscaping to avoid the use of fertilisers;
- Recommending a maintenance plan for the upkeep of the treatment train; and
- Recommending a monitoring program is implemented during construction and post development to ensure that the management measures for stormwater quality are meeting the design objectives.

Where development is associated with an ecosystem that is dependent on a particular hydrologic regime for survival, the water quality discharged to the groundwater must be in accordance with the requirements of DEC.

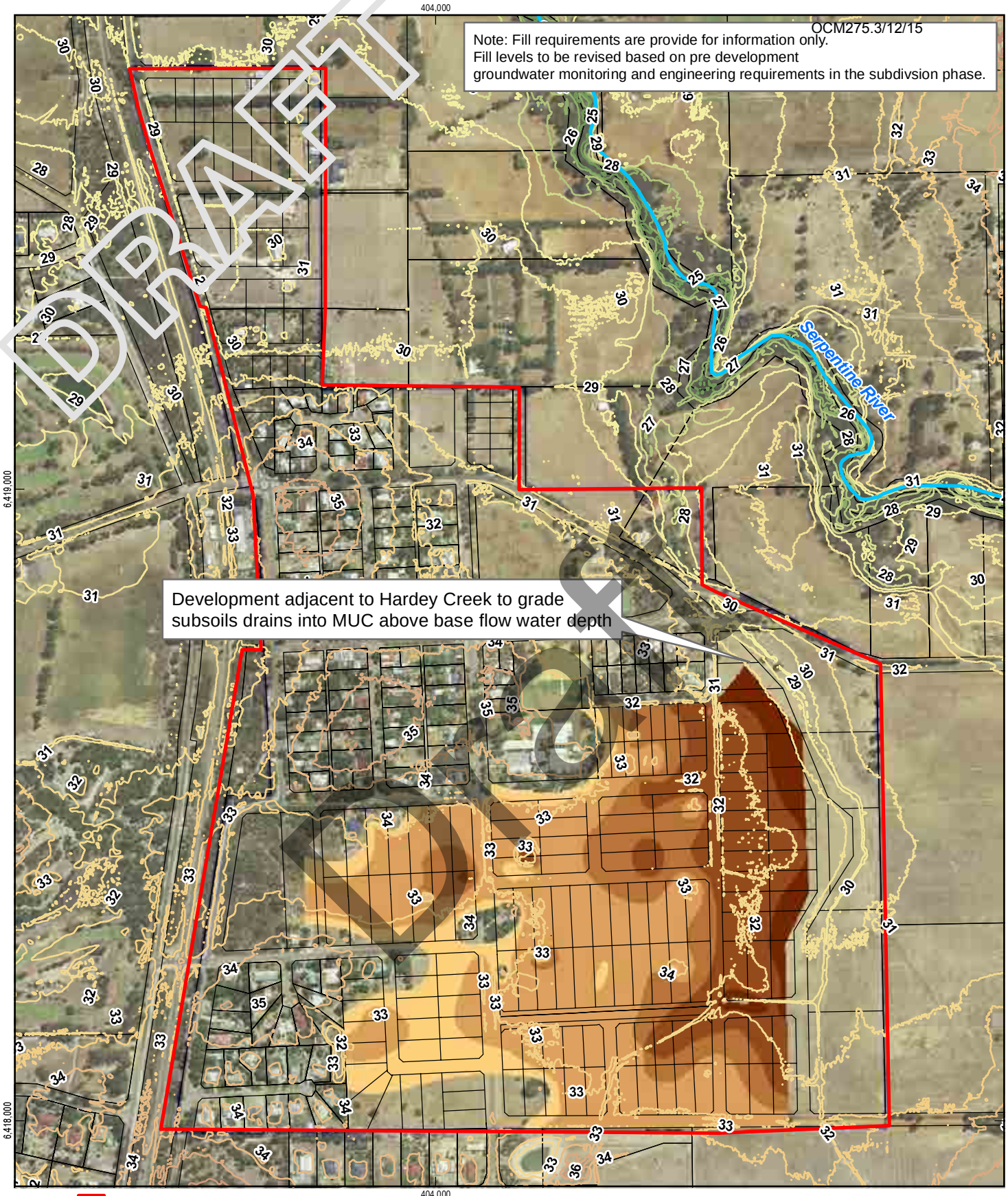
Where development is associated with any new or existing waterway or open drain that intersects the shallow water table, and that may discharge pollutants from the shallow groundwater to receiving environments, the following interim targets will be adopted until such time as appropriate site-specific targets are developed.

- As compared with a development that does not actively manage water quality, the following should be achieved:
  - at least 60 per cent reduction of total phosphorous
  - at least 45 per cent reduction of total nitrogen

Engineering drawings submitted to council for approval must be supported by clear and auditable documentation, providing details of proposed staging and implementation of the surface and groundwater quantity and quality management strategy.

It is strongly recommended that developers meet with the Shire to discuss proposed surface and groundwater management strategies and to gain further guidance on site-specific requirements of the Shire at commencement of any urban water management plan.

Note: Fill requirements are provide for information only.
Fill levels to be revised based on pre development groundwater monitoring and engineering requirements in the subdivsion phase.



LEGEND

- Study Area
- Cadastre

Approxminate Fill Height (based on MGL at surface)

- Greater than 1.5 m
- 1.0 - 1.5 m
- 0.5 - 1.0 m
- 0.2 - 0.5 m
- Less than 0.2 m

LIDAR Contour 1m

25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41

1: 8,224 (at A4)

0 100 200 300 400 Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

GHD CLIENTS | PEOPLE | PERFORMANCE

Department of Planning
Serpentine Outline Plan LWMS

Indicative Fill Requirements

Job Number 61-28174
Revision A
Date 18 Dec 2012

Figure 12

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

G:\61\28174\GIS\Maps\MXD\6128174_G008_Fig10_RevA.mxd

Data source: Water Corporation: Open Drains - 20120510; DoW: Rivers - 20120510, 100 year ARI Floodway and Flood Fringe Areas - 20120521; DoP: Serpentine Aerial - 20120517, Cadastre - 20120517, Contour 1m - 20120517; GHD: Study Area - 20120510. Created by: bflorczak

8. Monitoring

8.1 Predevelopment monitoring

The limited number of existing groundwater bores within the study area has led to an absence of pre-existing groundwater quantity/quality data. Therefore a pre-development monitoring program should be implemented to establish a baseline data set to inform the UWMP. Pre-development groundwater monitoring will commence at minimum eighteen (18) months before site works begin and continue through construction. Table 15 presents the recommended pre-development monitoring program for surface and groundwater quality and quantity for a minimum of 18 months or as indicated by the Department of Water.

Table 15 Recommended pre-development monitoring program

	Site	Frequency	Parameter
Surface Water	As indicated by the Regional Water Quality Monitoring Program by Shire of Serpentine Jarrahdale.	Monthly grab samples	◗ **Physical Properties** (pH, EC and temperature, DO, turbidity). ◗ **Nutrients** (TN, FRP, TKN, ammonia, TP, TOC, DOC) ◗ **TSS**
		Tri-annually	◗ TRH, PAH, BTEX, hardness as $CaCO_3$ and total metals (Al, As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Se, Zn)
Groundwater	Network of monitoring bores providing a suitable spatial representation of the study area.	Monthly, to be reviewed after the first year of monitoring.	◗ **In-situ** pH, EC and temperature. ◗ **Unfiltered sample**: pH, EC, TN, FRP, TKN, ammonia, TP ◗ **Filtered sample**: nitrate/nitrite and PO_4 ◗ Water level (max and min levels)

As there are multiple land owners within the study area, it is also recommended that the monitoring program should be a collaborative effort between all land owners. The advantages of such an approach include:

- Consistency in data collection, analysing and interpretation;
- Resource sharing; and
- Allows for the establishment of a communication network between land owners.

8.2 Recommended post-development monitoring program

In addition to the monitoring outlined in Table 15, the following is the recommended post-development monitoring program.

To assess the impacts of the development on water quality within the development area, surface water samples will be collected monthly during the winter (June, July and August if the drain is flowing) at locations to be specified in the UWMP. Groundwater levels will be measured and recorded on a monthly during the winter (June, July and August) and quarterly otherwise with samples collected quarterly for laboratory analysis in the months of January, April, July and

October from a network of monitoring bores providing a suitable spatial representation of the study area. Samples will be analysed for the following water quality parameters:

- Water flows and level;
- In-situ pH, Electrical Conductivity (EC) and Temperature;
- Total Suspended Solids (TSS);
- Total Nitrogen (TN) and Total Kjeldahl Nitrogen (TKN);
- Ammonia (NH_4);
- Nitrate and Nitrite (NO_x);
- Total phosphorus (TP); and
- Orthophosphate (PO_4^{3-}).

The following additional parameters are recommended in locations where drainage intercepts shallow groundwater systems:

- Total titratable acidity and total alkalinity;
- Major anions (chloride, bromide and sulphate);
- Major cations (calcium, magnesium, sodium and potassium); and
- Iron and aluminum.

A summary of an example of a surface water and groundwater monitoring program is presented in Table 16 below. Three years of post-development monitoring shall be carried out.

Table 16 Monitoring programme summary

	Sites	Frequency	Parameters
Surface water	Developments inflow and outflow locations Detention storages inflow and outflow Water bodies	Site specific	Water levels
		Monthly during the winter (June, July and August if the drain is flowing)	In-situ pH, EC and temperature. Unfiltered sample: pH, EC, TN, FRP, TKN, ammonia, TP Filtered sample: nitrate/nitrite and PO4,
Groundwater	Network of monitoring bores providing a suitable spatial representation of the study area.	Monthly during the winter (June, July and August) and quarterly (typically Jan, Apr, Oct)	Water level
		Quarterly (typically Jan, Apr, July, Oct)	In-situ pH, EC and temperature. Unfiltered sample: pH, EC, TN, FRP, TKN, ammonia, TP Filtered sample: nitrate/nitrite and PO4

8.3 Reporting

The Developer will prepare an annual water quality report for each year of monitoring, which will be presented to the Shire and DoW. This report will summarise the results from the years sampling, groundwater levels in areas where subsoil drainage has not been installed, and include a qualitative review of the performance of the drainage and water management system.

Reporting and Monitoring shall be in accordance with ANZECC and the DoW QA/QC systems to allow inclusion into DoW's WIN database.

8.4 Contingency Action Plan

A contingency action plan is a plan that sets out what is to be done when the monitoring results reach a certain trigger value. The plan identifies what the trigger values are, what is to be done, and by whom. Stakeholders include the developers, land owners, DoW, and the Shire of Serpentine-Jarrahdale.

Table 17 Trigger Values

	Units	ANZECC Guideline
Nutrients		Freshwater
Chlorophyll a	ug/L	3-5
Filterable reactive phosphate	ug/L	5
Total Nitrogen*	ug/L	350
Total Phosphorus	ug/L	10
Oxides of nitrogen	ug/L	10
Ammonium	ug/L	10
Total Kjeldahl nitrogen		-
Other		
Electrical conductivity (EC) a	uS/cm	300-1500
Turbidity b	NTU	10-100
Dissolved oxygen	% saturation	90 (lower limit)
pH	-	6.5-8.0
Total suspended solids		-

a: Lower EC values are typically associated with rainfall events. During summer, higher values are common due to water being lost to evaporation.
b: Deep water bodies typically are low in turbidity. Shallow water bodies generally have a higher turbidity due to wind induced mixing of sediments.

Should the trigger levels be exceeded in two consecutive monitoring events it is proposed that a meeting be held between the developers, land owners, DoW, DEC, the Shire and the Peel Harvey Catchment Council and other relevant parties to discuss likely causes (based on the constituent profile) and appropriate ways forward, as presented in Table 18.

Table 18 Contingency Action Matrix

Suspected Cause	Possible Solutions	Responsible Party for Implementing Contingency Action Plan
Over use of fertiliser	Community engagement on appropriate use of fertiliser	Developer /Shire
Animal waste from stables	Community engagement on appropriate disposal of animal waste	Shire
Sedimentation from construction erosion	Control of erosion by contractors	Developer/Land Owner
Green waste	Community engagement on the appropriate collection and disposal of green waste; Implement street sweeping	Shire
Spills	Referral to EPA	Developer/Land owner
Failure of WSUD devices	Repair and/or maintenance of WSUD devices	Developer /Shire
Other	As appropriate	As appropriate

9. Implementation plan

9.1 Developer commitments

The next stage for water management is to be subdivision approvals supported by an UWMP. The UWMP is to be prepared to be consistent with the designs and strategies proposed in this LWMS. The UWMP should address:

- Detail to the design proposed in the LWMS and compliance with the objectives;
- Detailed storm water management design; and
- Specific structural and non-structural methods to be implemented.

The developer is committed to the roles detailed in the report and outlined in Table 19.

9.2 Roles and responsibilities

Table 19 outlines the roles and responsibilities for the actions recommended in this LWMS for the development area.

Table 19 Roles and responsibilities

Role	Responsibility	Requirement
UWMP	Developer	An approved Urban Water Management Plan at subdivision application.
Design and Construction of Drainage System	Developer	Hand over to Shire of Serpentine – Jarrahdale at Practical Completion.
Non-Structural Controls: Land use and Management	Developer	Sediment and erosion control during construction.
Water Quality Monitoring and Reporting	Developer	Monitoring Program (Section 8). Annual report prepared by the Developer to be submitted to the Shire of Serpentine – Jarrahdale and DoW following 12 months of monitoring.
Water Use Efficiency	Developer	Developer to provide landowners with rainwater tank and garden bore information packs at settlement.
Water Use Efficiency	Landowner	Landowner to comply with Building Code of Australia requirements checked during building approval stage.
Installation and maintenance of on-site effluent disposal system (ATUs)	Landowners	Approved Installation will be conducted during building construction. Once installed, the ATU systems require quarterly servicing by a Department of Health approved contractor.

9.3 Funding

Drainage infrastructure specific to the subdivision will be financed by the developer. Drainage infrastructure at the lot scale will be funded by individual landowners.

9.4 Next steps

The next stage for water management is to obtain subdivisional approvals supported by a UWMP. The UWMP is to be consistent with the design criteria and strategies outlined in this LWMS and include site-specific detail design of the drainage system in consideration of other aspects of the overall design concept.

The following issue will be addressed prior to the development of the UWMP and will be used to inform the UWMP:

- Detailed design and refinement of proposed infrastructure including drainage and development requirements for stormwater and shallow groundwater management;
- Modifications proposed to the Hardey Creek Drain will need to be approved in writing by the Water Corporation
- Confirmation is required demonstrating an in-principal agreement to the modification of the drain and future governance of the infrastructure by the Shire of Serpentine-Jarrahdale
- Additional groundwater studies if sufficient groundwater resource is available for irrigation of the proposed POS or if further groundwater allocation is required.

The following issues will need to be addressed within the UWMP:

- Demonstration that the UWMP will meet the objectives and criteria stated in the LWMS;
- Demonstration of compliance with regulatory requirements, including required licences and approvals, *Building Code of Australia* and *Plumbing Code of Australia*;
- Detailed designs for the major/minor stormwater management system, including Best Management Practices (BMPs) to achieve the water quality and quantity objectives given in the LWMS;
- Identifying floor level heights;
- Undertake pre-development monitoring as outlined in Section 8.1;
- Establish a groundwater monitoring program to establish local controlled groundwater level;
- Operational and maintenance responsibilities and liabilities.
- The EMP should address any potential impacts associated with construction activities including acid sulfate soils, erosion and sediment control and management of any required dewatering.

10. References

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Western Australian Planning Commission, 2008. Liveable Neighbourhoods Edition 4, Perth.

Western Australian Planning Commission (2003) *State Planning Policy (SPP) 2.1 Peel Harvey Catchment*

Appendices

Appendix A – Town Planning Scheme

Produced by Mapping and GeoSpatial Data Branch, Department of Planning.

Whilst all care has been taken to accurately portray the current Scheme provisions, no responsibility shall be taken for any omissions or errors in this documentation.

Consultation with the respective Local Government should be made to view a legal version of the Scheme. Please advise the Department of Planning of any omissions or errors in the document.

Base Information Supplied by the Western Australian Land Information Authority, GL248-2007-2

SHIRE OF SERPENTINE-JARRAHDALE

TOWN PLANNING SCHEME NO 2

(DISTRICT SCHEME)

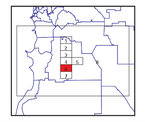
SJS TRIM - IN13/7119

SCALE 1:20000

0 500 m

GDA GEODETIC DATUM OF AUSTRALIA

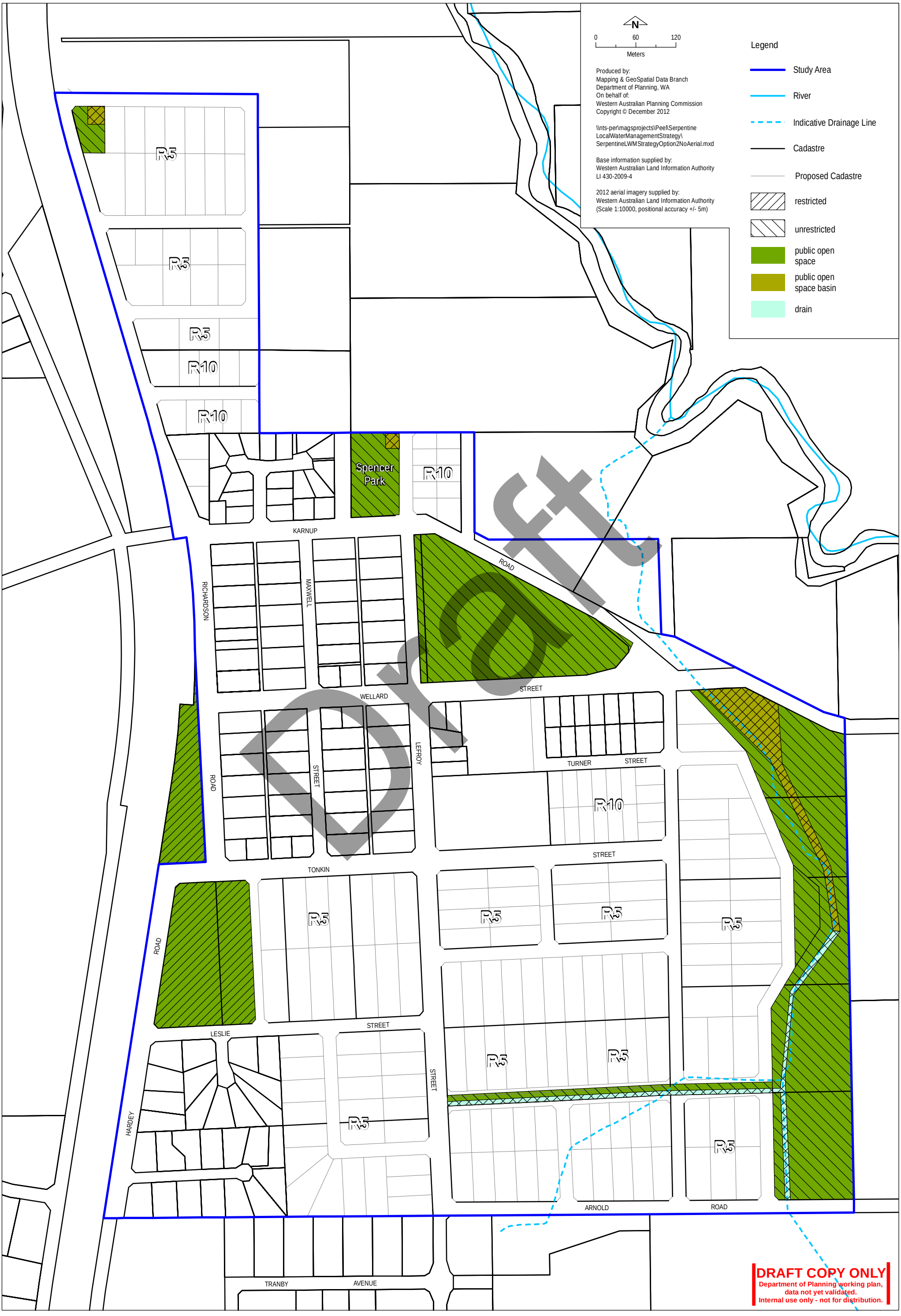
MAP OVERVIEW



Authorised: Victor Chew
Plot date: 16 Feb 2012
G.Gazette: 04-August-1989

TOWN PLANNING SCHEME MAP No. 6 of 8

Appendix B - Development Plan



Serpentine Townsite outline plan - option 2

SJS TRIM - IN13/7119

Appendix C – POS Schedule

Serpentine Townsite Local Structure Plan

Land Parcels	Area (m²)
Total Townsite Area (m²)	1191345.47
Lambkin Reserve CCW	17037.9
Richardson POS	11278.74
Total Net Site Area	1163028.83
Other Deductions	
Primary School site	19260.2
Church Lot 51 Tonkin Street	19396.2
Commercial Lots Richardson St	4073
Wellard St Shops	8328.5
Other Commercial, Public,Com.	8095
Total Deductions	59152.9
Gross Subdivisable Area	1103875.93
Total POS Required (10% GSA)	110388
POS (Unrestricted)	
Hardeys Creek POS	3699
Hardeys Creek POS	80788.41
Karnup Road	45528.81
Lefroy Street POS	8028.88
North Park	2902.27
Spencer Park	8981.91
Total Unrestricted POS	149929.28
80% Credit	119943.42
POS (Restricted)	
Hardeys Creek Basin	10140.09
Hardeys Creek Drain	3065.19
Lefroy Street Drain	3436.42
North Park Basin	673.17
Richardson Street POS	10500
Total Restricted POS	27814.87
Max 20% credit	5562.97
Unrestricted POS Component	119943.42
Restricted POS Component	5562.97
Total POS Required	110388
Total POS Contribution	125506.39
POS Oversupply	15121.39

N

0 50 100

Metres

Produced by:
Mapping & GeoSpatial Data Branch
Department of Planning, WA
On behalf of:
Western Australian Planning Commission
Copyright © December 2012

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Peel\SerpentineTownsiteLSP_v1.0_20121204\
SerpentineTownsiteLSP.mxd

Base information supplied by:
Western Australian Land Information Authority
LI 430-2009-4

Legend

- residential R5
- residential R10
- local centre
- educational/institutional
- community facility
  - PS - *primary school*
  - CH - *church*
- community facility - other
- public open space
- drainage
- local road
- Bush Forever
- structure plan boundary
- R code extent
- existing cadastre

Serpentine Townsite Local Structure Plan

Figure X

SJS TRIM - IN13/7119

Appendix D – 5-Star Plus

Department of Housing and Works
Government of Western Australia

OCM275.3/12/15

5 Star Plus

Energy Use in Houses Code
Water Use in Houses Code

Introduction

In May 2006, Western Australia adopted the minimum 5 Star energy efficiency provisions of the Building Code of Australia for all new homes. Now the Government has gone further and introduced 5 Star Plus – that builds on the energy efficiencies from 5 Star with the added benefits of water reduction measures for all homes right across the State.

5 Star Plus is based around two new Codes:

The Energy Use in Houses Code - confirms the existing 5 Star provisions for house design and construction and adds requirements for energy efficient water heating.

The Water Use in Houses Code - aims to reduce the consumption of water in residential homes by requiring water efficient fittings, minimising the wastage of water and facilitating the appropriate use of alternative sources of water such as grey water and rain water.

5 Star Plus will be applicable to new homes approved for construction after 1 September 2007, however, existing home owners can also use these Codes to improve energy and water efficiency in their homes. During 2008, the Government will investigate measures to apply the 5 Star Plus provisions to existing homes.

The Energy Use in Houses Code and Water Use in Houses Code are written to supplement the Building Code of Australia (BCA) and adopt BCA definitions and format for consistency. The Codes are published together for the convenience of builders, plumbers and certifiers who may need a convenient reference on site.

The Codes are available online at **www.5starplus.wa.gov.au**

Energy Use in Houses Code

Application

This Code applies to all new buildings classified as Class 1 and 10 buildings by the Building Code of Australia.

Interpretation

"The Building Code of Australia" means the latest edition of the Building Code of Australia published from time to time by, or on behalf of, the Australian Building Codes Board, but not including explanatory information published with that Code.

Objective

The objective of this Code is to reduce greenhouse gas emissions.

Functional Statement

In order to reduce greenhouse gas emissions, a building, including its services, is to be capable of efficiently using appropriate sources of energy.

Compliance With This Code

A building will comply with this Code if its construction satisfies all the Performance Requirements. Compliance with the Performance Requirements can be shown by:

(a) Complying with the Deemed-to-Satisfy provisions as listed in the Acceptable Construction Practice; or

(b) Formulating an alternative solution that is shown to be equivalent to the Deemed-to-Satisfy provisions; or

(c) Formulating an alternative solution that is verified using an acceptable verification method; or

(d) Formulating an alternative solution that is based on expert judgement or supported by suitable evidence in accordance with clause 1.2.2 of the Building Code of Australia; or

(e) Any combination of the above.

Energy Use in Houses Code

Performance Requirements

PR1 – Building

A building must comply with the Building Code of Australia Performance Requirement P2.6.1.

PR2 – Services

A building's domestic services including any associated distribution system and components must have features that comply with the Building Code of Australia, Performance Requirement P2.6.2.

PR3 – Hot Water Systems

A building's hot water systems including any associated components must have features that produce low levels of greenhouse gases when heating water.

Acceptable Construction Practice

(a) Compliance with all of the Deemed-to-Satisfy provisions of DTS1 satisfy the Performance Requirement PR1 for a building.

(b) Compliance with all of the Deemed-to-Satisfy provisions of DTS2 satisfy the Performance Requirement PR2 for a building.

(c) Compliance with all of the Deemed-to-Satisfy provisions of DTS3 satisfy the Performance Requirement PR3 for a building.

Deemed to Satisfy Provisions

DTS 1 – Thermal Comfort

The building must comply with the provisions of Part 3.12 of the Building Code of Australia for Building Fabric, External Glazing, Building Sealing and Air Movement.

DTS 2 – Services

The building must comply with the provisions of Part 3.12 of the Building Code of Australia for Services.

DTS 3 – Hot Water Systems

A hot water system must be either:

(i) a solar hot water system, complying with AS 2712-2002, that has been tested in accordance with AS 4234-1994, and achieves a minimum energy saving of 60% for a hot water demand level of 38MJ per day for climate zone 3; or

(ii) a gas hot water system, complying with AS 4552-2005 that achieves a minimum energy rating of "5 stars"; or

(iii) a heat pump hot water system, complying with AS 2712-2002 that has been tested in accordance with AS 4234-1994, and achieves a minimum energy saving of 60% for a hot water demand level of 38MJ per day for climate zone 3.

Explanatory Notes:

1. **BCA Performance Requirement P2.6.1**

   A building must have, to the degree necessary, a level of thermal performance to facilitate the efficient use of energy for artificial heating and cooling appropriate to –

   (a) the function and use of the building; and
   (b) the internal environment; and
   (c) the geographic location of the building; and
   (d) the effects of nearby permanent features such as topography, structures and buildings; and
   (e) solar radiation being—
      (i) utilised for heating; and
      (ii) controlled to minimise energy for cooling; and
   (f) the sealing of the building envelope against air leakage; and
   (g) the utilisation of air movement to assist cooling.

2. **BCA Performance Requirement P2.6.2 – Services**

   A building's domestic services including any associated distribution system and components must have features that, to the degree necessary, facilitate the efficient use of energy appropriate to –

   (a) the domestic services and its usage; and
   (b) the geographic location of the building; and
   (c) the location of the domestic services; and
   (d) the energy source.

3. **AS 2712-2002** details the design and construction of solar and heat pump water heaters.

4. **AS 4234-1994** sets out the method of testing and calculation of energy consumption for domestic solar water heaters and heat pumps.

5. **AS 4552-2005** details the design of gas forced water heaters for hot water supply and/or central heating.

Water Use in Houses Code

Application

This Code applies to all new buildings classified as Class 1 and 10 buildings by the Building Code of Australia.

Interpretation

"The Building Code of Australia" means the latest edition of the Building Code of Australia published from time to time by, or on behalf of, the Australian Building Codes Board, but not including explanatory information published with that Code.

"Alternative Internal Water Supply" refers to a water supply such as collection of rainwater on site, external third pipe non-potable water source, on-site bores or the like, other than potable water supplied by a licensed water service provider, and approved for use inside a dwelling.

"Alternative External Water Supply" refers to a water supply such as collection of rainwater on site, external third pipe non-potable water source, re-cycled grey water, on-site bores or the like, other than potable water supplied by a licensed water service provider, and approved for use outside a dwelling.

"Potable Water" refers to water intended for human consumption supplied by a licensed water service provider.

Objective

The objective of this Code is to reduce water demand by efficiently using water, and minimising the wasting of water, and facilitating the appropriate use of alternative sources of water.

Functional Statement

To reduce potable water demand a building must:

(a) enable the efficient use of potable water; and
(b) prevent excessive loss of potable water; and
(c) have the capacity to connect to alternative sources of water supply; and
(d) use alternative sources in situations of high water demand or restricted availability of potable water.

Compliance With This Code

A building will comply with this Code if its construction satisfies all the Performance Requirements. Compliance with the Performance Requirements can be shown by:

(a) complying with the Deemed-to-Satisfy provisions as listed in the Acceptable Construction Practice; or
(b) formulating an alternative solution that is shown to be equivalent to the Deemed-to-Satisfy provisions; or
(c) formulating an alternative solution that is verified using an acceptable verification method; or
(d) formulating an alternative solution that is based on expert judgement or supported by suitable evidence in accordance with clause 1.2.2 of the Building Code of Australia; or
(e) any combination of the above.

Explanatory Notes:

Stage 1 of the Code will be prescribed in the Building Regulations to apply from 1 September 2007.

Stage 2 of the Code will be prescribed in the Building Regulations to apply from date to be determined.

Implementation of Stage 2 of the Code is dependent on further consultation and research to determine areas of application and on amendments to plumbing regulations and processes as well as ensuring compliance with health regulations and policies.

Water Use in Houses Code

Stage 1 - To apply from 1 September 2007

Performance Requirements

PR1 – Water Use Efficiency

A building must have features that, to the degree necessary, facilitate the efficient use of potable water appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for the building; and
(c) the function and use of the building.

PR2 – Water Loss Prevention

A building, including any water holding structures, must have features that, to the degree necessary, prevent the excessive loss of potable water appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for the building; and
(c) the function and use of the building; and
(d) the effects of permanent features such as topography, structures and buildings.

PR3 – Hot Water Use Efficiency

A building must have features that, to the degree necessary, facilitate the efficient use of hot water appropriate to:

(a) the geographic location of the building; and
(b) the available hot water supply for the building; and
(c) the function and use of the building.

Acceptable Construction Practice

(a) Compliance with all of the Deemed-to-Satisfy provisions of DTS1 satisfies the Performance Requirement PR1 for a building.
(b) Compliance with all of the Deemed-to-Satisfy provisions of DTS2 satisfies the Performance Requirement PR2 for a building.
(c) Compliance with all of the Deemed-to-Satisfy provisions of DTS3 satisfies the Performance Requirement PR3 for a building.

Deemed to Satisfy Provisions

DTS 1 – Water Use Efficiency

(a) all tap fittings other than bath outlets and garden taps must be minimum 4 stars WELS rated.
(b) all showerheads must be minimum 3 stars WELS rated.
(c) all sanitary flushing systems must be a minimum 4 stars WELS rated dual flush.

DTS 2 – Swimming Pool Covers and Blankets

An outdoor private swimming pool or spa associated with a Class 1 building must be supplied with a cover, blanket or the like that:

(a) is designed to reduce water evaporation; and
(b) is listed on the Smart Approved Watermark Scheme.

DTS 3 – Hot Water Use Efficiency

All internal hot water outlets (taps, showers, washing machine water supplies) must be connected to a hot water system or a recirculating hot water system with pipes installed and insulated in accordance with AS/NZS 3500:2003. Plumbing and Drainage, Part 4 Heated Water Services. The pipe from the hot water system or recirculating hot water system to the furthest hot water outlet must not exceed 20 metres in length or 2 litres of internal volume.

Explanatory Notes:

The Smart Approved Watermark Scheme is implemented through the National Water Commission as a simple identification label about water efficient products. Further information can be obtained from www.nwc.gov.au

Stage 2 - To apply from (date to be determined)

Performance Requirements

PR4 – Alternative Water Supply Use Capacity

A building, including any associated plumbing, must have features that, to the degree necessary, facilitate the future use of alternative water supplies appropriate to:

(a) the geographic location of the building; and
(b) the function and use of the building; and
(c) the soil type and ground condition; and
(d) the available alternative sources of water; and
(e) the size and type of external landscaping.

PR5 – Grey Water Use Capacity

A building including any associated plumbing, located on a lot of a size and in a location suitable for recycling of grey water, must have features that, to the degree necessary, facilitate the future use of grey water recycling appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for landscaping; and
(c) the function and use of the building; and
(d) the soil type and ground condition; and
(e) the available alternative sources of water; and
(f) the size and type of external landscaping.

Acceptable Construction Practice

(a) Compliance with all of the Deemed-to-Satisfy provisions of DTS4 satisfies the Performance Requirement PR4 for a building.
(b) Compliance with all of the Deemed-to-Satisfy provisions of DTS5 satisfies the Performance Requirement PR5 for a building.

Deemed to Satisfy Provisions

DTS 4 – Alternative Water Supply Use Capacity

All sanitary flushing systems and washing machines must be able to be connected at a later date, to an appropriate alternative water supply without the need to break, or cut into the fabric of the building to run new pipes.

DTS 5 – Grey Water Use Capacity

All shower, bath, laundry trough and washing machine drains must be able to be connected at a later date to an appropriate grey water diversion system without the need to break, or cut into the fabric of the building to run new pipes.

Explanatory Notes:

1. Health regulations apply to the use of alternative water supplies and will, amongst other things, limit the alternative water sources suitable for various uses.
2. The DTS 4 provisions do not require rainwater tanks. They require buildings to be able to be connected to such alternative water supplies relatively easily at a later date (i.e. the buildings are to be alternative supply 'ready'). Subject to health regulations and policies, alternative water supplies could also include bore water, third pipes, and the like.
3. All plumbing work associated with these requirements must be carried out by licensed plumbers and in accordance with all relevant plumbing regulations.

Water Use in Houses Code

Performance Requirements

PR6 – Alternative Internal Water Supply

A building with more than two showers or two WC facilities must use alternative internal water supplies for internal uses appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for the building; and
(c) the function and use of the building; and
(d) the available alternative sources of water.

PR7 – Alternative External Water Supply

A building located on a lot of a size and in a location likely to use significant potable water for landscaping use must use alternative internal or external water supplies appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for the building; and
(c) the function and use of the building; and
(d) the soil type and ground condition; and
(e) the available alternative sources of water; and
(f) the size and type of external landscaping.

Deemed to Satisfy Provisions

DTS 6 – Alternative Internal Water Supply

All sanitary flushing systems and clothes washing facilities must be connected to an alternative internal cold water supply.

DTS 7 – Alternative External Water Supply

(a) All external garden taps and irrigation systems must be connected to an alternative external water supply; or
(b) all shower, bath, laundry trough and washing machine drains must be connected to an approved grey water diversion and recycling system.

Acceptable Construction Practice

(a) Compliance with all of the Deemed-to-Satisfy provisions of DTS6 satisfies the Performance Requirement PR6 for a building.
(b) Compliance with all of the Deemed-to-Satisfy provisions of DTS6 or DTS7 satisfies the Performance Requirement PR7 for a building.

Explanatory Notes:

1. Houses required to be "grey water ready" under PR5 are those on large enough lots to allow drains carrying appropriate water to be run outside the house before connection to other waste pipes, and where there is likely to be enough landscaped area to adequately dilute the grey water.
2. Lots where houses are required to comply with PR7 will be identified through regulations. Further research is needed with relevant stakeholders to resolve which lots will be subject to this requirement.
3. Health regulations apply to the use of alternative water supplies and will, amongst other things, limit the alternative water sources suitable for internal or external use in different localities. For example most private bore water, whilst it may be suitable for garden use, may be inappropriate for use internally.
4. Alternative water supplies can include but is not limited to, rainwater tanks, bore water, third pipes, and the like.
5. Subject to health regulations an acceptable alternative internal water supply is an appropriately sized rainwater tank harvesting the rainwater runoff from the roof.
6. Subject to health regulations an acceptable alternative external water supply is a domestic bore.
7. All plumbing work associated with alternative water supplies must be carried out by licensed plumbers and in accordance with all relevant plumbing regulations.
8. The Water Use in Houses Code is implemented in two stages to allow amendment of plumbing regulations and training of licensed plumbers to ensure alternative water supplies are appropriate and safe, and that there is no risk of cross contamination with potable water supplies.

Further information

These Codes are intended to supplement the Building Code of Australia and will be called up by the Building Regulations 1989

For further information about 5 Star Plus please visit our website at www.5starplus.wa.gov.au

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Appendix E – Hydraulic and Hydrologic Modelling Outputs

Modelling Discussion

GHD built an InfoWorks CS hydrologic and one-dimensional hydraulic model of the existing and proposed development, and simulated the model for a range of design storms. InfoWorks CS is a computer program for simulating catchment hydrology and one-dimensional flows in conduits and open channels. Data is input via GIS files, tables and a graphical user interface, and results are produced graphically and in GIS and tabular format.

The hydrology was simulated using the SWMM model, based on the parameters listed in Table 20, Table 21 and Table 22. These parameters are consistent with regional storm water modeling for the Serpentine area.

Existing drainage pipe sizes and number was supplied by the Shire of Serpentine-Jarrahdale. Existing drains were modeled through supplied LIDAR elevation information accurate to 200 mm.

Modelling assumptions

- Infiltration modeled at a constant rate of 4 mm/hour
- Existing culverts as per Shire of Serpentine Jarrahdale information
- All existing table drains 1:2, 0.5 m deep, 1 m wide, Manning's n 0.030
- Groundwater inflow is 50 L/s/km drain (0.131 m^3/s at Hardey's Creek1)
- River level 29.858 m (100 year ARI flood level reaches 30 m AHD contours which corresponds to a flood depth of 600 mm, therefore assume 400 mm flood depth for 5 year ARI flood depth which corresponds to 29.858 m AHD)

Modelling parameters

Table 20 InfoWorks model runoff surface properties

Runoff surface	Surface roughness (Mannings n)	Initial loss (mm)	Infiltration loss (mm/hour)	Fixed runoff coefficient
Road	0.015	0.001	N/A	0.9
Rural	0.050	0.010	4	N/A
Building	0.015	0.016	4	N/A
Upper Catchment	0.035	0.008	N/A	0.6

Table 21 IFD data

Input	Value
2 yr ARI intensity	
- 1 hr	23.31
- 12 hr	4.9

Input	Value
- 72 hr	1.51
50 yr ARI intensity	
- 1hr	37.44
- 12 hr	7.9
- 72 hr	2.46
Geographical factors	
- F2	4.86
- F50	17.29
Location skewness	0.67
Zone	8

Table 22 InfoWorks model catchment properties for pre development scenario

Subcatchment ID	Total area (ha)	Vector slope (m/m)	Catchment dimension (m)	Road (%)	Rural (%)	Building (%)
1	4.332	0.004	117.4	9.973	83.363	6.664
2	6.566	0.001	144.6	21.716	62.787	15.497
3	14.576	0.001	215.4	25.159	59.919	14.922
4	8.154	0.004	161.1	17.28	72.396	10.324
5	14.49	0.002	214.8	23.146	71.734	5.12
6	10.834	0.001	185.7	16.053	80.463	3.484
7	7.014	0.003	149.4	18.043	59.504	21.95
8	17.532	0.001	236.2	9.943	89.868	0.189
A	32.665	0.012	322.5	0	99.911	0
B	8.977	0.001	169	5.855	94.145	0
C	50.63	0.001	401.4	0.024	99.765	0
D	87.527	0.002	527.8	7.675	87.651	4.618
E	18.119	0.001	240.2	0	100	0
F	48.488	0.009	392.9	0	100	0
G	11.926	0.009	594.2	0	99.976	0

Validation

No flow data was available to validate model parameters so some values (surface roughness and initial losses) were obtained from a validated model for Mundijong Whitby (8 km north) due to the similarities between the two sites.

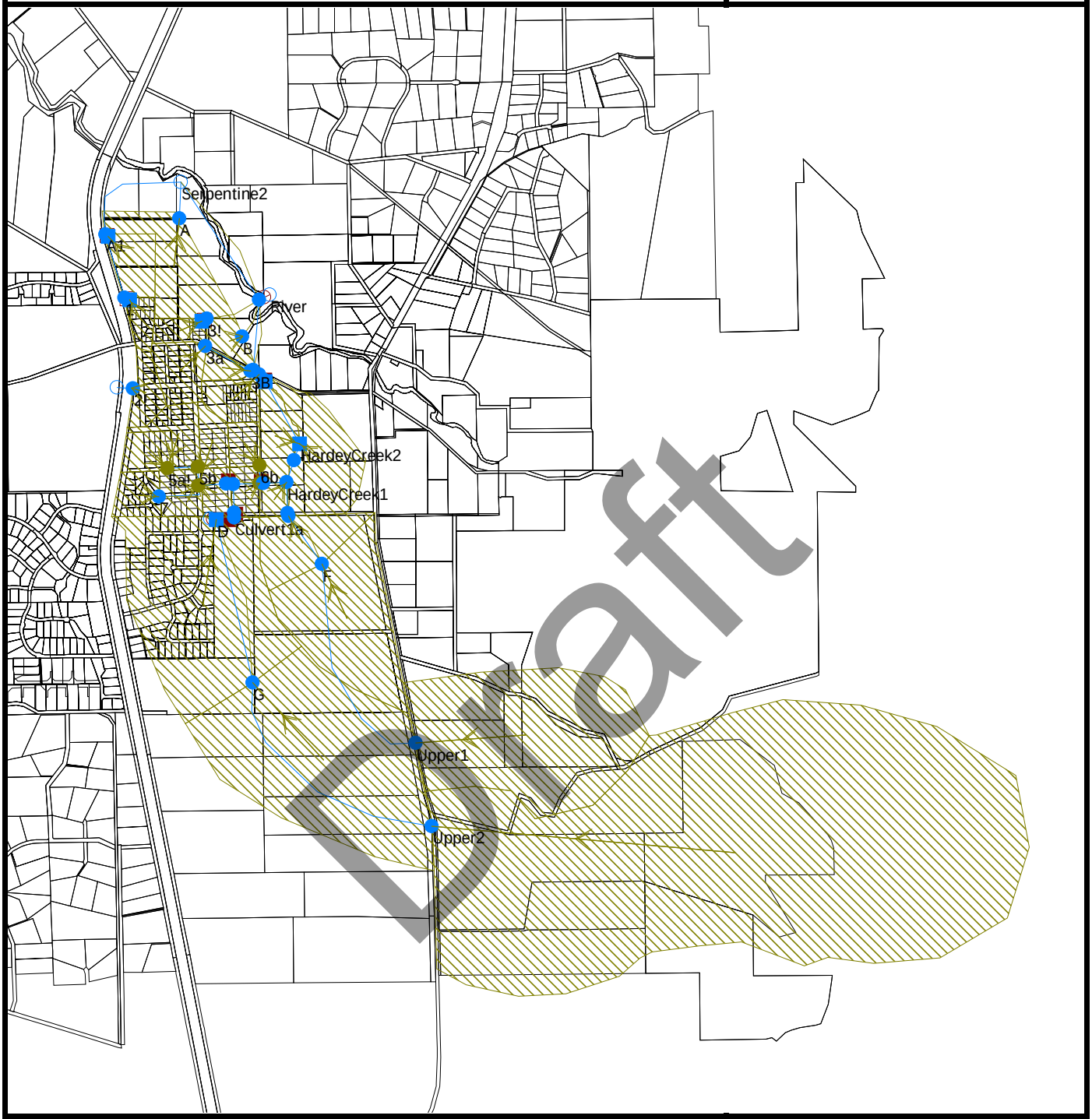
Comparison of calculated peak flows from the Serpentine LWMS to previous modeling results was undertaken for upland catchments. Peak Infoworks 100 year ARI flow rates for the 660 ha

catchment of the Arnold Rd basin were modeled at 11.68 m^3/s. This is in close agreement to the Serpentine Downs Estate Drainage Strategy (cardno, 2009) modelled flow rate of 12 m^3/s.

An independent check on these models was undertaken based on modelling of upland catchments within the 2008 Byford Townsite DWMP. Calculated peak flows on a unit area basis for the 660 ha Arnold Rd basin catchment gives a 100 year peak flow of 11.9 m^3/s thus the developed Serpentine Outline Plan LWMS Infoworks model is consistent with past calibrated regional models.

Network - Serpentine Outline Plan LWMS Simulation - 6H100Y

Map Centre Coords
x: 406147, y: 6417725
Date Printed: 18/12/2012
Scale 1:35000
1000m



- Data Flags
  - #A - Asset Data
  - #D - System Default
  - #G - Data from GeoPlan
  - #I - Model Import
  - #V - CSV Import
  - SC - ball
- Serpentine_post#12 (mb) open channel_100#1
- Key
- Nodes [system types]
  - [combined,foul,storm]
  - [other,overland]
- Links [system types]
  - 2D Boundary
  - CC TV
  - Conduit [combined,foul,storm]
  - Conduit [other,overland]
  - Culvert Inlet [all]
  - Culvert Outlet [all]
  - Flap valve [all]
- Flume [all]
- General Line
- Node [all]
- Orifice [all]
- Porous Wall
- Prune [all]
- Pump (all types) [all]
- Results Line (2D)
- River [all]
- River [combined,foul,other,overland]
- River [storm]
- Screen [all]
- Siphon [all]
- Sluice gate [all]
- User Control [all]
- Weir [all]
- Subcatchments [system types]
  - 2D IC Polygon
  - 2D Simulation Polygon
  - Flood Compartment
- Mesh Polygon
- Polygon Zone
- Porous Polygon
- Results Polygon (2D)
- Roughness Polygon
- Subcatchment [all]
- Symbols
  - 2D Point Source
  - Break Node
  - Compound Weir/Orifice
  - Flood Point
  - Hyperlink
  - Outflow Node
  - Pond node
  - Results Point (2D)
  - Storage Node
  - Var. crest level weir
  - Var. sluice gate
  - Var. width weir
  - Vortex

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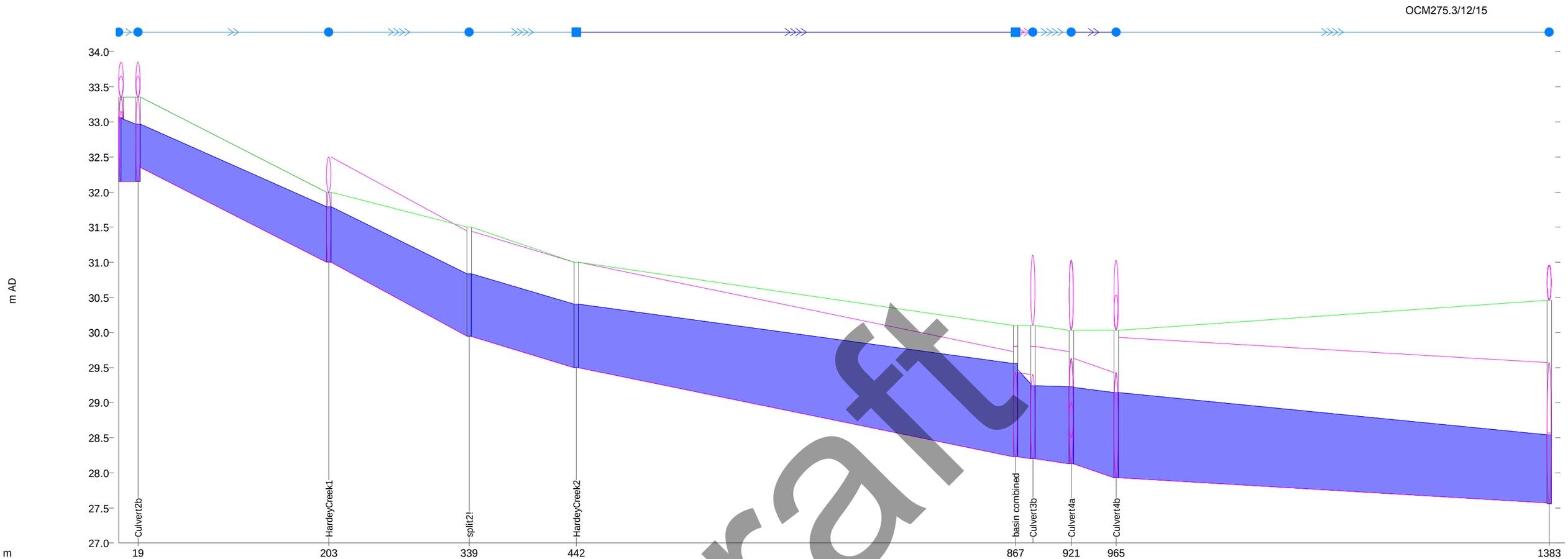
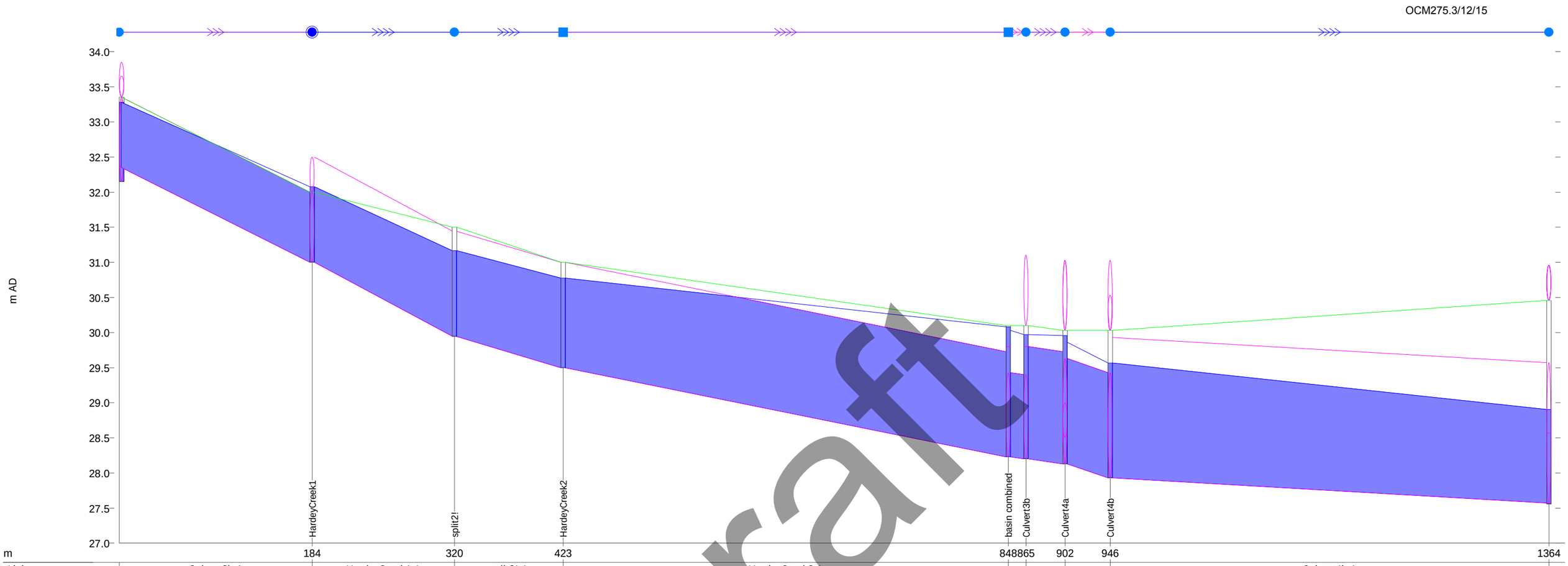


Link	-	Culvert2b.1	HardeyCreek1.1	split2!.1	HardeyCreek2.1	-	-	-	Culvert4b.1	
US Node ID	-	Culvert2b	HardeyCreek1	split2!	HardeyCreek2	-	-	Culvert4a	Culvert4b	
ds node	-	HardeyCreek1	split2!	HardeyCreek2	basin combined	-	-	Culvert4b	Serpentine1	
length (m)	-	184.2	135.7	103.5	424.6	-	37.2	43.3	418.5	
Shape ID	-	OT1:6	OT1:6	OT1:6	OT1:6	-	OT1:2	CIRC	OT1:6	
width (mm)	-	1000	1000	1000	2000	-	10000	1500	1000	
height (mm)	-	1000	1500	1500	1500	-	1600	1500	2000	
Sediment Depth (r	0	0	0	0	0	0	0	0	0	
us inv (m AD)	-	32.352	31.000	29.944	29.500	-	28.200	28.130	27.930	
ds inv (m AD)	-	31.000	29.948	29.500	28.230	-	28.130	27.930	27.570	
DS Depth (m)	-	0.791	0.888	0.905	1.328	-	1.096	1.216	0.973	
DS Flow (m3/s)	-	3.98565	7.54702	7.54690	7.74877	-	7.66144	2.61610	7.84529	
DS Velocity (m/s)	-	0.881	1.342	1.304	1.744	-	0.575	1.706	1.180	
US Flow (m3/s)	-	3.98508	7.54711	7.54702	7.79343	-	7.66005	2.61616	7.84830	

Node	Culvert2b	HardeyCreek1	split2!	HardeyCreek2	basin combined	-	-	Culvert4b	Serpentine1
Node ID	Culvert2b	HardeyCreek1	split2!	HardeyCreek2	basin combined	-	-	Culvert4b	Serpentine1
x (m)	404612.8	404606.7	404650.7	404684.3	404478.3	-	-	404408.9	404443.4
y (m)	6418005.9	6418190.0	6418318.4	6418416.3	6418787.6	-	-	6418855.7	6419272.8
ground (m AD)	33.352	32.000	31.500	31.000	30.100	-	30.030	30.030	30.458
level (m AD)	32.968	31.791	30.836	30.405	29.558	-	29.226	29.146	28.543

Long Section (Hardy's Creek MD Arnold Rd to Karnup Rd)
5 year ARI

SJS TRIM - IN13/7119



Link	Culvert2b.1	HardeyCreek1.1	split2!.1	HardeyCreek2.1	-	-	-	Culvert4b.1
US Node ID	Culvert2b	HardeyCreek1	split2!	HardeyCreek2	-	-	Culvert4a	Culvert4b
ds node	HardeyCreek1	split2!	HardeyCreek2	basin combined	-	-	Culvert4b	Serpentine1
length (m)	184.2	135.7	103.5	424.6	-	37.2	43.3	418.5
Shape ID	OT1:6	OT1:6	OT1:6	OT1:6	-	OT1:2	CIRC	OT1:6
width (mm)	1000	1000	1000	2000	-	10000	1500	1000
height (mm)	1000	1500	1500	1500	-	1600	1500	2000
Sediment Depth (r	0	0	0	0	0	0	0	0
us inv (m AD)	32.352	31.000	29.944	29.500	-	28.200	28.130	27.930
ds inv (m AD)	31.000	29.948	29.500	28.230	-	28.130	27.930	27.570
DS Depth (m)	1.076	1.217	1.277	1.853	-	1.826	1.639	1.335
DS Flow (m3/s)	10.95723	16.10159	16.09916	16.86476	-	-	5.78762	17.35406
DS Velocity (m/s)	1.368	1.595	1.455	1.884	-	0.677	3.166	1.444
US Flow (m3/s)	10.95586	16.10315	16.10159	17.11255	-	-	5.78763	17.36283

Node	Culvert2b	HardeyCreek1	split2!	HardeyCreek2	basin combined	-	-	Culvert4b	Serpentine1
Node ID	Culvert2b	HardeyCreek1	split2!	HardeyCreek2	basin combined	-	-	Culvert4b	Serpentine1
x (m)	404612.8	404606.7	404650.7	404684.3	404478.3	-	-	404408.9	404443.4
y (m)	6418005.9	6418190.0	6418318.4	6418416.3	6418787.6	-	-	6418855.7	6419272.8
ground (m AD)	33.352	32.000	31.500	31.000	30.100	-	30.030	30.030	30.458
level (m AD)	33.282	32.076	31.165	30.777	30.083	-	29.956	29.569	28.905

Long Section (Hardy's Creek MD Arnold Rd to Karnup Rd) 100 year ARI

SJS TRIM - IN13/7119

Appendix F – DEC Wetland Reclassification Response

Government of **Western Australia**
Department of **Environment and Conservation**

Your ref:
Our ref:
Enquiries: Anthea Jones
Phone 08 9219 8710
Email anthea.jones@dec.wa.gov.au

Ms Jorine Bothma
Senior Strategic Planner- Metropolitan South East
Department of Planning
L 5, 140 William Street
PERTH WA 6000

Dear Ms Bothma

RE: REQUEST TO REVIEW THE *GEOMORPHIC WETLANDS SWAN COASTAL PLAIN* DATASET FOR UFI 15002

I refer to your email correspondence of 4 December 2012 requesting modifications to the management category of Conservation management category dampland UFI 15002 within the *Geomorphic Wetlands Swan Coastal Plain* dataset (the dataset).

The area of particular focus with respect to this review was the portion of Conservation category dampland directly east of the UCL on Richardson Road, which extends over a road reserve and private property. A bitumen road (Richardson Road) extends through the centre of the road reserve and dwellings are located on the private properties within the mapped Conservation management category dampland.

As this wetland is an extensive dampland, differing management categories may be assigned to areas of dampland with differing values. In this case, the portion of the dampland that extends over Richardson Road and residential dwellings contains few remaining natural values, and its values are therefore commensurate with Multiple Use management category.

It should be noted that the Conservation management category boundary extends beyond the UCL to include the roadside vegetation on the western side of Richardson Road. This is because the aerial photography appears to show some native vegetation within the road reserve and because the boundary of a threatened ecological community extends into the road reserve.

Figure 1 shows the current management category of UFI 15002 within the dataset. Figure 2 shows the proposed modifications to the management category within the dataset.

Please be aware that this review relates only to wetland mapping, and not any associated land use proposal.

Please contact Anthea Jones on 9219 8710 if you require further information on this matter.

Yours sincerely,

Dr Michael Coote
Principal Coordinator, Wetlands Section
for the Director General

5 December 2012

Figures:

Figure 1: Current *Geomorphic Wetlands Swan Coastal Plain* dataset mapping.

Figure 2: Proposed modifications to *Geomorphic Wetlands Swan Coastal Plain* dataset.

References:

Hill AL, Semeniuk CA, Semeniuk V & Del Marco A (1996) *Wetlands of the Swan Coastal Plain Volume 2B: Wetland Mapping, Classification and Evaluation.* Wetland Atlas, Water and Rivers Commission and Department of Environmental Protection, Perth.

Figure 1: Current *Geomorphic Wetlands Swan Coastal Plain* dataset mapping (UCL highlighted in blue).

Species and Communities Branch, Nature Conservation Division
Address: 17 Dick Perry Ave, Kensington
Ph: (08) 9334 0333
Postal: Locked Bag 104 Bentley Delivery Centre, BENTLEY WA 6983

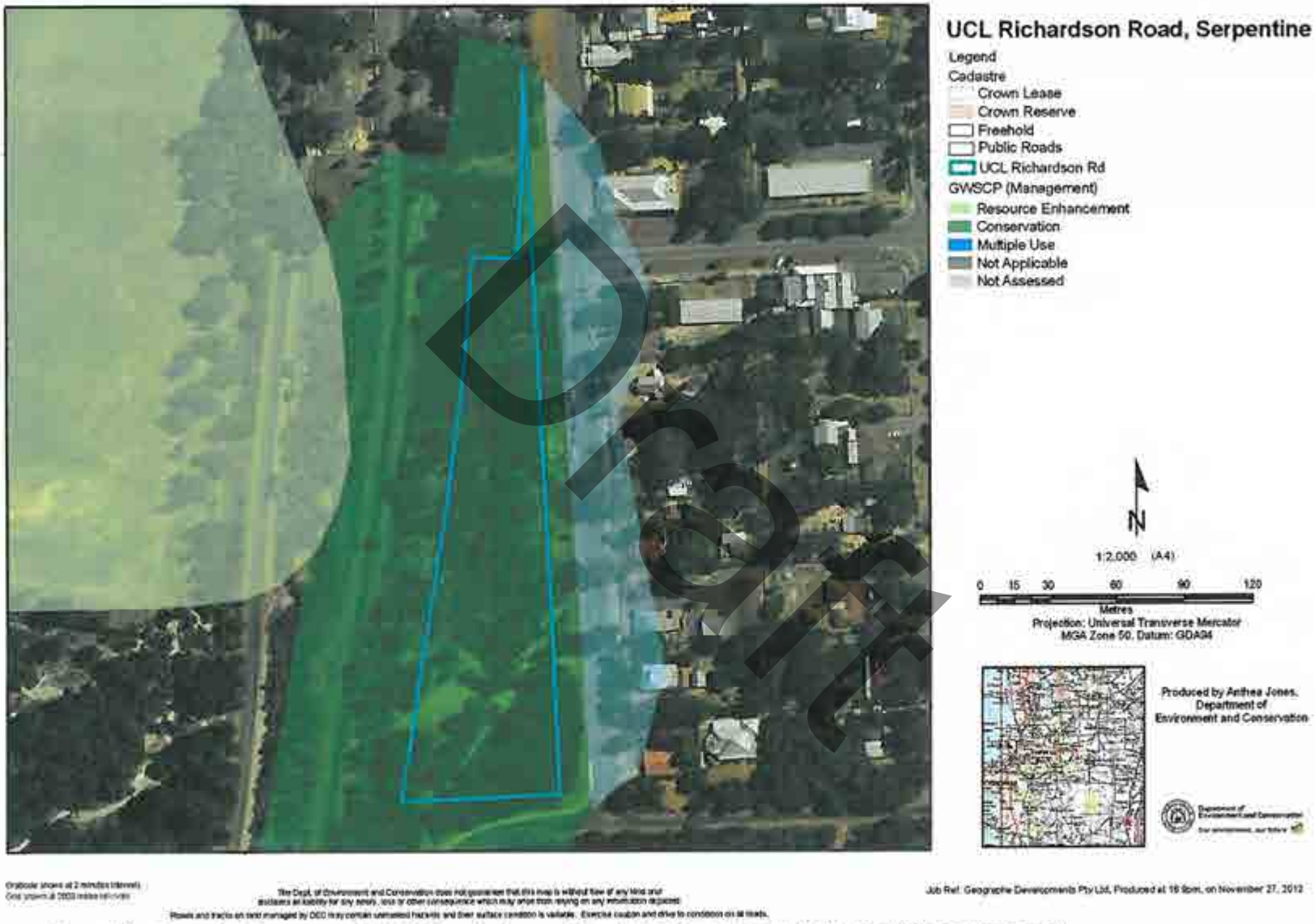


Figure 2: Proposed modifications to *Geomorphic Wetlands Swan Coastal Plain* dataset (UCL highlighted in blue).

Myles Busbridge

From: Bothma, Jorine <Jorine.Bothma@planning.wa.gov.au>
Sent: Tuesday, 9 October 2012 2:13 PM
To: Myles Busbridge
Subject: FW: Advice on reclassification of CCW in Serpentine Townsite

Myles

I have received comments from DEC on the eastern CCW lot in Tonkin Street below. I am awaiting feedback on whether the newly created road width adjacent to the western CCW site (as per our revised layout plan) will be sufficient to accommodate a buffer area for these sites and will report back as soon as possible.

Kind Regards

JORINE BOTHMA
Senior Strategic Planner– Metropolitan South East
Perth and Peel Planning
Department of Planning
L 5, 140 William Street
PERTH WA 6000
P: 08 6551 9539 | F: 08 6551 9001
E: Jorine.Bothma@planning.wa.gov.au

From: Maguire, Jacqui [mailto:Jacqui.Maguire@dec.wa.gov.au]
Sent: Tuesday, 9 October 2012 8:29 AM
To: Bothma, Jorine
Cc: Jones, Anthea
Subject: RE: Advice on reclassification of CCW in Serpentine Townsite

Hi Jorine,

Thanks for sending through the photos. As you would be aware I forwarded these on to an officer at DEC's Wetlands Section who reviewed them in the context of the management classification of the mapped conservation category wetland (CCW). It was determined that on the basis of the photographs and the most recent aerial photography, Wetlands Section would re-evaluate UFI 14974 as Multiple Use (MU) management category.

The Wetlands Section will include this wetland reclassification in the modifications queue and will address the changes to the dataset accordingly. This could take one or two months.

However for the purposes of planning and finalisation of the LWMS, DEC would be satisfied for the current CCW (UFI 14974) to be considered as a MU wetland.

It would be recommended however that prior to finalising any structure plans for the site that an adequate study on the wetlands in the area be undertaken to confirm mapping and if necessary modify any wetlands boundaries and classification for the subject site in accordance with DEC's standard process. If you are involved in any other similar planning processes it would be good to see this wetland review work done prior to any water and drainage planning to avoid similar situations (and ensure that the LWMS can be implemented without wetland impacts).

Thanks and if you have any queries then feel free to ring.

Jacqui

Jacqui Maguire
Department of Environment & Conservation
Swan Coastal District
Ph: 9303 7743 Fax: 9405 0777
Mobile: 0439 977 455
Email: jacqui.maguire@dec.wa.gov.au

From: Bothma, Jorine [mailto:Jorine.Bothma@planning.wa.gov.au]
Sent: Monday, 8 October 2012 2:40 PM
To: Maguire, Jacqui
Subject: RE: Advice on reclassification of CCW in Serpentine Townsite

Jacqui

Hope you had a great weekend and good luck for the first full week ahead after the Public Holiday.

I am attaching the photos I have taken of the site this morning. I hope I have captured the correct species and that it was done at the right angles. Could you please forward them on to your Wetlands branch? I have captured the entire scope of the CCW 14974 site. However, if I need to take some more pictures I will do so gladly please do not hesitate to ask.

Thanks so much for your kind assistance.

Kind Regards

JORINE BOTHMA
Senior Strategic Planner– Metropolitan South East
Perth and Peel Planning
Department of Planning
L 5, 140 William Street
PERTH WA 6000
P: 08 6551 9539 | F: 08 6551 9001
E: Jorine.Bothma@planning.wa.gov.au

From: Maguire, Jacqui [mailto:Jacqui.Maguire@dec.wa.gov.au]
Sent: Monday, 24 September 2012 10:04 AM
To: Bothma, Jorine
Subject: RE: Advice on reclassification of CCW in Serpentine Townsite

HI Jorine,

I have sent your email onto our Wetlands Branch at DEC and they have agreed that the site does appears degraded from the aerial photo and probably warrants a reclassification (downgrade of management category). While they accept that on this occasion that the full process may not be required, it would be very useful for them to have some current on-ground photos of the site. They will not have the opportunity to get out there and take these so I wondered if you could arrange for the consultants to do it? They just need to note the current vegetation (if any) on site and level of inundation (if any).

If you can get these photos, you can send them to me and I can provide them to our Wetlands Branch for review.

Cheers

Jacqui

Jacqui Maguire
Department of Environment & Conservation
Swan Coastal District
Ph: 9303 7743 Fax: 9405 0777
Mobile: 0439 977 455
Email: jacqui.maguire@dec.wa.gov.au

From: Bothma, Jorine [mailto:Jorine.Bothma@planning.wa.gov.au]
Sent: Friday, 21 September 2012 11:20 AM
To: Maguire, Jacqui
Subject: Advice on reclassification of CCW in Serpentine Townsite

Jacqui

I am so sorry I missed your visit the other day; it would have lovely to meet up with you. Hope all is well with the weekend a few hours away.

I need to pick your brain on something please. I have decided to send you my question in an email as I do not want to bombard you unnecessarily and it allows you to respond at your own leisure. If we could have a way forward to the consultants within the next two weeks it would be just fine.

OK, HERE IT IS...
The Department of Planning has appointed GHD to undertake a Local Water Management Strategy for the Serpentine Townsite area. This is done in good faith to assist the Shire with a Local Structure Plan for the Townsite area.

There is a conservation category wetland located at 51 Tonkin Street (no 14974). (See attachment to this email). The consultant reported that this wetland appears to have been cleared in the past and is unlikely to support any values for which water conservation was awarded. However, in order to re-classify this wetland under a less stringent management category, a request to update the Geomorphic Wetlands Swan Coastal Plain dataset must be submitted to DEC. This would involve amongst other things a desktop study and wetland vegetation condition assessment. The draft LWMS was also referred to Department of Water (DoW). DoW inquired whether the wetland was going to be reclassified before or after approval of the LWMS. Is it possible to defer this re-classification to after the LWMS? The Department does not have sufficient funds left on this project budget to undertake the re-classification prior to finalising the LWMS and I was wondering whether there was any way around it. I could also maybe add that the proposed land use of this wetland will remain R10 and R5.

I may also be worth to mention that the Lambkin Reserve (Conservation Category wetland) and Richardson Street POS (Bush Forever site) is also located within the Townsite area even though they are not part of the developable area. We are currently amending our proposed layout plan to have road interfaces right around Lambkin Reserve similar to the Richardson Street POS.

Kind Regards and thanks a million

JORINE BOTHMA
Senior Strategic Planner– Metropolitan South East
Perth and Peel Planning
Department of Planning
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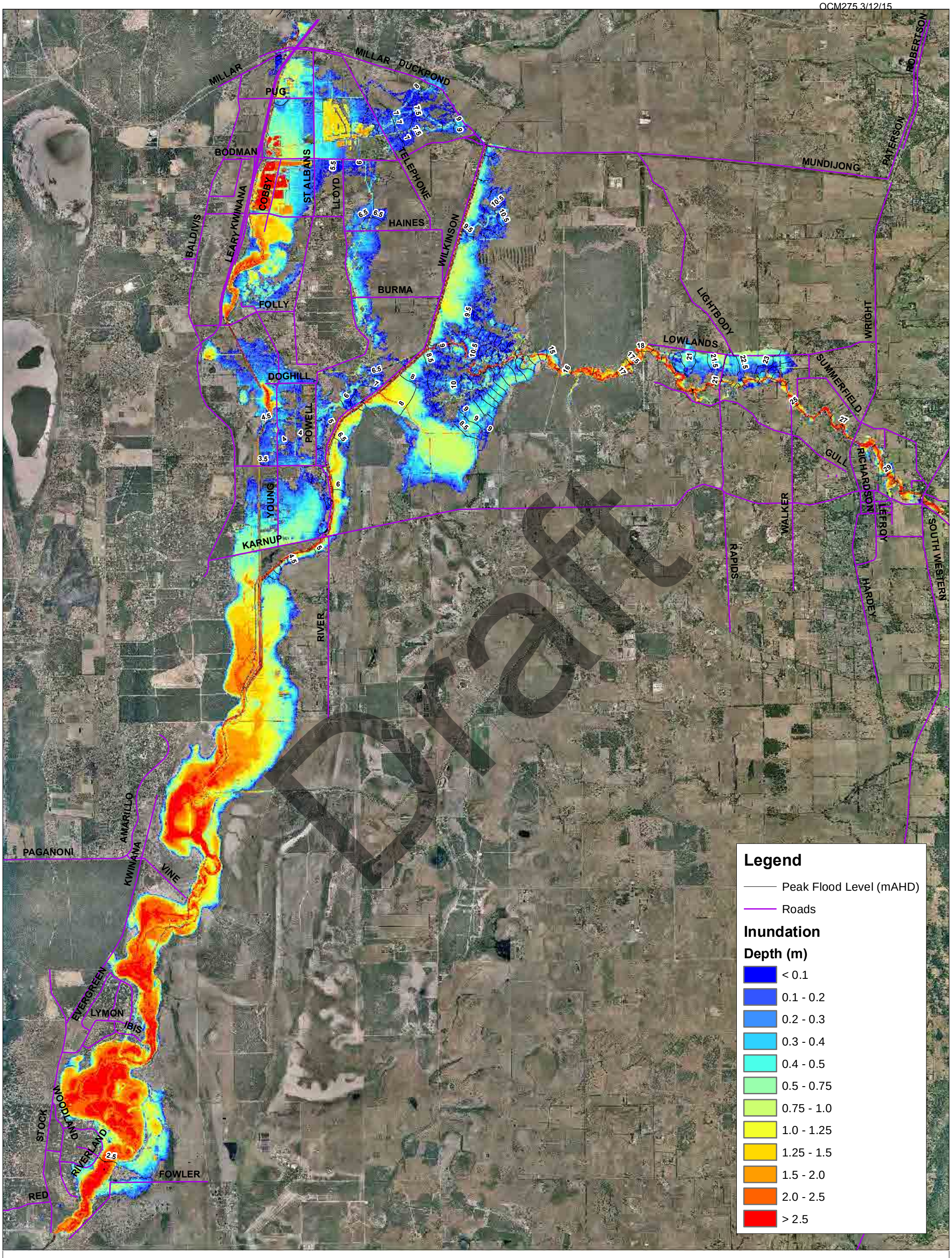
Appendix G – SKM Serpentine Flood Study 100 year ARI Flood map



SERPENTINE RIVER FLOOD STUDY

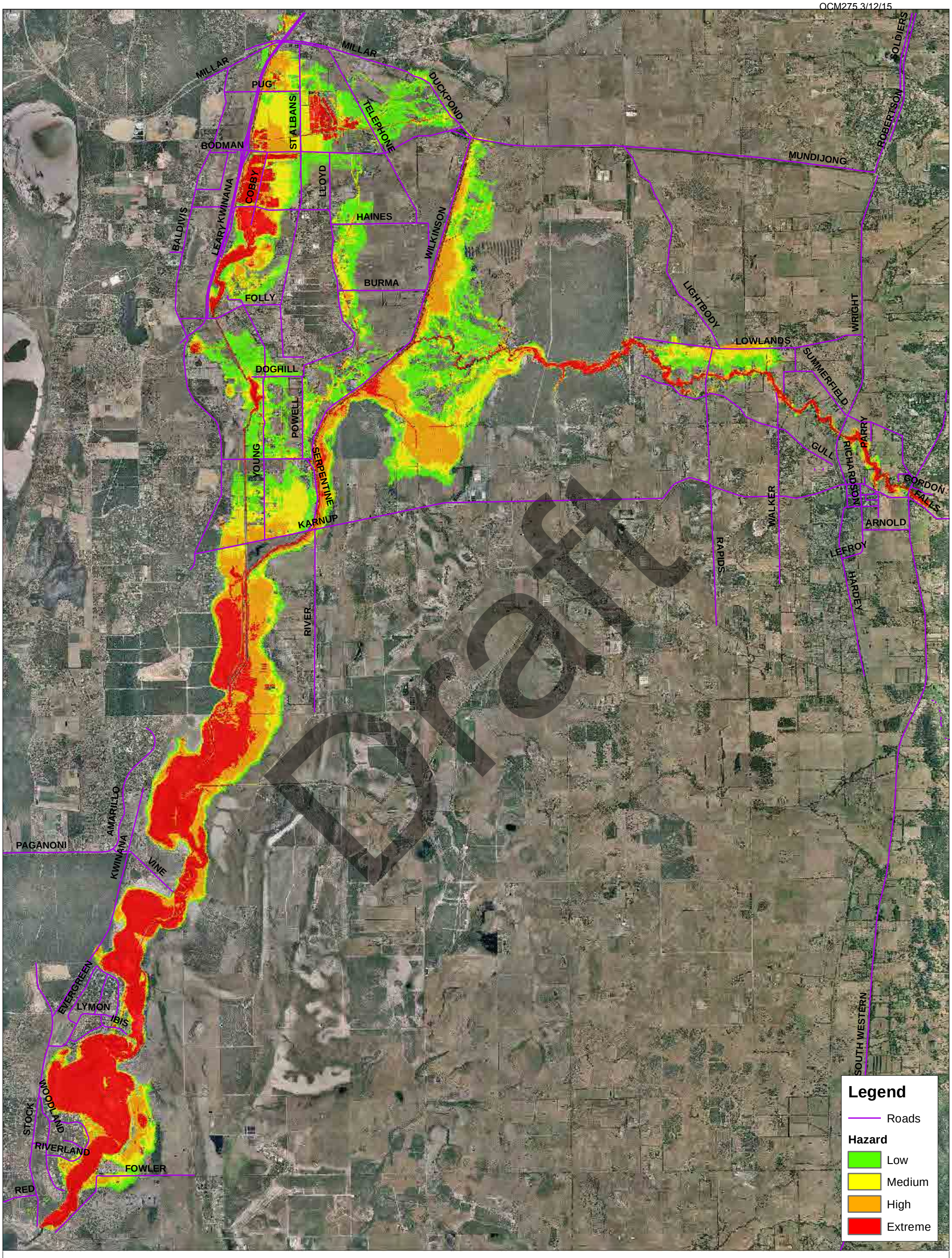
Figure A-1 100 Year ARI Event Flood Levels – As Existing

0 0.5 1 2 3 4 5
Kilometres

Author: Sarah Gosling
Date: 05/02/10
Job No: QE09396.100

SINCLAIR KNIGHT MERZ SKM

I:\QENV\Projects\QE09396\Spatial\Arc_MXD\Serpentine\Figures\Serpentine_Existing_100y_Inundation.mxd



SERPENTINE RIVER FLOOD STUDY

Figure A-2 100 Year ARI Event Flood Hazard - As Existing

0 0.5 1 2 3 4
Kilometres

Author: Sarah Gosling
Date: 05/02/10
Job No: QE09396.100

SINCLAIR KNIGHT MERZ
SKM

I:\QENV\Projects\QE09391\Spatial\Arc_MXD\Serpentine\Figures\Serpentine_Existing_100y_Hazard.mxd

Appendix H – Plant Selection List

	6128174 "Serpentine Outline Plan LWMS"- PLANT SELECTION LIST						
	Infiltration Basins						
	BOTANICAL NAME		**COMMON NAME**	**HEIGHT**	**WIDTH**	**LOCATION**	
	Melaleuca	preissiana	Stout paperbark	6-10m	3-5m	Tolerates waterlogged soils. Periodic inundation Salt Water Tolerant	Uplands
	Melaleuca	rhaphiophylla	Freshwater paperbark	6m	3m	Wet depressions or clay flats	Levee/ Channel
	Melaleuca	cuticularis	Saltwater paperbark	5m	6m	tolerant to both waterlogging and in the salt air and water - Drought tolerant	
	Melaleuca	lateritia	Robin redbreast bush	2.5m		Fringing watercourses and in wet seasonally depressions	
	Banksia	littoralis	Swamp banksia	12m		Swampy areas, does not tollerate inundation, prefers areas subject to only short winter water logging. -Deep sands and well drained soils, drought resistant	
	Banksia	seminuda	River banksia	20m		Richer heavier soils along riverbanks and seasonally wet depressions	
	Carex	appressa	Tall sedge	2m	0.5m	Brackish water, occur seasonally inundated or shallow permanent water	Levee
	Carex	fascicularis	Tassel sedge	1.5m	1m	Fresh to brackish water. Seasonally waterlogged or partially inundated watercourses and lake margins	Levee
	Carex	inversa	Knob sedge	0.1-0.15m	0.2m	seasonally wet or water logged soils and in fresh to semi saline conditions.	
	Dianella	caerulea	King Alfred	0.3-0.5m			
	Dianela	revoluta	Little Rev	0.3-1.5m		Variety of soils, laterite, granite, limestone	
	Lomandra	histrix	Tropic Belle				
	Lomandra	longifolia					
	Juncus	caespiticius	Grassy rush	.09-.6m		Peaty Saline sand, winter depressions	
	Juncus	holoschoenus	Jointleaf rush	.3-1m		Sand, swamps, creeks.	
	Juncus	kraussii	Sea rush	0.8-1.5m		Saline to brackish habitats fringing watercourses and lakes, also on sea shores	Channel- Levee
	Juncus	pallidus	Pale rush	2m		Common in seasonally damp areas. Max water depth 0.05m	(Levee)
	Juncus	pauciflorus	Loose flower rush	1m		Permanently damp or seasonally wet soil fringing fresh watercourses	Levee
	Juncus	subsecundus	Finger rush	1m		Moist seasonally wet soils	Levee
	Goodenia	pulchella	subsp. Coastal Plain	0.5m		Seasonally wet sites, undulating dunes	
	Eucalyptus	occidentalis	Flat-topped-yate	20m	5m	Wet depressions or clay flats	Uplands
	Eucalyptus	rudis	Flooded gum	25m	4m	prolonged periods of flooding usually found in waterlogged areas,	
	Casuarina	cunninghamiana		5-9m	5m	Loam over granite, Eucalyptus woodlands along creek edge	
							Levee
	Ficinia	nodosa	Knotted club rush	1m		Sands coastal dunes, winter wet depressions and fringing rivers and lke margins - Highly tolerant to salt spray and waterlogging-	
							levee/ uplands
	Lepidosperma	gladiatum	Coastal sword-sedge	1.5m		Perennial, found in seasonally moist or wet sands as well as dry dunes, full sun- part shade - Tolerates direct salt winds and alkaline soils.	
	Bioretention Swales and Pockets						
	Carex	appressa	Tall sedge	2m	0.5m	Brackish water, occur seasonally inundated or shallow permanent water	
	Carex	appressa	Tassel sedge	1.5m	1m	Fresh to brackish water. Seasonally waterlogged or partially inundated watercourses and lake margins	
	Carex	inversa	Knob sedge	0.1-0.15m	0.2m	seasonally wet or water logged soils and in fresh to semi saline conditions.	
	Juncus	caespiticius	Grassy rush	.09-.6m		Peaty Saline sand, winter depressions	Channel- Levee
	Juncus	holoschoenus	Jointleaf rush	.3-1m		Sand, swamps, creeks.	(Levee)
	Juncus	kraussii	Sea rush	0.8-1.5m		Saline to brackish habitats fringing watercourses and lakes, also on sea shores	Levee
	Juncus	pallidus	Pale rush	2m		Common in seasonally damp areas. Max water depth 0.05m	Levee
	Juncus	pauciflorus	Loose flower rush	1m		Permanently damp or seasonally wet soil fringing fresh watercourses	
	Juncus	subsecundus	Finger rush	1m		Moist seasonally wet soils	

							Levee
	Ficinia	nodosa	Knotted club rush	1m		Sands coastal dunes, winter wet depressions and fringing rivers and lke margins - Highly tolerant to salt spray and waterlogging-	
	Dianella	caerulea	King Alfred	0.3-0.5m			levee/ uplands
	Dianela	revoluta	Little Rev	0.3-1.5m		Variety of soils, laterite, granite, limestone	
	Lomandra	histrix	Tropic Belle				
	Lomandra	longifolia					
	Lepidosperma	gladiatum	Coastal sword-sedge	1.5m		Perennial, found in seasonally moist or wet sands as well as dry dunes, full sun- part shade - Tolerates direct salt winds and alkaline soils.	
		Found In SMEC_Enviro Report-Species Extracted					
	Ornimental Landscape Plant						

Appendix I – Checklist for integrated water cycle management assessment of local structure plan

Checklist for integrated water cycle management assessment of local structure plan or local planning scheme amendment

1. Tick the status column for items for which information is provided.
2. Enter N/A in the status column if the item is not appropriate and enter the reason in the comments column.
3. Provide brief comments on any relevant issues.
4. Provide brief description of any proposed best management practices, eg. multi-use corridors, community based-social marketing, water re-use proposals.

Local water management strategy item	Deliverable	☑	Comments
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements & requirements for BMPs and critical control points	☑	
Introduction			
Total water cycle management – principles & objectives Planning background Previous studies		☑	Section 1
Proposed development			
Structure plan, zoning and land use. Key landscape features Previous land use	Site context plan Structure plan	☑ ☑	Section 2 Appendix A, B and C
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas	Landscape Plan	☑	Section 2 Figure 2
Design criteria			
Agreed design objectives and source of objective		☑	Section 3
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		☑	Section 4
Site Conditions - existing topography/ contours, aerial photo underlay, major physical features	Site condition plan	☑	Figure 5
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	☑	Figure 6
Environmental - areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	☑	Figure 8
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	☑	Figure 5 Appendix E and G
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	☑	Available information provided in Section 3
Water use sustainability initiatives			
Water efficiency measures – private and public open spaces including method of enforcement		☑	Section 5
Water supply (fit-for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		☑	Section 5
Wastewater management		☑	Section 5
Stormwater management strategy			
Flood protection - peak flow rates, volumes and top water levels at control points,100 year flow paths and 100 year detentions storage areas	100yr event Plan Long section of critical points	☑ ☑	Section 6 Figure 10 Appendix E
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5yr event Plan	☑	Section 6 Appendix E

Local water management strategy item	Deliverable	☑	Comments
Protect ecology – detention areas for the 1 yr 1 hr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1yr event plan Typical cross sections	☑ ☑	Section 6 Typical cross section provided in Figure 9
Groundwater management strategy			
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoils areas/exclusion zones	Groundwater/subsoil Plan	☑	Section 7 Figure 11 and 12
Actions to address acid sulfate soils or contamination		☑	
The next stage – subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design.		☑	Section 8
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		☑	Section 9
Implementation			
Developer commitments		☑	Section 10
Roles, responsibilities, funding for implementation		☑	Section 10
Review		☑	Section 10

GHD

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	A Drummond	M Busbridge	On File	N Gamage	On File	Not Released
1	M Busbridge	N Gamage	On File	N Gamage	On File	06/06
2	M Busbridge	N Gamage	On File	N Gamage	On File	18/12
3	M Busbridge					

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Appendix 2

Transport Assessment (Opus, 2013)

OPUS

Serpentine Structure Plan

Transport Assessment

Shire of Serpentine Jarrahdale

OPUS

Serpentine Structure Plan

Transport Assessment

Shire of Serpentine Jarrahdale

Prepared By
Tim Judd
Transportation Work Group Manager

Reviewed By
Tim Selby
Technical Principal - Transportation

Approved for Release By
Tim Selby
Technical Principal - Transportation

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Date: 06/09/ 2013
Reference: WP1334.00
Status: Final

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1 Introduction

The Shire of Serpentine Jarrahdale (the Shire) has commissioned Opus International Consultants (Opus) to prepare a high level 'broad brush' Transport Assessment to provide input and guidance on transport issues as part of the overall structure planning process for the town site of Serpentine.

This report has been prepared to provide supporting traffic assessment information for the formal structure plan planning process and is in response to the Western Australian Planning Commission (WAPC)'s *State Planning Policy No1 (SPP1 February 2006)* which sets out the key principles relating to environment, community, economy, infrastructure and regional development which will then guide the structure planning decisions. The objective of the 'infrastructure' component is to facilitate strategic development by making provision for efficient and equitable transport and public utilities[1].

This report addresses the existing and proposed traffic, safety and parking related aspects of the structure plan and in accordance with the WAPC Transport Assessment guidelines and the Shire's local planning policy number 61, includes details relating to:

- Existing traffic flows and surrounding car parking provision;
- Structure Plan traffic generation and parking;
- Access strategy;
- Road safety;
- Impact on surrounding land use and transport network; and
- Site sustainable transport links.

Further to this, the WAPC has an alternative operational policy – Liveable Neighbourhoods. This also requires a transport assessment to be undertaken as part of the structure planning process under the element of 'Movement Network' requring an asseesment of the same items, listed above.

1.1 Background

At a meeting on the 21st June 2012 with the Department of Planning, the Shire was presented with a copy of a study area as part of the Local Water Management Plan that the Department of Planning (DoP) commissioned. The DoP has requested that the Shire undertake the preparation of a Transport Assessment for the study area to ensure that some form of planned/formal planning process/structure is in place for the town site of Serpentine with regard to transport.

1.1.1 Background Documentation

GHD Pty Ltd (GHD) was commissioned by the Department of Planning to prepare a Local Water Management Strategy (LWMS) for the Serpentine Outline Plan area, which is within the structure plan area.

The purpose of the LWMS was to:

- Provide objectives, criteria and requirements for the protection and management of the water cycle as part of land use planning and development for the Outline Plan area;

[1] WAPC Transport Assessment Guidelines for Developments – Vol.2 Structure Plans, 2006

- Identify key water environments and management issues across the Serpentine Outline Plan area;
- Provide guidance for the protection of significant water resource assets and the management of water resources and flooding and stormwater management, as part of future land use planning and development in the Outline Plan area; and
- Incorporate applicable principles from Better Urban Water Management (Western Australian Planning Commission, 2008).

The strategy goes on to identify measures to make the Outline Plan area a leading example of water efficiency.

The LWMS also identifies that the outline plan area predominantely consists of residential lots and contains a combination of R10 and R5 residential zoned lots. The development area also contains a number of commercial lots and public and community lots, public open space and recreation areas[2].

The strategy goes on to note that the landuse will remain largely residential with R5 and R10 zoning; however, lot boundaries, public open space and draignage networks maybe relocated, depending of future development plans.

[2] Department of Planning Serpentine Outline Plan, Local Water Management Strategy – prepared by GHD, January 2013

2 Structure Plan Proposal

2.1 Regional Context

The Shire of Serpentine Jarrahdale is located on the fringe of Perth, approximately 45 kilometres south of the Perth CBD. In 2011, the total population of the Shire was estimated at 17,746, with Serpentine's population estimated at 1,089 (6% of the total shire popultaion) with 391 private dwellings[3]. The average number of motor vehicles per dwelling was 2.4. 68% of people were reported to have travelled to work by car as a driver or as a passenger whilst 5% travelled to work by public transport.

The Shire's population is expected to increase significantly by almost 12,700 people to 26,054 by 2016, at an average annual growth rate of 6.9%. This is based on an increase of more than 4,200 households during the period, with the average number of persons per household remaining relatively stable at about 2.95[4].

Through discussions with the Shire, it is assumed that during this same period (2011 to 2016) the population of Serpentine will remain at approximatley 6% of the Shire's total population.

2.2 Proposed Land Use

The structure plan proposes to increase the number of residential lots, primarily to the south of the Serpentine local town centre, with a small number of new residential lots also being provided to the north and a small increase in the commercial land use within the local centre. The structure plan area is presented in Appendix A.

2.2.1 Table of Land Uses and Quantities

Table 1 presents the additional proposed land use type with approximate quantities.

Table 1 - Structure Plan additional proposed land use

Land Use Type	Quantity
Residential – R5	12.933ha
Local Centre	0.46ha

Any remaining land use type within the structure plan area is noted as either, existing residential, local centres, community facilities, public open space, local road or reserved Bush Forever land.

2.3 Major Attractors / Generators

There are no major trip attractors or generators planned within the structure plan site. The existing local centre, educational facilities and community facilities are not proposed to increase in size.

[3] Australian Bureau of Statistics, 2011 census data
[4] Information obtained from the Shire website – accessed 07.02.2013

To the east of the structure plan site is the Serpentine National Park. While this is a regional trip attractor, the main access to the national park is from the South Western Highway, with minimal trips passing through Serpentine itself.

2.3.1 Specific Issues

The proposed intersection of Wellard Street, Karnup Road and Rudall Street is noted as having a potential capacity and safety issue by the Shire. This location is addressed in more detail within later sections of this report.

3 Existing Conditions

3.1 Site Description

The existing town of Serpentine encompasses a small area of approximately 4km². The proposed structure plan site sits within this and is broadly defined by the Railway Line to the West, Arnold Road on the South, and Rudall Street on the East. The northern boundary of the study area is defined along Giblett Street and Lot 82.

To the east of the site is a large area of public open space which connects from Wellard Street to the north of the site to Arnold Street to the south. Within the public open space is a drainage swale that runs the entire length, north to south, and bends east toward Lefroy Street.

There are two areas that have been designated as Bush Forever within the structure plan area. One Bush Forever area boarders the west of the structure plan, running north of Karnup Road. The other Bush Forever area also boarders the west of the structure plan, running south from Wellard Street to Leslie Street approximately.

3.2 Existing Land Use

The Shire's Rural Land Strategy (2012 – 2032) designates the Serpentine town site as a Rural Settlement, requiring low density residential lots. As depicted in the structure plan area, presented in Appendix A, the existing land use within Serpentine is predominately residential (zoned at R5 and R10 lots sizes), with a local centre, community facilities (school, church and recreation) and areas of public open space. Table 2 presents the existing land use type with approximate quantities.

Table 2 - Existing land use within the structure plan area

Land Use Type	Quantity
Residential – R5	34.9ha
Residential – R10	21.96ha
Local Centre	1.43ha
Educational	1.92ha
Community Facility	0.40ha

3.3 Surrounding Land Use

Surrounding the structure plan site are large, rural properties and open farming land. Within the Shire's Rural Land Strategy this area has be designated Rural Residential with one hectare (ha) minimum plots. The land surrounding this has been designated Rural Small Holding (4 to 40ha) and Rural Balance (80ha minimum) with approximately 450 'rural living' lots within a 3km radius of the structure plan site.

3.4 Existing road network

The existing road network consists of three roads running east-west through the site (Karnup Road, Wellard Street and Tonkin Street) with Karnup Road being the main access into the town. There are also two roads running north-south through the site (Lefroy Street and Rudall Street). The remaining roads within the site are small access roads connecting the main north-south and east-west roads.

The classification of roads within and surrounding the structure plan has been assessed using the Main Roads WA Information Mapping System and are as follows:

- Karnup Road is classed as a Regional Distributer Road connecting from Serpentine to the Kwinana Freeway with a posted speed limit of 60km/h, increasing to 70km/h as it leaves the town.
- Richardson Street is classed as a Regional Distributer Road connecting Serpentine to Mundijong with a posted speed limit of 60km/h increasing to 80km/h as it leaves the town.

All other existing roads within the town site are classed as local access roads with the default residential speed limit of 50km/h. The road hierarchy's are presented in Figure 1.

3.4.1 Surrounding road network

Bordering the study area is the South Western Highway (to the east) and Hall Road (to the west). Both of these roads run in a north-south orientation connecting to and from Karnup Road. The Main Roads WA Information Mapping System road classification can be seen in Figure 1 and are described as follows:

- South West Highway is classed as a Primary Distributer Road running to the east of the structure plan site with a posted speed limit of 60km/h as it passes the edge of the town site, increasing to 80km/h and ultimately 110km/h.
- Hall Road is classed as a Local Distributer running to the west of the structure plan site with a posted speed limit of 60km/h increasing to 80km/h as it leaves Serpentine.

Beyond this are predominantly rural roads linking to small settlements or individual residential lots.

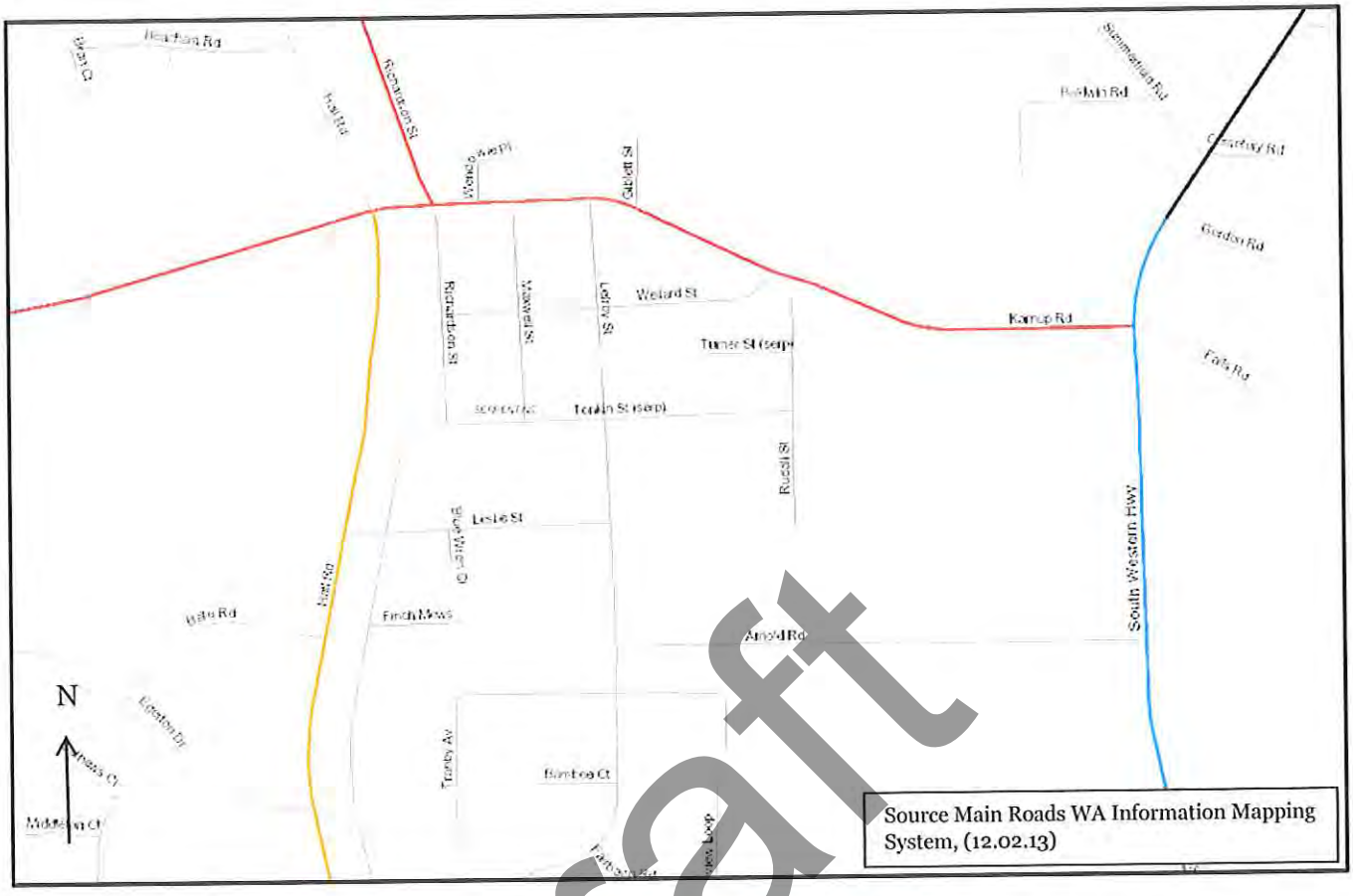


Figure 1 - Main Roads WA Road Hierarchy Map

The cross-sections of the existing road network are typically categorised (in accordance with Liveable Neighbourhoods[5]) as Access Streets, with the higher order roads (such as Karnup Road, Wellard Street and Richardson Street) being of an Access Street B standard which consists of 2 lane undivided roads with some in-dented on-street parking and footpath on at least one side. All other roads within the structure plan area can be typically categorised as Access Street D standard which consists of 2 lane undivided roads with no in-dented on-street parking and in some cases, no footpath provision.

3.4.2 On-Street Parking

There are no parking restrictions within the town with informal on-street or on-verge parking occurring in a few locations related to local residential properties.

Formal, in-dented on-street parking is provided along Wellard Street forming part of the local centre, with angled parking bays between Richardson Street and Lefroy Street. There are also on-street parking bays along Richardson Street close to its intersection with Wellard Street.

Formal on-street parking is also provided along Lefroy Street in the form of demarcated parking bays, within close proximity to the primary school. There are no other areas that have formal on-street parking bays provided.

[5] Western Australian Planning Commission, Liveable Neighbourhoods, January 2009, update 2, Element 2 – movement network

Anecdotal evidence indicates that parking along Lefroy Street and spilling into Tonkin Street is a particular issue during school drop off/pick up time.

3.5 Existing pedestrian/cycle networks

The Serpentine Jarrahdale Shire Local Area Bicycle and Shared Path Plan (Revised July 2012) reports that there is a concrete footpath on the eastern side of Lefroy Street between Tonkin Street & Wellard Street. This then swaps to the western side of Lefroy Street, between Wellard Street & Karnup Road. There is a sealed footpath (average condition) on Karnup Road from South Western Highway to Wellard Street (service road) and then runs along the south side of Wellard Street to Lefroy Street. The footpath continues along Wellard Street in sections of concrete and brick paving (all in good condition).

Serpentine is reasonably well serviced by footpaths however various improvements are recommended within the Shire's bicycle plan for the following roads:

- Wright Road;
- Richardson Road;
- Karnup Road;
- Tonkin Street;
- Maxwell Street;
- Hardy Road;
- Transby Avenue;
- Hall Road; and
- Wattle Road.

The proposed bicycle paths and routes as detailed in the Serpentine Jarrahdale Shire Local Area Bicycle Plan are presented in Appendix B.

3.6 Existing public transport services

There is one existing bus service that runs through the town. Route 252 connects Serpentine to Mundijong to the north and ultimately to Armadale Station. This service is a Saturday only service with very low patronage[6]. On site observations also noted sheltered bus stops which provide waiting facilities for a local school bus service.

Further, there is a railway line that runs to the west of the town site travelling through the Serpentine railway station connecting through to Mundijong.

3.7 Traffic Volume and Speed Analysis

Traffic volume and speed data has been collected for the majority of roads within Serpentine. This data is presented in Appendix C. A review of the traffic data generally indicates that the volume of traffic using the roads within the study area is within the acceptable range associated with the road hierarchy and consistent with the relevant functional classification of the roads.

[6] Low patronage noted by the Public Transport Authority representative, no figures provided

A review of measured operational speeds supplied by the Shire of Serpentine Jarrahdale indicates that mean speeds are typically at or less than the posted speed limit albeit with a few roads noted to have travel speeds consistently higher than the posted speed limit. Notwithstanding this, a number of roads have 85th percentile speeds[7] which exceed the speed limit by 5km/h as indicated in the table in Appendix C. Of particular note are those road sections with 85th percentile speeds exceeding 10km/h, with Hall Road, Lefroy Street and Richardson Street standing out as having consistently higher speeds along their length.

3.8 Road Safety

Crash data for the last five years (2007 to 2011) has been obtained from Main Roads WA Crash Analysis Reporting System (CARS) and assessed for the town of Serpentine. This crash data has been analysed and mapped – see Figure 2.

In total, 21 crashes have been reported for the town of which 1 required hospital treatment, 4 required medical assistance with the remaining 16 being Property Damage Only. No fatal crashes have been reported. Of these 21 crashes, 10 crashes occurred on the roads bordering the site (South Western Highway and Hall Road), 2 of which required medical treatment. The remaining 11 occurred within the internal site area, with 2 crashes requiring medical treatment and 1 needing to be taken to hospital.

14 of the total crashes occurred at intersections, of which 3 involved either hospital or medical treatment to road users. The remaining 7 crashes occurred at mid-block locations with 2 involving either hospital or medical treatment to road users. No collisions were reported that involved cyclists or pedestrians.

4 of the 8 crashes recorded at the intersection of South Western Highway and Karnup Road (bordering the study area) occurred when exiting Karnup Road, with 3 of the crashes colliding with vehicles on South Western Highway when travelling east onto Falls Road. The remaining crash at the intersection involved a vehicle turning right onto South Western Highway from Karnup Road colliding with a vehicle travelling along South Western Highway.

Notwithstanding intersection crashes that total 7 out of the 21 recorded crashes within the study area (33%), no other crash type is predominant.

7 The 85th percentile speed is the speed at which 85 precent of vehicles move at or below.

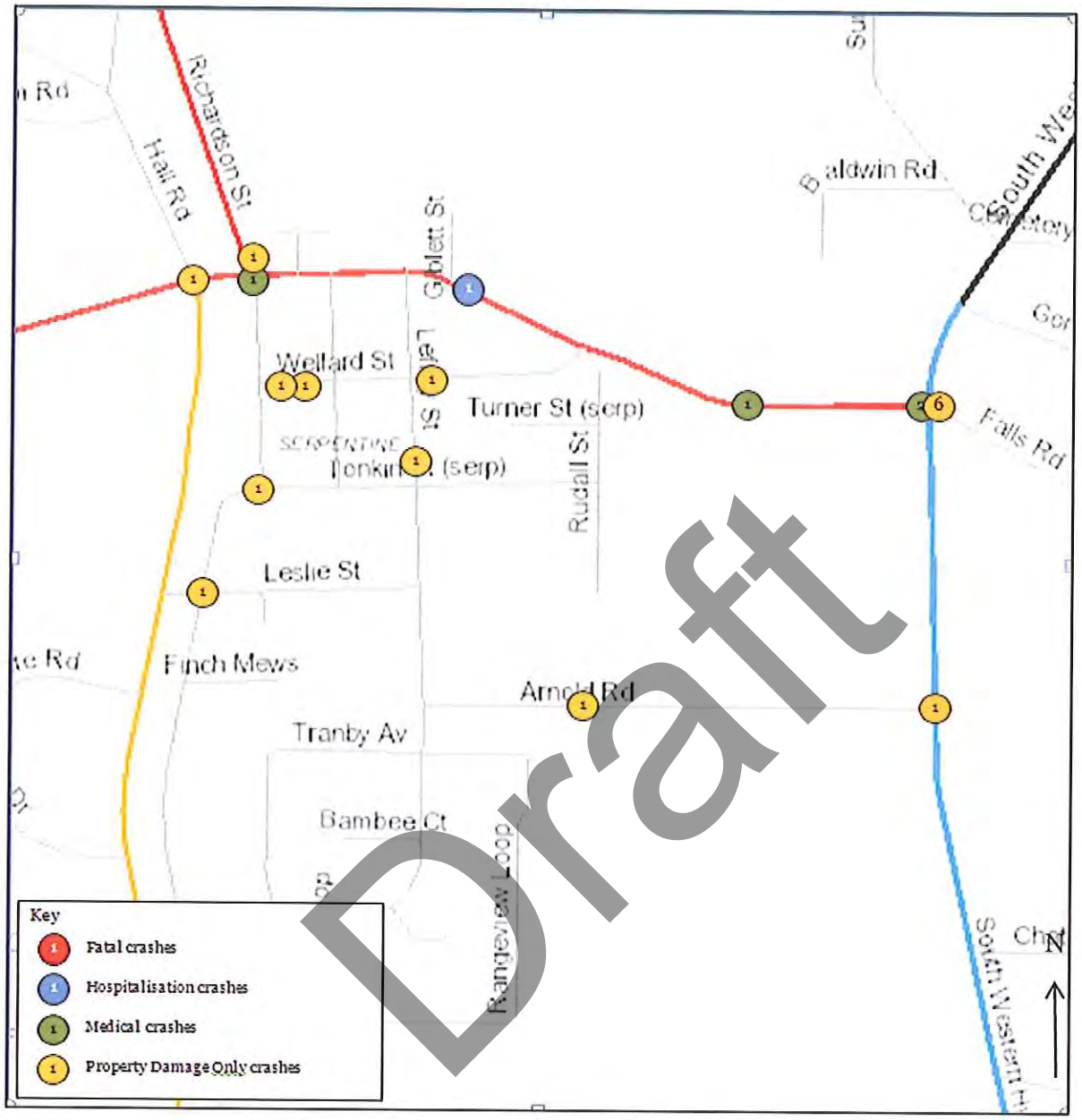


Figure 2 - Crash Locations

4 Future Demand

4.1 Analysis of internal road network

4.1.1 Traffic Growth

The Structure Planning process is usually a long term process, with the development of an area usually occurring over a number of years, often 15 or 20 years before the area is fully developed. The analysis of the existing and future transport network should therefore reflect the year of full development.

The Main Roads WA transport model (ROM) forecast traffic flows have been provided for 2011, 2021 and 2031. The two years of 2021 and 2031 have been used when assessing the impact of development traffic, taking the assumption that the structure plan will be fully developed by either 2021 or 2031.

The ROM forecast traffic volumes are available for the higher order roads within Serpentine and are presented in Table 3.

Table 3 - ROM model forecasts for Serpentine

Forecast count site	Direction		ROM model forecast years (24hr average weekday volumes)				
		2011 observed volumes	2011	2021	*Volume Increase % (2011 – 2021)*	2031	*Volume increase % (2021 – 2031)*
Karnup Road (west of Hall Road)	Eastbound	758	1,573	2,750	*75*	3,371	*23*
	Westbound	770	1,603	2,781	*74*	3,569	*28*
Karnup Road (east of Hall Road)	Eastbound	708	1,044	2,044	*95*	2,434	*19*
	Westbound	755	1,073	2,076	*93*	2,630	*27*
South Western Highway (north of Karnup Road)	Northbound	-	2,445	4,530	*85*	6,751	*49*
	Southbound	-	2,535	4,656	*83*	7,193	*54*
South Western Highway (south of Karnup Road)	Northbound	3,569 (combined)	1,666	2,928	*75*	4,854	*65*
	Southbound		1,727	3,022	*75*	5,100	*68*

The data presented within Table 3 notes an approximate increase in forecast traffic volumes between 2011 and 2021 of between 75% and 95% for Karnup Road. This increases further by approximately 25% between 2021 and 2031.

However, it is noted that the ROM model forecast flows for 2011 are considerably higher than the actual observed flows for Karnup Road and South Western Highway. As such, the forecast increase in traffic volume to 2021 and 2031 may also be less than presented in Table 3.

4.2 Proposed Transport Network

The proposed transport network within the structure plan is to provide new local access roads to serve the proposed residential lots to the south and north of the existing Serpentine local centre. In total there are 7 roads proposed to the north of the existing local centre and 8 roads proposed to the south of the existing local centre. Further to this, there is also an extension to Rudall Street to connect to Arnold Road along with modification to the intersection of Karnup Road, Wellard Street and Rudall Street. The new roads are highlighted in Appendix A.

4.2.1 Road cross-sections and speed limits

To ensure a consistent approach across the entire road network within the structure plan area, it is recommended that the proposed cross-sections are Access Streets as categorised by Liveable Neighbourhoods. Access Street B standards, which consist of 2 lane undivided roads with some indented on-street parking and a footpath on at least one side should be provided for the 'higher order road' (the proposed road to the very east of the structure plan). All other proposed roads can be categorised as Access Street D standard which consists of 2 lane undivided roads with no indented on-street parking and with a footpath on at least one side.

One further road type should also be considered for the proposed road connecting Lefroy Street east into the large public open space area. It is seen on the plan in Appendix A that this road is proposed to have a central swale drain. Therefore, it is recommended that this road should be an Access Street A, as categorised by Liveable Neighbourhoods, with a 6m wide central median containing swale drains, indented parking and a footpath.

The speed limit for all new roads should remain consistent with the existing roads within the structure plan, which are 50km/h. Further, the appropriateness of traffic management measures also needs to be investigated in detail along such roads as Lefroy Street and Richardson Road to assess why the operating speed of the road, as noted in section 3.7 of this report is considerably higher than the posted speed.

4.2.2 Intersection control

The forecast traffic growth for Karnup Road within the structure plan is estimated to increase by approximately 75% to 95% from 2011 to 2021, albeit with observed volumes being much lower than the modelled forecast volumes for 2011. Using a 'worst case' 95% increase in traffic to the existing volumes, the total traffic volumes will still be within the acceptable range associated with the road hierarchy and consistent with the relevant functional classification of the road.

All existing and proposed intersections within the structure plan are priority controlled intersections. The correct priority control (Give-Way or Stop) should be provided based on the Main Roads WA design guidelines at the point where the existing and/or proposed roads intersect with each other. Notwithstanding this however, through future planning for the development of the structure plan, detailed modelling of specific intersections (such as Tonkin Street and Lefroy Street or Karnup Road and Wellard Street) may be required in order to determine the most appropriate form of intersection treatment.

Further to this, it is noted that the existing T-intersection of Karnup Road and Wellard Street is to change to include access from Rudall Street. There are no specific details proposed for this intersection. The intersection may benefit from road realignment or specific treatment such as a roundabout. It is recommended therefore that the intersection and any proposed designs are subject to a Road Safety Audit to ensure safety of the road users is considered.

4.2.3 Pedestrian and cycle network planning

No cycle routes are proposed within the structure plan, however, as detailed in Appendix B, the Shire of Serpentine Jarrahdale are proposing cycle routes to link Karnup Road to Richardson Road, Lefroy Street and Wellard Street. This will provide good cycle linkages to the local centre, school and community facilities as well as the proposed residential lots to the north of the local centre and should be incorporated into the structure plan.

Further, cycle links (shared paths) should also be included to connect the proposed residential lots to the south to these planned routes to complete a network across the entire structure plan and provide a viable transport alternative to local residents.

4.2.4 Public Transport Access

A brief discussion with the Public Transport Authority (PTA) has indicated that there are no planned changes to the existing bus network servicing the Serpentine Area and would only consider additional services if there was a significant demand.

4.3 Proposed changes to external transport network

Discussions with the Shire have indicated that the structure plan does not propose any changes to the external transport network.

4.4 Integration with surrounding area

4.4.1 Proposed changes to trip attractors/generators surrounding the structure plan

Discussions with the Shire have indicated that there are no planned changes to the trip attractors/generators surrounding the structure plan.

The structure plan is not proposing any new links to surrounding land use and as such the integration and level of accessibility with surrounding land use will remain as it is, with one main access onto the South Western Highway and one main access through to Hall Road and Karnup Road westbound toward the Kwinana Freeway.

It is noted that there is a secondary access onto South Western Highway via Arnold Road. The impact of increased traffic flows as a result of the structure plan development on this intersection is discussed in later sections of this report.

4.5 Traffic Generation

4.5.1 Typical Rates Traffic Generation Databases

The Western Australian Planning Commission Transport Assessment Guidelines for Developments provides typical land use vehicle trip rates as detailed in Table 4.

Table 4 - Typical land use vehicle trip rates

Land Use	Unit	AM peak hour trip rate		PM peak hour trip rate	
		In	Out	In	Out
Residential	Dwellings	0.2	0.6	0.5	0.3
School	Pupils	0.5	0.5	0.5	0.5
Commercial	100m² GFA	0.6	0.4	0.4	0.6

Note: these typical values are an 'average' trip rate extracted from land use traffic generation databases which are detailed in Volume 2 of the WAPC guidelines.

4.5.2 Structure Plan proposed land use

The structure plan area consists of a number of differing land uses which have been presented in Table 5 along with the approximate Gross Floor Area (GFA) and/or number of dwellings per site. The land use areas are the total of the existing land use types and the additional proposed residential and commercial development as provided by the Shire of Serpentine Jarrahdale.

Table 5 – existing and proposed land use totals

Land Use Type	Area	Unit	Ratio Unit to Area
Residential – R5	47.83ha	150 dwellings	0.32 dwellings per ha
Residential – R10	18.80ha	40 dwellings	0.47 dwellings per ha
Local Centre (commercial)	1.89ha	18,900m²	-
Educational	1.92ha	19,2000m²	-
Community Facility (commercial)	0.40ha	4,000m²	-

Note: for this high level assessment the total hectares provided are considered to equate to usable GFA for assessment purposes.

The proposed new residential and commercial development consists of an increase in the number of R5 zone residential lots and a slight increase in the commercial element of the local centre. All other land use types remain as existing with the exception of the R10 zone residential lots, which in the final structure plan will decrease from the existing number within the town.

4.5.3 Existing Land Use Traffic Generation

Using the ratio's provided in Table 5 the approximate number of dwellings and the resulting theoretical traffic generation of the existing land use types can be calculated, and is presented in Table 6.

Table 6 - existing land use traffic generation

Land Use Type	Area	Unit	Traffic Generation				
			Peak Hour trip generation	AM Peak		PM Peak	
				In	Out	In	Out
Residential – R5	34.9ha	110 dwellings	88	22	66	55	33
Residential – R10	21.96ha	47 dwellings	38	9	29	24	14
Local Centre (commercial)	1.43ha	14,300m²	286	172	114	114	172
Educational	1.92ha	19,200m²	192	96	96	96	96
Community Facility (commercial)	0.40ha	4,000m²	80	48	32	32	48

4.5.4 Additional Land Use Traffic Generation

As the structure plan area already consists of a number of existing residential and commercial properties that currently utilise the road network, the calculation of the estimated trip generation for the new residential and commercial properties proposed within the structure plan area is presented in Table 7.

Table 7 – additional development traffic generation

Land Use Type	Area	Unit	Traffic Generation				
			Peak Hour trip generation	AM Peak		PM Peak	
				In	Out	In	Out
Residential – R5	12.93ha	40 dwellings	32	8	24	20	12
Local Centre (commercial)	0.46ha	4,600m²	92	55	37	37	55

4.6 Traffic Distribution

Vehicle access to the local centre, local primary school and other community facilities will be undertaken using a number of the proposed and existing internal access roads within the structure plan area. However, it is assumed that Karnup Road and Richardson Road may experience an increase in use as these are the main distributor roads and main access points to South Western Highway and the Kwinana Freeway. Wellard Street, Tonkin Street and Lefroy Street may also experience a higher usage than other local access roads due to the access to the local centre and primary school.

4.6.1 Traffic Impact on road network

The ROM model flows (as presented in Table 3) indicate that by 2021 the average 2-way daily traffic flow will be approximately 4,120 for Karnup Road (east of Hall Road) increasing to 5,064 by 2031.

It is assumed that the ROM model forecasts includes the traffic generated by the existing land uses within Serpentine and equates to an approximate peak hour flow of 453 vehicles per hour in 2021 and 557 vehicles per hour by 2031 along Karnup Road.

Given the forecast peak hour traffic volumes stated above for Karnup Road, the estimated traffic generation from the additional development within the Structure Plan area (presented in Table 7) is approximately 22% of the forecast flows and likely to have minimal impact on the higher order distributer roads for traffic accessing South Western Highway or through to the Kwinana Freeway.

Further, Lefroy Street, has one of the highest peak hour counts for local access roads, (a presented in Appendix C) recorded as 134 vehicles per hour. Using the similar percentage increase in traffic volumes as seen by the ROM data, the traffic on Lefroy Street may increase by as much as 95% by 2021 equating to an estimated peak hour flow of approximately 260 vehicles possibly increasing to 330 vehicles in the peak hour by 2031 (based on a 27% increase as seen in the ROM data).

The estimated traffic generation from the additional development within the structure plan area (presented in Table 7) in addition to the Lefroy Street estimated peak hour flows for 2021 and 2031 indicates that the traffic on the local access roads is likely to triple from current levels. However, the peak hour flows are within the theoretical mid-block capacity, as noted in Appendix D, which indicates an urban style road (which when built out, the local access roads within the Structure plan can be classed as) can accommodate up to 900 vehicles per hour (one way). The forecast traffic flows for Lefroy Street will therefore be within the acceptable traffic levels for the standard and functionality of the road.

4.7 Parking

No additional parking has been proposed as part of the structure plan. With large residential plots proposed, on street parking within the residential areas is not envisaged to be an issue. The local centre and primary school walking catchment (based on 800m or a 10 minute walk) encompasses all of the structure plan area and as such, it is expected that a high proportion of local trips to the local centre/or primary school may be undertaken on foot.

There are currently a number of on street parking bays provided along Wellard Street servicing the local centre and along Lefroy Street servicing the local primary school. At the structure planning stage, it is not possible to determine the number, if any, of additional parking bays that maybe required at these two locations. It is recommended therefore, that a parking study be undertaken at the detailed planning stage. However, with the walking catchment being the whole of the structure plan area, adequate pedestrian infrastructure should ensure that any new parking infrastructure required would be minimal.

4.8 Access Strategy

Arnold Road, the road bordering the very south of the structure plan area is currently an unsealed road connecting through to the South Western Highway. With an increase in residential properties in the south of the structure plan, Arnold Road has the potential to be frequently utilised by local residents to access the South Western Highway. The existing intersection of Arnold Road and South Western Highway has poor visibility both for vehicles travelling on South Western Highway and vehicles wishing to enter the South Western Highway from Arnold Road. It is recommended therefore, that Arnold Road either becomes a sealed road on the approach to the South Western Highway, along with an upgrade of the intersection to improve visibility, or, Arnold Road is closed to through traffic to reduce the use of the intersection, requiring residents from the structure plan area to travel through to Karnup Road in order to access the South Western Highway.

As part of the Access Strategy, it is noted that the structure plan area does not propose any direct access from residential properties onto roads likely to carry more than 500 vehicles per hour which is noted as good practice.

4.8.1 Public Transport

No increase in the public transport bus service is proposed for the structure plan area. However, should there be an increase in demand to access other local centres and/or Armadale City centre; discussions will need to be had with the Public Transport Authority.

4.8.2 Walking and Cycling

The Western Australian Planning Commission Transport Assessment Guidelines for Developments notes that roads which are likely to have traffic volumes that would adversely impact on the efficiency and safety of pedestrians trying to cross would need to provide adequate pedestrian footpath and crossing infrastructure.

The guidelines go on to note that for a 2 lane undivided road (road similar to that proposed for the majority of the structure plan area) pedestrians ability to cross would be affected by a peak hour traffic volume of approximately 1,100 vehicles per hour and as such formal pedestrian crossing facilities would not be required.

It is noted that the ROM model forecasts and the traffic generation rates for the entire structure plan area (which includes existing and proposed land uses) would not equate to peak hour volumes equivalent to 1,100 vehicles per hour.

However, in areas of likely high pedestrian and cycling activity such as along Wellard Street within the local centre, or on Lefroy Street within the vicinity of the local primary school, adequate safe

crossing facilities maybe required and would need to be positioned in line with likely pedestrian desire lines with acceptable lines of sight for passing traffic and crossing pedestrians.

The *Liveable Neighbourhoods* guidelines suggest a 'pedshed' analysis to be undertaken at the structure planning stage to assess the permeability and efficiency of the proposed pedestrian network. For this structure plan assessment, sufficient detail has not been provided at this stage.

However, it is noted that the 'pedshed' guidelines state that 'at least 60 precent of dwellings within a 400m radius of an existing or potential neighbourhood or town centre should be within 400m safe walking distance. As stated previously the walking catchment of the local centre within the structure plan is within 400m, therefore adequate footpath infrastructure should be provided on all local roads to enable residents to safely walk to the local centre and reduce the need to use the car for short trips.

5 Summary

It is likely that the impact of traffic as a result of the additional development within the structure plan will have minimal impact on the surrounding road network. However, the 2021 and 2031 traffic volumes forecast based on the ROM model will increase the traffic volumes on the local access road network. Further, intersections that would be frequently used, such as the Karnup Road / Wellard Street intersection may require further analysis to determine appropriate treatment.

5.1 Recommendations

Recommendations proposed as a result of this assessment include:

- The crash data presented in section 3.8 notes a number of crashes occurring at the intersection of Karnup Road and South Western Highway. The crash patterns at this intersection appear to be related to slow moving traffic exiting Karnup Road colliding with the higher speed traffic passing along the South Western Highway. Due to the likely increase in use of this intersection as traffic volumes increase, the intersection would benefit from a Road Safety Audit to establish possible causalities to the recorded crashes and recommend safety improvements.

- Further, it is noted the intersection of Karnup Road and Wellard Street will require further analysis to determine its capacity and functionality.

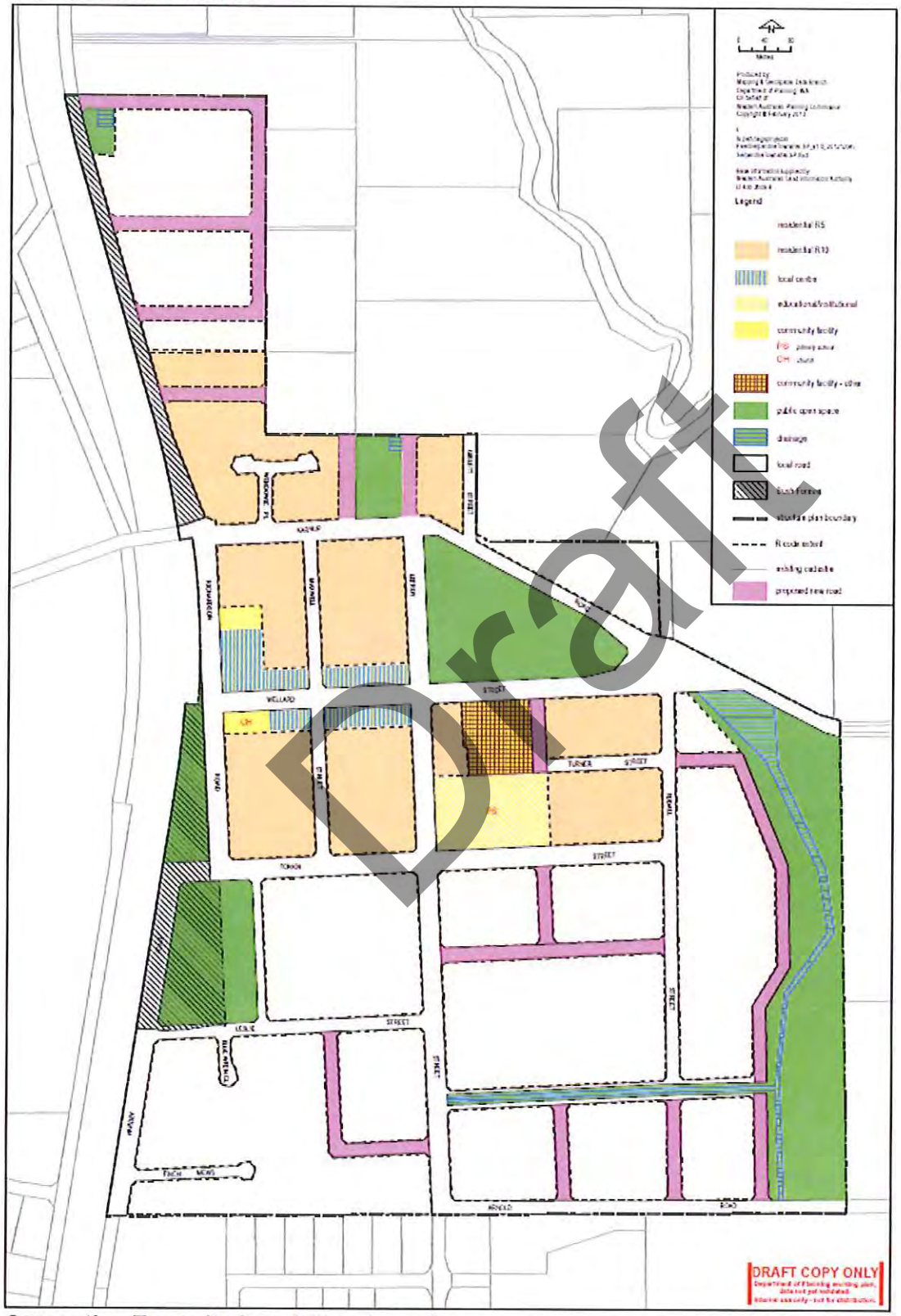
- An assessment of Arnold Road has recommended that Arnold Road either becomes a sealed road on approach to South Western Highway, along with an upgrade of the intersection to improve visibility, or, Arnold Road is closed to through traffic.

- Appropriate pedestrian infrastructure should be provided to enable all residents within the structure plan to easily and safely access the local centre and primary school. Specific safe crossing facilities to complement this would need to be assessed at a later stage of the development process.

- An extension of the proposed cycle network to incorporate the new proposed road network to the south of the structure plan should be included to ensure a complete and connected cycle network for the town.

Appendix A – Local Structure Plan Area

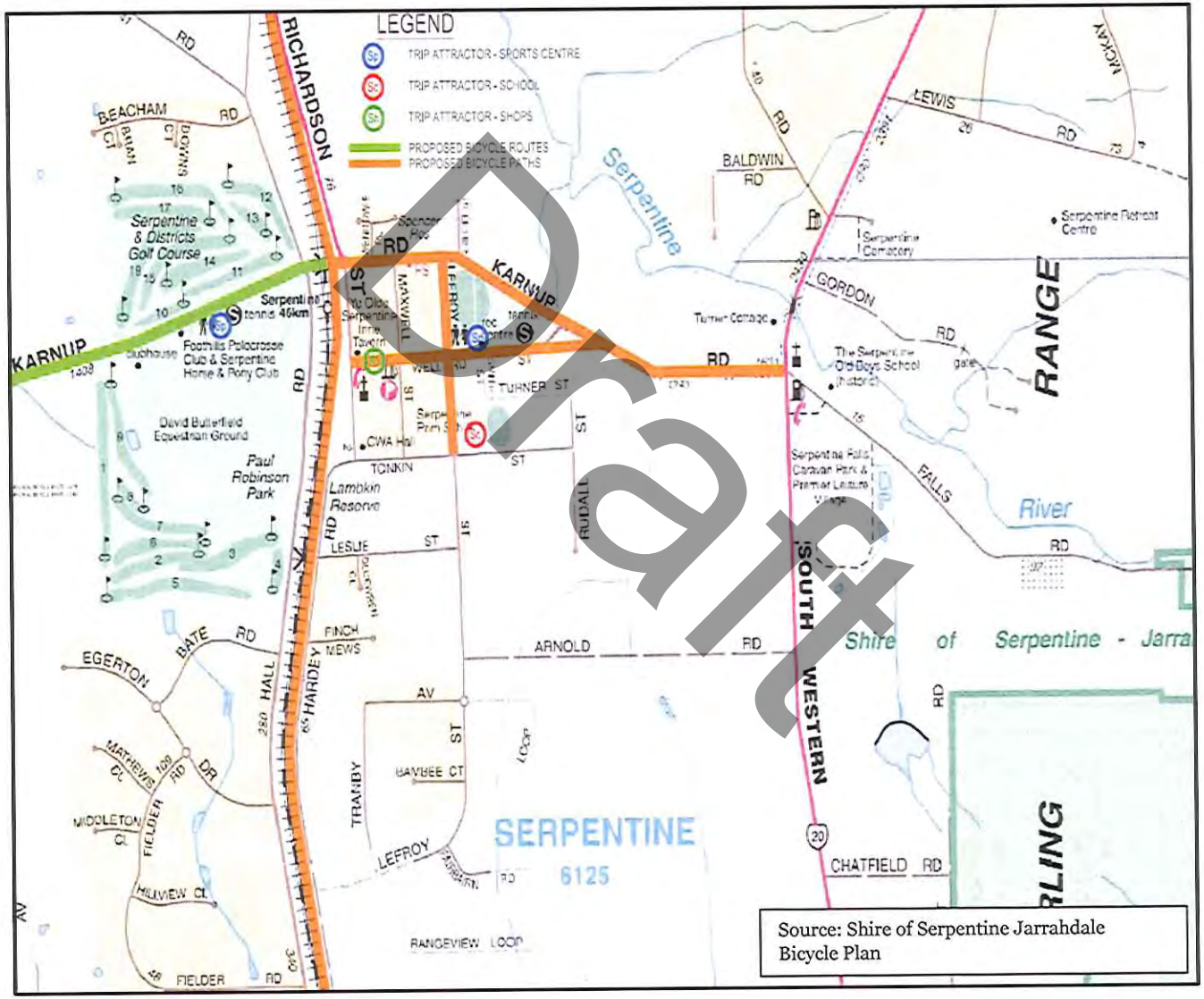
Serpentine Townsite Local Structure Plan



Serpentine Townsite Local Structure Plan Figure X

Source: Department of Planning (07.02.2013)

Appendix B – local bicycle plan



Appendix C - Traffic Volume and Speed Data

85% speeds highlighted in orange are 5km or more of the posted speed limit
85% speed highlighted in red are 10km or more of the posted speed limit

Location	Dir	Date	Average Weekday Volumes	Heavy Vehicles (%)	AM Peak	PM Peak	*Posted Speed (km/h)	85% Speed (km/h)	Average Speed (km/h)
Hall Road – 100m N of Karnup Road	N	Feb 13	129	6.8	12	15	60	73	63.1
	S	Feb 13	115	7.3	12	13			
Hall Road – 100m N of Leslie Street	N	Feb 13	379	7.5	20	55	70	86.3	75.3
	S	Feb 13	413	8.9	53	29			
Hall Road – 100m S of Karnup Road	N	Feb 13	417	9.6	52	29	60	83.0	72.5
	S	Feb 13	383	8.7	20	52			
Hall Road – 100m S of Leslie Street	N	Feb 13	605	8.8	78	50	60	83.4	69.4
	S	Feb 13	605	6.9	36	82			
Hardey Road – 100m N of Leslie Street	N	Feb 13	205	4.4	24	23	60	53.8	47.3
	S	Feb 13	269	4.8	25	41			
Hardey Road – 100m S of Leslie Street	N	Feb 13	85	8.9	14	10	60	57.9	45.3
	S	Feb 13	85	11	7	14			
Karnup Road – 100m W of Hall Road	E	Feb 13	758	9.3	66	67	70	74.6	66.2
	W	Feb 13	770	9.3	63	76			
Karnup Road – 200m E of Wellard St	E	Feb 13	949	11.0	89	81	60	73.8	65.6
	W	Feb 13	1033	9.5	87	109			
Karnup Road – 200m W of Wellard St	E	Feb 13	598	11.5	57	46	70	75.4	66.8
	W	Feb 13	604	11.5	44	70			
Karnup Road – between Richardson St & Wendowie Pl	E	Feb 13	708	12.1	65	59	60	56.8	48.9
	W	Feb 13	755	734	56	82			
Lefroy Street – between Leslie St & Arnold St	N	Feb 13	219	8.2	29	23	50	72.8	62.5
	S	Feb 13	221	6.4	14	32			
Lefroy Street – between Leslie St & Tonkin St	N	Feb 13	293	3.8	66	43	50	65.5	55.2
	S	Feb 13	267	2.0	23	54			

Location	Dir	Date	Average Weekday Volumes	Heavy Vehicles (%)	AM Peak	PM Peak	*Posted Speed (km/h)	85% Speed (km/h)	Average Speed (km/h)
Lefroy Street – between Wellard St & Tonkin St	N	Feb 13	369	3.4	57	59	50	54.7	44.9
	S	Feb 13	362	4.6	77	57			
Leslie Street – between Lefroy St & Blue Wren Cl	E	Feb 13	126	5.2	39	24	50	65	55.6
	W	Feb 13	97	3.5	12	27			
Maxwell Street – between Karnup Rd & Wellard St	N	Feb 13	85	12.1	8	15	50	48.8	38.9
	S	Feb 13	84	12.0	10	12			
Maxwell Street – between Tonkin Rd & Wellard St	N	Feb 13	77	9.6	18	14	50	49.3	39.7
	S	Feb 13	59	4.7	5	9			
Richardson St – 100m N of Karnup Rd	N	Feb 13	506	9.9	48	44	60	83.8	72.7
	S	Feb 13	455	11.6	28	60			
Richardson St – between Wellard St & Tonkin St	N	Feb 13	258	5.3	29	32	50	57.3	48.6
	S	Feb 13	318	6.4	28	41			
Richardson St – 100m S of Karnup Rd	N	Feb 13	526	9.6	50	64	50	54.5	45.6
	S	Feb 13	524	9.1	45	65			
Rudall St – 100m N of Tonkin St	N	Feb 13	4	4.5	1	1	50	31.1	26.9
	S	Feb 13	4	15	1	1			
Rudall St – 100m S of Tonkin St	N	Feb 13	6	30.0	2	1	50	39.5	33.6
	S	Feb 13	6	27.6	2	2			
Tonkin St – Between Lefroy St & Maxwell St	E	Feb 13	94	3.8	15	14	50	52.1	42.4
	W	Feb 13	112	6.0	27	34			
Tonkin St – Between Lefroy St & Rudall St	E	Feb 13	153	3.7	62	49	50	39.6	30.8
	W	Feb 13	153	2.4	33	60			
Wellard St – Between Maxwell St & Lefroy St	E	Feb 13	379	7.6	40	44	50	53.0	45.1
	W	Feb 13	441	7.9	41	56			
Wellard St – Between Maxwell St & Richardson St	E	Feb 13	536	7.8	47	65	50	40.7	32.1
	W	Feb 13	603	6	53	68			

Location	Dir	Date	Average Weekday Volumes	Heavy Vehicles (%)	AM Peak	PM Peak	*Posted Speed (km/h)	85% Speed (km/h)	Average Speed (km/h)
South Western Highway – S of Karnup Road	Both	Apr 10	3569	16.2			60		

*posted speed limit based on speed limits recorded by Main Roads WA speed limit data accessed 20th March 2013

Appendix D – Typical Mid-block capacities

Typical mid-block capacities for Urban Roads with Interrupted Flows

Type of lane	One-way mid-block capacity (veh/h)
Median or inner lane	
Divided road	1000
Undivided road	900
Middle lane (of a 3 lane carriageway)	
Divided road	900
Undivided road	1000
Kerb lane	
Adjacent to parking lane	900
Occasional parked vehicles	600
Clearway conditions	900

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Appendix 3

Environmental Assessment (PGV Environmental, 2013)

SERPENTINE TOWNSITE

ENVIRONMENTAL ASSESSMENT

Prepared for: Serpentine Jarrahdale Shire

Report Date: 19 December 2013

Version: 2

Report No. 2013-110

pgv ENVIRONMENTAL

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1 INTRODUCTION

1.1 Site Location

Serpentine Townsite is located in Serpentine Jarrahdale Shire, approximately 50km south-south-east of the Perth Central Business District (Figure 1).

The area studied for this Environmental Assessment (hereafter referred to as 'the site') is bound by Arnold Road to the south, Richardson Street to the west, Summerfield Road to the north and Rudall Street to the east (Figure 2).

1.2 Scope of Works

The Department of Planning has prepared a Local Structure Plan in April 2013 for proposed expansion to the Serpentine Townsite (Appendix 1). Upon review of the structure plan the Serpentine Jarrahdale Shire identified some environmental attributes that were not captured. Therefore the Serpentine Jarrahdale Shire are seeking to review the Local Structure Plan to enhance the environmental outcomes for the town. The Environmental Assessment was undertaken to inform the review of the Local Structure Plan.

1.3 Legislation, Policy and Guidelines

The following legislation, policy and guidelines have been considered during this environmental assessment and will guide the required and expected management outcomes from Commonwealth, State and Local government agencies.

- *Environment Protection and Biodiversity Conservation Act 1999*
  - *The Matters of National Environmental Significance. Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (DoE, 2013a).
- *Environmental Protection Act 1986*
- *Wildlife Conservation Act 1950*
- *Aboriginal Heritage Act 1972*
- State Policy
  - State Planning Policy No. 2.1 *Peel-Harvey Coastal Plain Catchment* (WAPC, 2003);
  - State Planning Policy No. 2.8 *Bushland Policy for the Perth Metropolitan Region* (WAPC, 2010);
  - State Planning Policy No. 2.9 *Water Resources* (WAPC, 2006);
  - State Planning Policy No. 5.4 *Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (WAPC, 2009b);
  - Environmental Protection Authority Position Statement No. 4 *Environmental Protection of Wetlands* (EPA, 2004);
  - EPA Guidance Statement No. 3: *Separation Distances between Industrial and Sensitive Land Uses* (EPA, 2005); and
  - Environmental Protection Authority Guidance Statement No 33 *Environmental Guidance for Planning and Development* (EPA, 2008).

- Serpentine Jarrahdale Shire
  - Local Biodiversity Strategy (Ironbark, 2008);
  - Local Planning Policy (LPP) 4 *Revegetation Strategy* (SJS, 2010);
  - LPP 6 *Water Sensitive Design* (SJS, 2001);
  - LPP 8 *Landscape Protection* (SJS, 2002);
  - LPP 22 *Water Sensitive Urban Design* (SJS, 2009a);
  - LPP 26 *Biodiversity Planning* (SJS, 2009b); and
  - LPP 67 *Landscape and Vegetation* (SJS, 2012).

2 EXISTING ENVIRONMENT

2.1 Past and Existing Land Use

The Townsite of Serpentine was established on the South Western Railway between Perth and Bunbury, and was one of the original stations when the line was opened in 1893. Development and main streets within the town were established prior to 1965 as shown in historical aerial photography (Plate 1).

Plate 1: Historical Aerial Photography from 1965 (Landgate, 2013a)

Currently the Townsite has a small area of commercial land along Wellard Street and several existing public open spaces. The remainder of the Townsite is utilised for rural and residential purposes.

2.2 Surrounding Land Use

The Serpentine Townsite is adjacent to the South Western Railway and some industrial development such as Steelkit Homes off Karnup Road and Richardson Street. The site is surrounded to the south, north and east by land developed for 'rural living' and rural grazing land.

2.3 Topography

The site is generally flat to very gently undulating with elevations ranging from approximately 36m AHD to 30m AHD (Figure 2).

2.4 Geology and Soils

The site is located on the eastern side of the Swan Coastal Plain. The site is mapped as part of the Pinjarra Plain System. The Pinjarra Plain extends from the eastern side of the Bassendean Dunes to the western edge of the Darling Scarp, which joins the Ridge Hill Shelf and forms the denuded slope of the Darling Fault (Beard 1990). The Pinjarra Plain System consists of a broad low relief plain west of the foothills, comprising predominantly Pleistocene fluvial sediments and some Holocene alluvium associated with major current drainage systems. The major soils are naturally poorly drained and many swamps occur.

The description of the soil phases mapped by the Department of Agriculture and Food Western Australia (DAFWA) on the site is provided in Table 1 (Figure 3).

Table 1: Soil Landscape Sub-Systems Found Within the Site

Reference	Description*
213Pj_B1	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises. Deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at generally >2m.
213Pj_B2	Well to moderately well drained flat to very gently undulating sandplain. Deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2m.
213Pj_B3	Very poorly drained closed depressions and poorly defined stream channels. Moderately deep bleached sands with an iron-organic pan, or clay subsoil. Surfaces are dark grey sand.
213Pj_P1a	Flat to very gently undulating plain. Imperfect to poorly drained and generally not susceptible to salinity. Deep acidic mottled yellow duplex soils. Shallow pale sand to sandy loam over clay.
213Pj_P1d	Pale grey sand to sandy loam over clay; imperfect to poorly drained and moderately susceptible to salinity
213Pj_P3	Flat to very gently undulating plain. Imperfect to poorly drained. Deep acidic gradational yellow or grey-brown earths and mottled yellow duplex soils, with loam to clay loam surface horizons.
213PjSWP6a	Very gently undulating alluvial terraces and low rises contiguous with the plain. Associated with major current river systems and larger streams. Deep moderately well to well drained acidic red and yellow duplex and less commonly, gradational soils.

* From van Gool, 1990

2.5 Acid Sulphate Soils

Acid sulphate soils (ASS) are wetland soils and unconsolidated sediments that contain iron sulphides which, when exposed to atmospheric oxygen in the presence of water, form sulphuric acid. ASS form in protected low energy environments such as barrier estuaries and coastal lakes and commonly occurs in low-lying coastal lands such as Holocene marine muds and sands. When disturbed, these soils are prone to produce sulphuric acid and mobilise iron, aluminium, manganese and other heavy metals. The release of these reaction products can be detrimental to biota, human health and built infrastructure.

The ASS Risk on the site has been mapped by the Department of Parks and Wildlife (DPaW) (previously the Department of Environment and Conservation, DEC) (Landgate, 2013b) as being Moderate to Low (<3m from the surface) over most of the site with a small area of High to Moderate (<3m from the surface) on the western boundary (Figure 4).

2.6 Hydrology

2.6.1 Groundwater

The Superficial Swan aquifer overlays the Leederville aquifer and consists of poorly sorted fine- to medium-grained quartz with feldspar and occasionally trace heavy minerals. This overlays the Cattamara Coal Measures (DoW, 2013). The Perth Groundwater Atlas indicates that the groundwater in this area is 'unsuitable for additional garden bores' due to the characteristics of the regional aquifer potentially resulting in poor groundwater quality and/or quantity (DoW, 2013).

Groundwater flows from east to west across the region (GHD, 2013). The depth to groundwater from the natural surface is very shallow under the whole site and ranges from approximately 0 to 5m (GHD, 2013). Groundwater is generally perched at surface level in low lying areas during the winter months (GHD, 2013).

2.6.2 Surface Water

The site is within the Serpentine River Catchment. Surface water in the Serpentine Jarrahdale Shire drains to the Serpentine River and ultimately the Peel Harvey Estuary.

Much of the area within the Townsite is prone to waterlogging in the wetter winter period due to the high groundwater table and poor internal drainage of the soils on the site (GHD, 2013).

Surface runoff from the site is via overland flow, following the natural topography and Water Corporation drainage systems. There are some development related detention basins which water drains into such as that near Blue Wren Close (Plate 2).

Plate 2: Water Drainage Termination on Blue Wren Close

There are some shallow drains (approximately 0.2 - 0.5m deep) which help to drain the site. Located in the eastern part of the site is Water Corporation Hardey's Creek Main Drain which drains a small area in the south-east of the development area near Arnold Rd, intersects the eastern site boundary near Wellard St and conveys runoff north to the Serpentine River (Plate 3; Figure 5).

Plate 3: Hardey's Creek Main Drain

Hardey's Creek Main Drain has a second branch to the west. This drains water from the south west into the other branch of the Main Drain and then into the Serpentine River (Figure 5). The western side of the LSP area drains in a westerly direction across the Railway Reserve.

2.7 Wetlands

There are seven wetlands mapped on the site. These include three Multiple Use, two Resource Enhancement and two Conservation Category wetlands according to the Department of Parks and Wildlife (DPaW) *Geomorphic Wetlands of the Swan Coastal Plain* dataset. The definitions of these categories are outlined in Table 2.

Table 2: Management Categories of Wetlands

Management Category	General Description	EPA Management Objectives (EPA, 2008)
Conservation Category Wetland (CCW)	Wetlands which support high levels of attributes and functions.	Highest priority wetlands. Objective is to preserve and protect the existing conservation values of the wetlands through various mechanisms including: • reservation in national parks; • crown reserves and State owned land; • protection under Environmental Protection Policies; and • wetland covenanting by landowners. No development or clearing is considered appropriate. These are the most valuable wetlands and any activity that may lead to further loss or degradation is inappropriate.
Resource Enhancement Wetland (REW)	Wetlands which may have been partially modified but still support substantial ecological attributes and functions.	Priority wetlands. Ultimate objective is to manage, restore and protect towards improving their conservation value. These wetlands have the potential to be restored to Conservation category. This can be achieved by restoring wetland function, structure and biodiversity. Protection is recommended through a number of mechanisms.
Multiple Use Wetland (MUW)	Wetlands with few attributes which still provide important wetland functions	Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through landcare.

A significant portion of the site is mapped as Multiple Use Palusplains (Unique Feature Identifiers (UFI) 15785 and 14974) (Landgate, 2013b) (Figure 5). A Palusplain is defined as seasonally waterlogged flats. In the western part of the site there is a Multiple Use Dampland (UFI 14989) (Figure 5). A Dampland is defined as seasonally waterlogged basin.

A Resource Enhancement Dampland (IFI 14984) is mapped in the north-east of the site. A small Resource Enhancement Sumpland (seasonally inundated basin) (UFI 15204) occurs on the western side of the site, just south of Tonkin Street (Figure 5).

A Conservation Category Sumpland (UFI 15205) occurs in the area within and surrounding Lambkin Reserve in the western part of the site. Immediately adjacent is a Conservation Category Dampland (UFI 15002). The site is also adjacent to the Conservation Category Palusplain (UFI 14989) and in proximity to Conservation Category Palusplain which is to the north of the site (UFI 14989) (Figure 5).

2.8 Vegetation

2.8.1 Bioregional Data

Most of the site has been cleared for the Serpentine Townsite. Remnant native vegetation occurs in Lambkin Reserve and in fragmented parcels on private property, Council Reserves, the Railway

Reserve to the west of the LSP area and along Serpentine River to the north east. The site is in the Southwest Botanical Province within the Swan Coastal Plain Bioregion and is dominated by vegetation of the Pinjarra Plain and Bassendean System. According to Beard (1990) the vegetation on the site is located within the Drummond Botanical Subdistrict of the Swan Coastal Plain Subregion. The Drummond Botanical Subdistrict is mainly comprised of *Banksia* low woodland on leached sands with *Melaleuca* swamps where ill-drained; woodland of *Eucalyptus gomphocephala* (Tuart), *Eucalyptus marginata* (Jarrah) and *Corymbia calophylla* (Marri) on less leached soils. This is a general description of the botanical sub-district. Tuart does not occur on the site.

According to mapping of the Swan Coastal Plain by Heddle *et al*. (1980), the site falls within the Guildford Vegetation Complex. The pre-European structure of this complex is described as consisting of a mixture of Marri (*Corymbia calophylla*) – Wandoo (*Eucalyptus wandoo*) – Jarrah (*Eucalyptus marginata*) open forest (in places tall open forest) and Wandoo woodland, with a small number of locations fringed by *Eucalyptus rudis-Melaleuca rhaphiophylla* woodlands along streams. Occasional areas of *Eucalyptus lane-poolei* are also found within the Guildford complex, now restricted to an area between Cardup and Keysbrook in the Darling System (Heddle *et al*., 1980). This is a general description of the vegetation complex. Wandoo does not occur on the site

The Guildford Complex is considered to be poorly reserved with 5% of the original extent of the vegetation remaining and 0.2% (143ha) of the original extent in secure tenure (EPA, 2006).

2.8.2 Vegetation Types

Most of the native vegetation has been cleared and these areas are covered with pasture species. Some stands of Marri (*Corymbia calophylla*) occur in paddocks with clay soils. Many of the trees around the creeklines and in existing lots are exotic species.

Remnant vegetation occurs in the following locations:

- Lambkin Reserve north of Leslie Street;
- Part of Bush Forever Site 375 to the north of Tonkin Street;
- Road reserve in Turner Street; and
- In the east of the site to the south of Karnup Road (Shire Reserve R 9157).
- Railway Reserve to the west of the LSP area.

A survey of these areas was undertaken by Coffey Environments (2009) who mapped the vegetation as follows:

> ***CcLWAhPsOS*** *- Corymbia calophylla (Marri) Low Woodland to 6m over Allocasuarina humilis and Petrophile squamata Open Shrubland to 1.9m over *Watsonia meriana var. bulbillifera and Stylidium repens Very Open Herbland to 1.7m and Mesomelaena tetragona Very Open Sedgeland to 0.7m.*
>
> ***CcLWAhXpKaOS*** *- Corymbia calophylla Low Woodland to 7m over Allocasuarina humilis, Xanthorrhoea preissii and Kingia australis Open Shrubland to 1.8m over Banksia nivea Low Open Shrubland to 0.4m over Desmocladus fasciculatus Very Open Sedgeland to 0.25m and Stylidium repens Very Open Herbland to 0.15m.*

CcOF *- Corymbia calophylla Open Forest to 10m over Xanthorrhoea preissii Open Shrubland to 1.5m over Cyathochaeta avenacea Very Open Sedgeland to 1m.*

HaXpOS *- Hypocalymma angustifolium and Xanthorrhoea preissii Open Shrubland to 1m over Kunzea micrantha and Banksia nivea Low Open Shrubland to 0.7m over Schoenus clandestinus Very Open Sedgeland to 0.1m.*

HtOS *- Hakea trifurcata Open Shrubland to 1.7m over Hypocalymma angustifolium, Kunzea micrantha and Xanthorrhoea preissii Low Shrubland to 0.9m over *Watsonia meriana var. bulbillifera Very Open Herbland to 1.8m.*

The vegetation mapping from Coffey is shown in Appendix 2.

2.8.3 Threatened Ecological Communities

A search of the DPaW's Threatened (TEC) and Priority Ecological Communities (PEC) database was conducted for the site (Appendix 3; 04-0913EC) (Table 3). Eight ecological communities were identified in the database search as occurring or potentially occurring on the site (Table 3).

Table 3: Threatened and Priority Ecological Communities known to occur in the Serpentine Area

Ecological Community	Description	Status under the Wildlife Conservation Act	Status under the EPBC Act
SCP3a	*Eucalyptus calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain	Critically Endangered	Endangered
SCP3c	*Eucalyptus calophylla - Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain	Critically Endangered	Endangered
SCP10a	Shrublands on dry clay flats (Clay Pans of the Swan Coastal Plain)	Endangered	Critically Endangered
SCP20b	*Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain	Endangered	
SCP7	Herb rich saline shrublands in clay pans (Clay Pans of the Swan Coastal Plain)	Vulnerable	Critically Endangered
SCP8	Herb rich shrublands in clay pans (Clay Pans of the Swan Coastal Plain)	Vulnerable	Critically Endangered
SCP3b	*Eucalyptus calophylla - Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	
SCP1a	*Eucalyptus haematoxylon - E. marginata* woodlands on Whicher foothills	Priority 3	
SCP21c	Low lying *Banksia attenuata* woodlands or shrublands	Priority 3	

Definitions of the Conservation Codes are in Appendix 4.

The remnant vegetation some of in the areas in the LSP area was identified by Coffey Environments (2009) as resembling the Critically Endangered SCP3a *Corymbia calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain and Critically Endangered SCP3c *Eucalyptus calophylla - Xanthorrhoea preissii* woodlands and shrublands (Appendix 2).

The description of the Bush Forever Site 365 Byford to Serpentine Rail/Road Reserves and Adjacent Bushland (which is partially located in the LSP Area) as containing FCTs 3a, 3b, 3c, 20b, 10a and 8.

The vegetation to the south of Lambkin Reserve within Bush Forever Site 375 has vegetation similar to SCP3a although it possibly contains a mosaic of different TECs (Val English, DPaW, Pers Comm, 2013).

2.8.4 Vegetation Condition

The vegetation on the site has been largely historically cleared for the Townsite and rural purposes and is currently used as pasture for fodder conservation or grazing The condition of the vegetation was assessed by Coffey Environments (2009) according to the system devised by Keighery and described in Bush Forever (Government of Western Australia, 2000a). Keighery's condition rating scale ranges from Pristine where the vegetation exhibits no visible signs of disturbance to Completely Degraded where the vegetation structure in no longer intact and without native plant species (Table 4).

Table 4: Vegetation Condition Rating Scale.

Condition	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered, obvious signs of disturbance. For example, 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 disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, 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. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Source: Government of Western Australia, 2000.

The bushland vegetation on the site is considered to be in Excellent to Very Good condition (Coffey, 2009; Government of Western Australia, 2000). The remainder of the site would be considered Completely Degraded as the areas of native trees are parkland cleared and the pasture areas have very few native species present.

2.8.5 Regional Significance of Vegetation

The remnant vegetation on the site is representative of the poorly reserved Guildford Complex, contains TECs listed under Western Australian and Commonwealth Environmental Legislation and is

known to contain at least several conservation significant plant species. Therefore it would be considered that the remnant vegetation areas in Very Good to Excellent Condition on the site are considered to be regionally significant.

Bush Forever Site 375 includes Lambkin Reserve which is located within the site. Bush Forever Site 375 is part of the Byford to Serpentine Rail/Road Reserves and Adjacent Bushland. Bush Forever Site 365 is also part of Byford to Serpentine Rail/Road Reserves and Adjacent Bushland and is adjacent to the western boundary of the Local Structure Plan Area (Figure 6).

Bush Forever Site 371 is the Serpentine River, Lowlands to Serpentine and is in close proximity to the northern boundary of the site (Figure 6). Bush Forever Site 371 is the Serpentine River, Lowlands to Serpentine and is in close proximity to the northern boundary of the site (Figure 6). There are three Regional Ecological Linkages identified within the LSP area. These include Regional Ecological Linkage #88 which links from the LSP area in a westerly direction, Regional Ecological Linkage #90 which extends along the railway line and Regional Ecological Linkage #71 which follows the path of the Serpentine River.

2.9 Flora

2.9.1 Database Searches

A search of the DPaW Threatened Flora Database (DEFL), the WA Herbarium database (WAHerb), the Declared Rare and Priority Flora Species List (TFPL) (Appendix 5), Naturemap (Appendix 6) and the EPBC Act Protected Matters Search Tool (Appendix 7) indicates a number of species listed as Endangered, Threatened or Priority have been located within a 5km radius of the site. The results from the database searches are shown in Table 5.

Table 5: Conservation Significant Flora known to occur in the Serpentine Area

Species	Common Name	Status Under Wildlife Conservation Act 1950	Status Under EPBC Act 1999
Andersonia gracilis	Slender Andersonia	Threatened	Endangered
Anthocercis gracilis	Slender Tailflower	Threatened	Vulnerable
Caladenia huegelii	Grand Spider Orchid	Threatened	Endangered
Darwinia foetida	Muchea Bell	Threatened	Critically Endangered
Diuris micrantha	Dwarf Bee Orchid	Threatened	Vulnerable
Diuris purdiei	Purdie's Donkey Orchid	Threatened	Endangered
Drakaea elastica	Glossy-leaved Hammer Orchid	Threatened	Endangered
Drakaea micrantha	Dwarf Hammer Orchid	Threatened	Vulnerable
Eucalyptus balanites	Cadda Road Mallee	Threatened	Endangered
Lasiopetalum pterocarpum	Wing-fruited Lasiopetalum	Threatened	Endangered
Ornduffia calthifolia	Mountain Villarsia	Threatened	Endangered
Synaphea sp. Fairbridge Farm (D Papenfus 696)		Threatened	Critically Endangered
Synaphea sp. Pinjarra Plain (A.S. George 17182)		Threatened	

Species	Common Name	Status Under Wildlife Conservation Act 1950	Status Under EPBC Act 1999
Synaphea sp. Serpentine (G.R. Brand 103)		Threatened	
Tetraria australiensis	Southern Tetraria	Threatened	Vulnerable
Thelymitra dedmaniarum (Previously *manginii*)	Cinnamon Sun Orchid	Threatened	Endangered
Thelymitra stellata	Star Sun-orchid	Threatened	Endangered
Verticordia fimbrilepis subsp. *fimbrilepis*	Shy Feather-flower	Threatened	Endangered
Verticordia plumosa var. *ananeotes*	Tufted Plumed Feather-flower	Threatened	Endangered
Acacia lasiocarpa var. *bracteolata* long peduncle variant (G.J. Keighery 5026)		Priority 1	
Stachystemon sp. Keysbrook		Priority 1	
Synaphea odocoileops		Priority 1	
Johnsonia pubescens subsp. *cygnorum*		Priority 2	
Acacia horridula		Priority 3	
Acacia oncinophylla subsp. *oncinophylla*		Priority 3	
Dillwynia dillwynioides		Priority 3	
Eryngium pinnatifidum subsp. Palustre		Priority 3	
Isopogon drummondii		Priority 3	
Centrolepis caespitosa		Priority 4	Endangered
Drosera occidentalis subsp. *occidentalis*		Priority 4	
Eucalyptus rudis subsp. *cratyantha*		Priority 4	
Parsonsia diaphanophleba		Priority 4	
Senecio leucoglossus		Priority 4	
Stylidium ireneae		Priority 4	
Verticordia lindleyi subsp. *lindleyi*		Priority 4	

Conservation Codes are defined in Appendix 4

2.9.2 Likelihood of Significant Flora to Occur

Table 6 examines the preferred habitat of each species and the likelihood of the species listed in Table 5 to occur on the site as well as previous studies undertaken on the site.

Table 6: Likelihood of Identified Significant Flora Species occurring on the Site

Scientific Name	Preferred Habitat*	Likelihood of Presence on site
Andersonia gracilis	White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps	Possible
Anthocercis gracilis	Sandy or loamy soils. Granite outcrops	Unlikely
Caladenia huegelii	Grey or brown sand, clay loam	Possible
Darwinia foetida	Grey-white sand on swampy, seasonally wet sites	Highly Unlikely
Diuris micrantha	Brown loamy clay. Winter-wet swamps, in shallow water	Possible
Diuris purdiei	Grey-black sand, moist. Winter-wet swamps	Possible
Drakaea elastica	Low-lying situations adjoining winter-wet swamps. Does not survive in disturbed areas	Possible
Drakaea micrantha	White-grey sand	Possible
Eucalyptus balanites	Sandy soils with lateritic gravel	Possible
Lasiopetalum pterocarpum	Dark red-brown loam or clayey sand over granite. On sloping banks near creeklines.	Possible
Ornduffia calthifolia	Occurs in moist sheltered positions on the upper slopes of granite outcrops	Unlikely
Synaphea sp. Fairbridge Farm	Sandy with lateritic pebbles. Near winter-wet flats, in low woodland with weedy grasses	Possible
Synaphea sp. Pinjarra Plain (A.S. George 17182)	Grey sandy loam or clay, grey-brown clayey sand, brown clayey loam, laterite. Flats, seasonally wet	Recorded
Synaphea sp. Serpentine (G.R. Brand 103)	Brown sandy clay	Recorded
Tetraria australiensis	Grey sand over clay; sandy or clayey lateritic soils. Winter-wet swampy depressions	Recorded
Thelymitra dedmaniarum (Previously *manginii*)	Granite	Unlikely
Thelymitra stellata	Sand, gravel, lateritic loam.	Possible
Verticordia fimbrilepis subsp. *fimbrilepis*	Gravelly sandy or clayey soils. Flats, road verges	Possible
Verticordia plumosa var. *ananeotes*	Sandy loam. Seasonally inundated plains	Possible
Acacia lasiocarpa var. *bracteolata* long peduncle variant (G.J. Keighery 5026)	Grey or black sand over clay. Swampy areas, winter wet lowlands	Possible
Stachystemon sp. Keysbrook	Sandy soils	Possible
Synaphea odocoileops	Brown-orange loam & sandy clay, granite. Swamps, winter-wet areas	Possible
Johnsonia pubescens subsp. *cygnorum*	Grey-white-yellow sand. Flats, seasonally-wet sites	Possible

Scientific Name	Preferred Habitat*	Likelihood of Presence on site
Acacia horridula	Gravelly soils over granite, sand. Rocky hillsides	Possible
Acacia oncinophylla subsp. *oncinophylla*	Granitic soils	Possible
Dillwynia dillwynioides	Sandy soils. Winter-wet depressions	Possible
Eryngium pinnatifidum subsp. Palustre	Sandy soils or seasonally wet flats	Possible
Isopogon drummondii	White, grey or yellow sand, often over laterite.	Possible
Centrolepis caespitosa	White sand, clay. Salt flats, wet areas	Possible
Drosera occidentalis subsp. *occidentalis*	Sandy and clayey soils. Swamps and wet depressions	Possible
Eucalyptus rudis subsp. *cratyantha*	Loam. Flats, hillsides	Possible
Parsonsia diaphanophleba	Alluvial soils. Along rivers	Unlikely
Senecio leucoglossus	Gravelly lateritic or granitic soils. Granite outcrops, slopes	Unlikely
Stylidium ireneae	Sandy loam. Valleys near creek lines, woodland, often with *Agonis*.	Unlikely
Verticordia lindleyi subsp. *lindleyi*	Grey, black or peaty sand. Winter-wet depressions	Possible

* sourced from Florabase (DEC, 2013), SEWPaC SPRAT Database (SEWPaC, 2013a) as well as the DEC database searches.

The pockets of remnant vegetation are mostly wetland areas and many of the significant flora species identified are found in wetland habitats. Therefore it is possible many of the species could be present in these areas. However the site has been extensively cleared and grazed/developed for over 100 years. Therefore species on the list that may have once occurred on the site are only possibly present now. Significant vegetation has been identified to occur within Lambkin Reserve and in the Railway Reserve.

2.10 Fauna

2.10.1 Fauna Habitat

The site contains four habitat types:

- Completely cleared pasture (Plate 4);
- Parkland cleared Marri (Plate 4);
- Parkland cleared creeklines with exotic *Eucalyptus* Species (Plate 5);
- Native Woodland over Low Heath (Plate 6); and
- Low Heath and Weeds (Railway Reserve).

These provide habitat for terrestrial species, amphibians, and avifauna. The habitat on the site may provide 'foraging habitat' or food sources, 'roosting habitat' and 'breeding habitat' for birds.

Plate 4: Pasture habitat and Parkland Cleared Marri

Plate 5: Parkland cleared creeklines with exotic *Eucalyptus* Species

Plate 6: Native Woodland over Low Heath

The completely cleared pasture dominates the site in areas that are not developed. The Parkland cleared *Corymbia calophylla* occurs in scattered areas in the site with a larger stand in the south-east of the site.

Fauna habitat can be assessed according to the following categories:

High quality fauna habitat *– These areas closely approximate the vegetation mix and quality that would have been in the area prior to any disturbance. The habitat has connectivity with other habitats and is likely to contain the most natural vertebrate fauna assemblage.*

Very good fauna habitat *- These areas show minimal signs of disturbance (e.g. grazing, clearing, fragmentation, weeds) and generally retain many of the characteristics of the habitat if it had not been disturbed. The habitat has connectivity with other habitats and fauna assemblages in these areas are likely to be minimally effected by disturbance.*

Good fauna habitat *– These areas showed signs of disturbance (e.g. grazing, clearing, fragmentation, weeds) but generally retain many of the characteristics of the habitat if it had not been disturbed. The habitat has connectivity with other habitats and fauna assemblages in these areas are likely to be affected by disturbance.*

Disturbed fauna habitat *– These areas showed signs of significant disturbance. Many of the trees, shrubs and undergrowth are cleared. These areas may be in the early succession and regeneration stages. Areas may show signs of significant grazing, contain weeds or have been damaged by vehicle or machinery. Habitats are fragmented or have limited connectivity with other fauna habitats. Fauna assemblages in these areas are likely to differ significantly from what might be expected in the area had the disturbance not occurred.*

Highly degraded fauna habitat *– These areas often have a significant loss of vegetation, an abundance of weeds, and a large number of vehicle tracks or are completely cleared. Limited or no fauna habitat connectivity. Faunal assemblages in these areas are likely to be significantly different to what might have been in the area pre-disturbance.* (Coffey Environments, 2009)

Lambkin Reserve is considered to be Very Good Fauna Habitat as it has connectivity to the bushland along the rail and is in Very Good condition. The low heath and weeds present in the Railway Reserve is considered to be Good Fauna Habitat for bandicoots, reptiles and a suite of insects. The remaining pockets of native woodland over low heath are more fragmented and considered to be Good Fauna Habitat. The parkland cleared stands of trees are considered Disturbed Fauna Habitat. The remainder of the site that is completely cleared pasture is considered to be Highly Degraded Fauna Habitat.

2.10.2 Ecological Linkages

The site is mostly cleared. There are three Regional Ecological Linkages identified within the LSP area. These include Regional Ecological Linkage #88 which links from the LSP area in a westerly direction, Regional Ecological Linkage #90 which extends along the railway line and Regional Ecological Linkage #71 which follows the path of the Serpentine River. The scattered trees on the site also provide some linkage for avifauna, including Black Cockatoos, flying from the Scarp to the Swan Coastal Plain and back.

The rehabilitation of drainage lines within the Townsite would improve the connectivity and thereby the ecological linkage values over the site. Also the use of native endemic plants within POS and other public areas would improve the linkage values around the Townsite.

2.10.3 DEC Database Search Results

A search of the DPaW Threatened Fauna Database (Appendix 8) shows eight species listed as rare or priority have been located in the vicinity of the site. No additional species were identified in the Naturemap database searches (Appendix 6) and eleven additional species were identified in the Protected Matters Search Tool (Appendix 7). Table 7 lists the species identified in these database searches.

Table 7: List of Fauna Species Identified from Database Searches.

Scientific Name	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
Calyptorhynchus banksii subsp. *naso*	Forest Red-tailed Black-Cockatoo	Schedule 1	Vulnerable
Calyptorhynchus baudinii	Baudin's Cockatoo	Schedule 1	Vulnerable
Calyptorhynchus latirostris	Carnaby's Cockatoo	Schedule 1	Endangered
Dasyurus geoffroii	Chuditch, Western Quoll	Schedule 1	Vulnerable
Leipoa ocellata	Mallee Fowl	Schedule 1	Vulnerable
Phascogale tapoatafa subsp. *tapoatafa*	Brush-tailed Phascogale	Schedule 1	
Pseudocheirus occidentalis	Western Ringtail Possum	Schedule 1	Vulnerable
Rostratula benghalensis	Painted Snipe	Schedule 1	Vulnerable

Scientific Name	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
Setonix brachyurus	Quokka	Schedule 1	
Apus pacificus	Fork-tailed Swift	Schedule 3	Migratory
Ardea alba	Great Egret	Schedule 3	Migratory/ Wetland
Ardea ibis	Cattle Egret	Schedule 3	Migratory/ Wetland
Haliaeetus leucogaster	White-bellied Sea-eagle	Schedule 3	Migratory
Meeorps ornatus	Rainbow Bee-eater	Schedule 3	Migratory
Pandion haliaetus	Osprey		Marine/ Migratory
Rostratula australis	Australian Painted Snipe	Schedule 3	
Falco peregrinus	Peregrine Falcon	Schedule 4	
Westralunio carteri	Fresh water mussel	Priority 4	
Isoodon obesulus subsp. *fusciventer*	Southern Brown Bandicoot	Priority 5	

The DEC classifies fauna under five different Priority codes and rare and endangered fauna are classified under the *Wildlife Conservation (Specially Protected Fauna) Notice 2008* into four schedules of taxa (DEC, 2011). The definitions of these codes are in Appendix 4.

2.10.4 Conservation Significant Species

Outlined below is a short description of each of the species that were identified in the DEC database searches and Protected Matters Search Tool search and their preferred habitat. The preferred habitat has been compared to the habitats on the site described above and the likelihood of each species to be present on the site determined.

Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)

Carnaby's Cockatoo is found in the south-west of Australia from Kalbarri through to Ravensthorpe. It has a preference for feeding on the seeds of *Banksia, Dryandra, Hakea, Eucalyptus, Grevillea, Pinus* and *Allocasuarina* spp. It is nomadic often moving toward the coast after breeding. It breeds in tree hollows that are 2.5 – 12m above the ground and have an entrance 23-30cm with a depth of 1-2.5m. Nesting mostly occurs in smooth-barked trees (e.g. Salmon Gum, Wandoo, Red Morrell). Eggs are laid from July to October, with incubation lasting 29 days (DoE, 2013b).

The site contains some Marri (*Corymbia calophylla*) which are known feeding trees for Carnaby's Black Cockatoo (Higgins, 1999). Carnaby's Black-Cockatoos have been recorded during other fauna surveys in the general area and are likely to feed and potentially roost on the site. The likelihood of this species breeding on the site is low, though there are known breeding sites within foraging distance from the LSP area.

Baudin's Black Cockatoo (*Calyptorhynchus baudinii*)

This species is most common in the far south-west of Western Australia. It is known to breed from the southern forests north to Collie and east to near Kojonup. Baudin's Black Cockatoo is typically found in vagrant flocks and utilises the taller, more open Jarrah and Marri woodlands, where it feeds mainly on Marri seeds and various Proteaceous species.

This species are seasonally present on the Swan Coastal Plain, therefore Baudin's Black Cockatoo will potentially use trees on the site for foraging, and particularly the Marri trees (Garnett *et al.* 2011).

Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)

Forest Red-tailed Black Cockatoos frequent the humid to sub-humid south-west of Western Australia from Gingin in the north, to Albany in the south and west to Cape Leeuwin and Bunbury (DoE, 2013b). It nests in tree hollows with a depth of 1-5m, that are predominately Marri (*Corymbia calophylla*), Jarrah (*Eucalyptus marginata*) and Karri (*E. diversicolor*) and it feeds primarily on the seeds of Marri.

Red-Tailed Black Cockatoos have been recorded during other fauna surveys in the general area. They may occasionally roost in the large trees on-site. There is no record to indicate that they breed in the vicinity of the site (Johnstone and Kirkby, 2011).

Chuditch, Western Quoll (*Dasyurus geoffroii*)

The Chuditch was originally found in over 70% of Australian woodlands; however, since European settlement its range has diminished to a patchy distribution throughout the Jarrah forest and mixed Karri/Marri/Jarrah forest of south-west WA. They have been known to occupy a wide range of habitats including woodlands, dry sclerophyll forests, riparian vegetation, beaches and deserts. The Chuditch creates dens in hollow logs or burrows and have also been recorded in tree hollows and cavities. They are opportunistic feeders, and forage on the ground at night, feeding on invertebrates, small mammals, birds and reptiles (DoE, 2013b).

The Chuditch is highly unlikely to occur within the site as the pastures do not provide adequate cover for protection, the bushland areas are relatively fragmented and the proximity of human habitation increases the pressure of domestic predators.

Malleefowl (*Leipoa ocellata*)

Malleefowl have been found in mallee regions of southern Australia from approximately the 26th parallel of latitude southwards. Malleefowl are now only found throughout these regions in fragmented patches due to clearing of land for agriculture, increased fire frequency, competition with exotic herbivores (sheep, rabbits, goats and cattle) and kangaroos, predation by foxes and cats, inbreeding as a result of fragmentation and possibly hunting for food (DoE, 2013b).

Malleefowl are highly unlikely to be found on the site due the lack of appropriate Mallee habitat.

Southern Brush-tailed Phascogale (*Phascogale tapoatafa*)

Southern Brush-tailed Phascogales are arboreal marsupials which require tree hollows in suitable woodland or forest and rely on abundant invertebrate prey to sustain populations (Pescott, 2012).

This species is highly unlikely to occur on the site as the woodland areas are disturbed from the proximity of human development and due to the presence of domestic and feral predators.

Western Ringtail Possum (*Pseudocheirus occidentalis*)

The Western Ringtail Possum is a medium sized nocturnal marsupial. This species occurs in and near coastal Peppermint Tree (*Agonis flexuosa*) forest and Tuart (*Eucalyptus gomphocephala*) dominated forest with a Peppermint Tree understorey.

There are some *Agonis* trees scattered around the Townsite but it is considered highly unlikely this species would be present due to the Townsite development.

Painted Snipe (*Rostratula benghalensis*)

The Painted Snipe predominately occurs on the eastern coast of Australia and inhabits inland and coastal shallow ephemeral and permanent freshwater wetlands particularly where there is a cover of vegetation, including grasses.

The wetlands on the site are largely exposed and this species is unlikely to be present for a lengthy period of time or rely on the site.

Quokka (*Setonix brachyurus*)

Quokkas were originally very common on the Swan Coastal Plain, however, their distribution is now limited to Rottnest Island and a few isolated areas in the south-west of WA. On the mainland, they prefer densely vegetated areas around wetlands and streams, whereas on Rottnest Island they inhabit low scrubby coastal vegetation where water is not readily available year-round. Quokkas breed once a year and produce a single joey. They are herbivorous, and feed on leaves, bark, succulent plants and grasses.

The Quokka is considered not to occur on the site due to a lack of suitable habitat and a lack of recent records of this species in the area.

Fork-tailed Swift (*Apus pacificus*)

The Fork-tailed Swift is almost exclusively aerial and is not known to breed in Australia. They are seen in inland plains but sometimes above foothills or in coastal areas. They often occur over cliffs and beaches and also over islands and sometimes well out to sea. They also occur over settled areas, including towns, urban areas and cities (DoE, 2013b).

It is unlikely this species would visit or rely on the site.

Great Egret, White Egret (*Ardea alba* (*modesta*))

The Eastern Great Egret has been reported in a wide range of wetland habitats and usually frequents shallow waters (DoE, 2013b). This species feeds on fish, insects, crustaceans, molluscs, frogs, lizards, snakes and small birds and mammals (DoE, 2013b).

This species may visit the site but is not likely to rely on the site for survival.

Cattle Egret (*Ardea ibis*)

The Cattle Egret occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands with breeding in Western Australia recorded in the far north in Wyndham in colonies in wooded swamps such as mangrove forests (DoE, 2013b). This species forages away from water on low lying grasslands, improved pastures and croplands generally in areas that have livestock eating insects, frog, lizards and small mammals (DoE, 2013b).

This species may visit the site but is not likely to rely on the site for survival.

White-bellied Sea-Eagle (*Haliaeetus leucogaster*)

The White-bellied Sea-Eagle is found in coastal habitats with large areas of open water, especially those close to the sea-shore. This species feeds opportunistically on a variety of fish, birds, reptiles, mammals and crustaceans, and on carrion and offal (DoE, 2013b).

The habitat on site is not suitable for this species.

Rainbow Bee-eater (*Merops ornatus*)

The Rainbow Bee-eaters that breed in southern Australia are migratory. After breeding, they move north and remain there for the duration of the Australian winter. However, populations that breed in northern Australia are considered to be resident, and in many northern localities the Rainbow Bee-eater is present throughout the year (DoE, 2013b). The Rainbow Bee-eater nests in a burrow dug in the ground. It is found across the better-watered parts of WA including islands preferring lightly wooded, sandy country near water (DoE, 2013b).

The habitat disturbance and low lying areas that are not sandy on the site means the Rainbow Bee-eater is unlikely to be nesting within the site. It is however likely that they will be feeding in the area due to the nesting sites in the vicinity on sandy rises in Serpentine Downs.

Osprey (*Pandion haliaetus*)

Ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They feed on fish, especially mullet where available, and rarely take molluscs, crustaceans, insects, reptiles, birds and mammals (DoE, 2013b).

This species is highly unlikely to be present on the site due to the lack of appropriate food sources.

Australian Painted Snipe (*Rostratula australis*)

The Australian Painted Snipe is a stocky wading bird that generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans (DoE, 2013b).

This species may occur on the site intermittently but is unlikely to rely on the area for survival.

Peregrine Falcon (*Falco peregrinus*)

The Peregrine Falcon is found in a variety of habitats from woodlands to open grasslands and coastal cliffs. It feeds almost entirely on other birds and sometimes rabbits and other moderate sized mammals, bats and reptiles (DEC, 2013c).

This species is known to be easily frightened and flighty (DoE, 2013b) and therefore is highly unlikely to utilise the site due to the proximity of human activity.

Fresh Water Mussel (*Westralunio carteri*)

Westralunio carteri is a freshwater mussel and is found in ponds, lakes, rivers and streams, and has been collected from a dam in Western Australia. It is tolerant to human disturbance and organic pesticides but sensitive to salinity (ICUN, 2013).

There are no permanent water bodies on the site that are likely to be suitable for this species so this species is highly unlikely to be present. They are however present in the Serpentine River downstream of the LSP drainage systems.

Southern Brown Bandicoot (*Isoodon obesulus* subsp. f*usciventer*)

Southern Brown Bandicoots are small grey marsupials that prefer dense scrub (up to one metre high), often in or near swampy vegetation. Their diet includes invertebrates (including earthworms, adult beetles and their larvae), underground fungi, subterranean plant material, and very occasionally, small vertebrates (DEC, 2002).

This species prefers dense scrub and therefore is not likely to be present on most of the site except in the remnant bushland areas. Southern Brown Bandicoots have been recorded in the Railway Reserve, Shire Reserves and along the Serpentine River.

The likelihood of each species identified in the database searches being present on the site is summarised in Table 8.

Table 8: Likelihood of Conservation Significant species being present on the site

Scientific Name	Common Name	Likelihood to occur on the site
Calyptorhynchus banksii subsp. *naso*	Forest Red-tailed Black-Cockatoo	Likely
Calyptorhynchus baudinii	Baudin's Cockatoo	Possible
Calyptorhynchus latirostris	Carnaby's Cockatoo	Likely
Dasyurus geoffroii	Chuditch, Western Quoll	Highly Unlikely
Leipoa ocellata	Mallee Fowl	No
Phascogale tapoatafa subsp. *tapoatafa*	Brush-tailed Phascogale	Possible
Pseudocheirus occidentalis	Western Ringtail Possum	Highly Unlikely
Rostratula benghalensis	Painted Snipe	Unlikely
Setonix brachyurus	Quokka	No
Apus pacificus	Fork-tailed Swift	Highly Unlikely
Ardea alba	Great Egret	Unlikely
Ardea ibis	Cattle Egret	Possible

Scientific Name	Common Name	Likelihood to occur on the site
Haliaeetus leucogaster	White-bellied Sea-eagle	Highly Unlikely
Meeorps ornatus	Rainbow Bee-eater	Likely
Pandion haliaetus	Osprey	Highly Unlikely
Rostratula australis	Australian Painted Snipe	Highly Unlikely
Falco peregrinus	Peregrine Falcon	Highly Unlikely
Westralunio carteri	Fresh water mussel	Highly Unlikely
Isoodon obesulus subsp. *fusciventer*	Southern Brown Bandicoot	Likely

Therefore *Calyptorhynchus banksii* subsp. *naso*, *Calyptorhynchus baudinii* (Baudin's Cockatoo) and *Calyptorhynchus latirostris* (Carnaby's Black Cockatoo) likely to be present on the site at some times of the year. The Brush-tailed Phascogale may be present. The Schedule 3 Marine/Migratory listed Cattle Egret and Rainbow Bee-eater may also be an irregular visitor to the site. The Priority 4 Southern Brown Bandicoot may also be present in bushland areas of the site.

2.10.5 Biodiversity Value

The cleared pasture has almost no ecological value from a native fauna perspective. There are a few mature trees in the paddocks which provide foraging habitat.

The small pockets of remnant bushland may provide habitat to a greater number of species however the proximity of human habitation and therefore the likelihood of impacts on native fauna due to domestic predators would adversely impact on the fauna assemblage in these areas.

2.11 Heritage Values

2.11.1 Indigenous Heritage

A search of the Department of Aboriginal Affairs Aboriginal Heritage Inquiry System (DAA, 2013) recorded one registered site listed within the Serpentine Townsite (Appendix 9). This is listed as site 3582 and is the area associated with the Serpentine River.

2.11.2 Cultural Heritage

Heritage sites can be listed under the following lists/registers:

- World Heritage Sites;
- National Heritage Sites;
- Commonwealth Heritage Sites;
- Sites on the register of the National Estate;
- Sites on the State Register; and
- Sites listed in the Serpentine Jarrahdale Shire Municipal Heritage Inventory List.

There are no Listed, Registered or Interim Heritage Sites under Commonwealth Legislation on the site (DoE, 2013c). There are four sites in the Serpentine Townsite that are listed with the Heritage Council of Western Australia and on the Serpentine Jarrahdale Shire Municipal Inventory (Landgate, 2013b; Heritage Council of Western Australia, 2013; Serpentine Jarrahdale Shire, 2013) (Table 8).

Table 8: Heritage Sites within the Structure Plan Area

Names	Location
Serpentine Butcher Shop	19 Richardson St Serpentine
Old Serpentine Inn (Serpentine Falls Hotel, The Old Serpentine Tavern)	Cnr Richardson and Wellard Sts Serpentine
Serpentine General Store (Middleton's Store, Middleton's Tearooms)	6 Wellard St Serpentine
St Kevin's Church	Richardson St Serpentine

These sites have been identified in the current LSP.

3 IMPACT OF DEVELOPMENT

3.1 Past and Existing Land Use

The site has been largely cleared with the Townsite established over 100 years previously. The surrounds have been cleared for agriculture for a similar period of time.

If any areas to be developed in the future have previously had sheds or other structures a Preliminary Site Investigation is recommended prior to development to ensure there are no contaminated areas. The past and existing land use does not impede development. Any contaminated areas that may be located on the site such as leaking fuel tanks, pesticide/herbicide dumps or spills, asbestos in existing structures can be managed under the *Contaminated Sites Act 2003*.

The existing residential development and industry in and adjacent to the Townsite need to be considered when developing the LSP to accommodate existing land uses and ensuring that additional land uses do not conflict with existing land uses. This will require the application of *Separation Distances between Industrial and Sensitive Land Uses –Guidance Statement No. 3* (EPA, 2005).

EPA Guidance Statement No. 3: Separation Distances between Industrial and Sensitive Land Uses provides generic buffer distances required for different land uses and those defined as Sensitive Land Uses (EPA 2004). Residential development is considered a sensitive land use for the purpose of the guidance statement. The guidance statement recommends a generic buffer distances which are:

> *Not intended to be absolute separation distances, rather they are a default distance for the purposes of:*
>
> - *identifying the need for specific separation distance or buffer definition studies; and*
> - *providing general guidance on separation distances in the absence of site specific technical studies.*

Buffer studies may be required for future development proposals close to existing industry.

3.2 Surrounding Land Use

Surrounding Parks and Recreation, Rural and Rural Living land use will require consideration when developing the LSP to ensure remnant vegetation and rural amenity of the area is maintained. This should include appropriate density of housing adjacent to rural living areas and management of vegetation interfaces as per Section 3.8.

Environmental noise from the railway is likely to impact on the amenity of some parts of the site. Generally the areas along the railway have been developed however in the north of the site some new lots may be created. Under State Planning Policy No. 5.4 *Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (SPP 5.4) (WAPC, 2009) transport noise from within

major transport corridors, including freight routes, and its impact on noise sensitive land uses must be investigated. The policy aims 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 redeveloped transport infrastructure proposals.*
- *Facilitate the development and operation of an efficient freight network.*
- *Facilitate the strategic co-location of freight handling facilities.*

There are a variety of mitigation measures available to mitigate noise from walls to bunds etc. An acoustic assessment at the subdivision stages of planning in the northern part of the Serpentine Townsite should be undertaken and, if required, mitigation measures put into place.

There is also some industry adjacent to the site

3.3 Geomorphology and Soils

The site does not contain any unique topographical or geological formations and therefore these factors are not an impediment to the development of the site. Some of the soil types on the site are prone to waterlogging and ponding (DAFWA, 2013; GHD, 2013). Surface water management will be required to manage these soil types.

To minimise potential for soil erosion to occur the following management measures are recommended:

- Earthworks have the potential to add clay 'fines' into the drainage channels (Hardey's Creek Main Drain) or the Conservation Category Wetlands/remnant bushland areas (Lambkin Reserve) and the installation of temporary drop-out basins to capture and aid in the settling of clay fines should be considered.
- There may be a requirement for the filling of the landscape to address water sensitive urban design principles.

3.4 Acid Sulphate Soils

The ASS Risk on the site is mapped as being Moderate to Low (<3m from the surface) with a small area of High to Moderate associated with the wetland in Lambkin Reserve. WAPC *Acid Sulphate Soils Planning Guidelines* (WAPC, 2009c) indicate that "*acid sulphate soils are technically manageable in the majority of cases*" which would be applicable to the areas mapped Moderate to Low risk.

ASS Investigation and, if required, Management Plans should be prepared at subdivision stage once the detailed design of the site is finalised. This should be undertaken in accordance with the *Acid Sulphate Soils Guideline Series: Identification and Investigation of Acid Sulphate Soils and Acidic Landscapes* (DEC, 2009) and *Treatment and Management of Soils and Water in Acid Sulphate Soil Landscapes* (DEC, 2011).

3.5 Groundwater

Groundwater management has been outlined in the Local Water Management Strategy (GHD, 2013) and further details will be provided in Urban Water Management Plans (UWMP) that will be prepared for each subdivision as per *Better Urban Water Management* (WAPC, 2008). The Department of Water is currently developing a groundwater allocation plan for the area. The plan will include revised groundwater allocation limits and polices for managing water abstraction and use. The allocation plan will need to be considered when preparing UWMPs for future development.

Therefore potential impacts on groundwater can be mitigated and managed and does not impede further development of the Serpentine Townsite.

3.6 Surface Water

The management of surface water has been detailed in the Local Water Management Strategy (GHD, 2013) and will be further detailed in the Urban Water Management Plans that will be prepared for development within the site.

The LWMS shows the Water Corporation Hardey's Creek Main Drain to be partially re-routed and incorporated into a drainage corridor. The eastern part of the drain is proposed to be maintained in POS to the east of the site. The drain is close to the boundary of the POS on the Townsite (western) side of the POS.

Development of the site has the potential to increase the ecological value of the degraded channels through rehabilitation. This could be with the introduction of sedges to stabilise the banks and native species. Existing exotic vegetation should be retained until native endemic species are established to provide bank stabilisation.

3.7 Wetlands

A large proportion of the site is mapped as a palusplain Multiple Use Wetland with smaller areas mapped as Resource Enhancement. These wetlands have largely been developed or are Completely Degraded and could be used as detention basins or recharge areas.

The Conservation Category Wetlands on the site are within existing Conservation Reserves and are within the existing developed areas. Therefore management of the wetlands will need to be active to ensure weeds and other deleterious impacts are managed appropriately. Management of development to reduce potential impacts on wetland hydrologic regimes and attributes will be guided by the Western Australian Planning Commission Guidelines for Determination of Wetland Buffer Requirements.

3.8 Vegetation

The vegetation on the majority of the site is Completely Degraded and in small areas Degraded to Completely Degraded. There are several stands of Marri that could be retained within POS or alongside road reserves. In particular there is a stand of Marri in the south east of the site along the unmade Rudall Street Reserve that is dense and would be recommended to be retained.

During the detailed design process it is recommended that the retention of any trees that can be retained in landscaped areas, parking areas and in road/entry areas should be included in the plans for the area. All trees should be located on a site plan that shows canopy and trunk diameters and the natural ground level at the base of each trunk. Mature trees to be retained or transplanted must be identified and marked appropriately prior to commencement of any pre-construction activities. In some areas it may potentially be appropriate to create tree protection zones.

In development areas adjacent to the bushland areas, construction to provide services or to upgrade roads should be undertaken with minimal disturbance to the vegetation and be in accordance with the Australian Standards for Protection of Trees on Development Sites. Management procedures should be in place to ensure that the vegetation is protected.

3.9 Flora

There are Declared Rare Flora and priority species within the small pockets of bushland areas on the site. These species are highly unlikely to be present on the remainder of the Townsite. It is recommended that all areas of remnant vegetation subject to development are surveyed for significant flora and vegetation.

3.10 Fauna

Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii* subsp. *naso*), and possibly Baudin's Cockatoo (*Calyptorhynchus baudinii*) and Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*) could be impacted by the development of the site if mature trees will be cleared.

The three species of black cockatoo that do or may occur on the site are listed under Section 18 of the EPBC Act. Under the EPBC Act, a significant impact is determined by the sensitivity, value and quality of the environment which is to be impacted and the intensity, duration, magnitude and geographic extent of the impacts. If a proposed action is deemed to have a significant impact, this action should be referred to the Minister. Therefore the potential impact of development of the site in the context of the Local Structure Plan will need to be examined in the context of the *Matters of National Environmental Significance. Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (SEWPaC, 2013c). If, according to the Significant Impact Guidelines 1.1, an action is likely to have a significant impact on an endangered and vulnerable species it will need to be referred under the EPBC Act.

The habitat requirements for the Black Cockatoos include foraging (Marris, Flooded Gums, *Banksia* species, Parrot Bush and other Proteaceous shrubs), roosting (tall eucalypts and pines) or breeding habitat (specific Eucalypt trees). There are very few Proteaceous shrubs outside of the bushland areas and scattered Marri trees on the site. The bushland areas contain the best quality habitat and therefore should be retained. However each individual subdivision will need to make its own assessment to determine the implications of the proposed development under the EPBC Act.

To mitigate potential impact on Black Cockatoos it is suggested that in future planning phases as many Marri and Flooded Gum trees and significant trees (those greater than 500mm in diameter at breast height) be retained. There is also the potential to improve the Black Cockatoo habitat by planting appropriate species in drainage corridors, open space and road reserves.

The Cattle Egret is potentially a brief visitor to the site but would not be impacted by development in the Local Structure Plan Area. There are no other conservation species identified that are likely to be impacted by development in the Local Structure Plan Area.

3.11 Heritage

Aboriginal Heritage Site 3582, Serpentine River is mapped over much of the site, is registered with the Department of Aboriginal Affairs and as such advice on the implications under the *Aboriginal Heritage Act 1976* of the Heritage Site will need to be investigated.

The State and Locally listed sites that are within the Serpentine Townsite should not be impacted by the development of the town in accordance with the Local Structure Plan.

4 SUMMARY AND CONCLUSIONS

The Environmental Factors that were studied in this environmental assessment were:

- Past and Existing Land Use;
- Surrounding Land Use;
- Topography;
- Geomorphology and Soils;
- Surface and Groundwater;
- Vegetation;
- Flora;
- Fauna; and
- Heritage.

The desktop studies resulted in the following conclusions and recommendations:

- Past land uses indicate that rural activities may have some small localised areas that are contaminated. Therefore it is suggested that a Preliminary Site Investigation may be required at subdivision stage to identify if there is any potential contamination present that may require further investigation and remediation in order for the site to be suitable for development.
- Buffer studies may be required for future development proposals close to existing industry.
- The adjacent rail alignment may require acoustic studies to buffers and management during subdivision in the northern part of the site.
- The topography and geology on the site does not constrain the LSP design.
- The soils have a Low to Moderate risk of ASS. Therefore this is not considered a constraint to the design of the LSP. Site specific studies will be required for ASS risk at subdivision or development application stage.
- Surface water and groundwater will be managed under the hierarchy outlined in *Better Urban Water Management* (WAPC, 2008).
- Rehabilitation of the existing and proposed constructed drainage channels (Hardey's Main Drain) has the potential to increase the ecological value and linkage over the site.
- Native endemic species should be established in drainage channels prior to the present exotic species being removed to ensure the banks remain stable.
- The site has two Conservation Category Wetlands on the site and one adjacent that could be impacted by development.
- The generic 50m buffers to the Conservation Category Wetlands already contain established home-sites and therefore the existing boundaries for the retained vegetation should be maintained. Development adjacent to wetlands and wetland vegetation should meet Bushfire Attack Levels that do not require any change to the Wetland vegetation attributes and drainage controls that do not significantly alter the current wetland hydrology.
- The site is not in a priority surface or groundwater area. Therefore these factors do not constrain the design of the LSP.

- Drainage corridors open space and road reserves can be enhanced by planting native species.
- The current LSP retains the majority of remnant vegetation within the Townsite and this should not change in any updated LSP.
- Wherever possible, trees should be retained in the LSP area particularly in road reserves and POS.
- The patch of Marris in the south east of the site in the Rudall Street Road Reserve should be retained which will involve the road reserve being closed and designated as POS.
- There are Declared Rare and Priority Flora within the bushland areas on the site which are to be retained.
- It is highly unlikely any Declared Rare and Priority Flora are present outside of the bushland areas.
- There are TECs present on the site in the bushland areas to be retained.
- There are no TECs or PECs present outside of these areas in the LSP therefore the LSP does not have to be revised to protect TEC.
- Development is highly unlikely to have a significant impact according to the Significant Impact Guidelines 1.1 however each individual development should do its own assessment to determine the degree of impact under the EPBC Act.
- Consideration will need to be given to retaining Marri trees to protect habitat for the three species of Black Cockatoo.
- There is a registered Aboriginal heritage site (Site ID 3582) mapped over much of the LSP area and therefore advice will need to be sought to determine what approvals, if any, are required under the *Aboriginal Heritage Act, 1976*.
- There are three State and Locally listed heritage sites that will not be impacted by the LSP and any redesign should protect these areas.

The results of desktop assessment, preliminary field investigations and mitigation measures identified, concludes the potential for deleterious impacts of development of the Serpentine Townsite in accordance with the LSP as proposed by the Department of Planning is Low.

There are some adjustments that are recommended for the LSP to enhance the environmental outcome for the Townsite. These include:

- Realigning or removing the southern part of Rudall Street to retain the thick stand of Marri trees which currently exists in the road reserve. To facilitate this, the road reserve would be converted to public open space.
- Retention of trees to be encouraged during subdivision.

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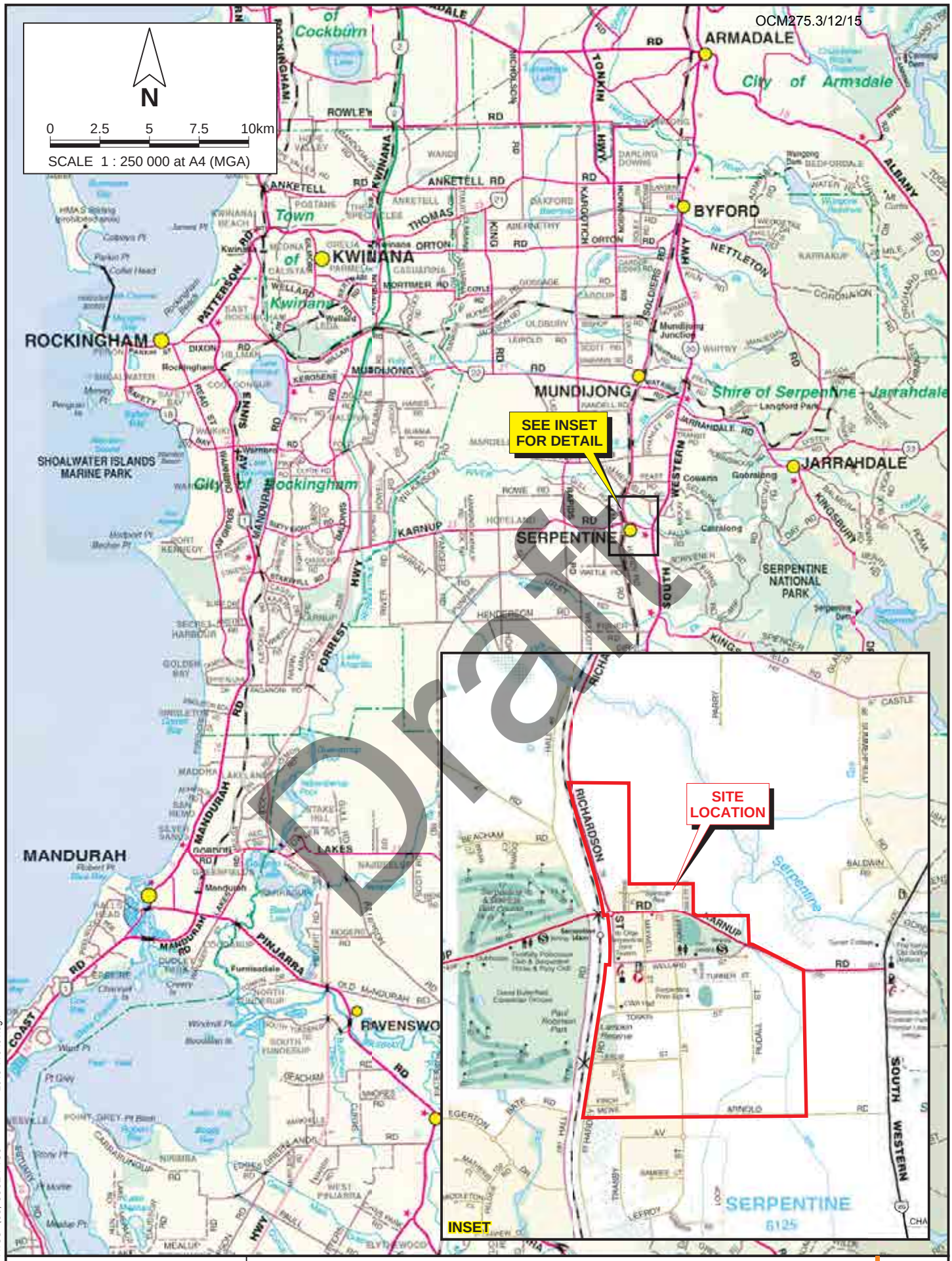
FIGURES



2013-110-f01.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

pgv ENVIRONMENTAL

Serpentine Jarrahdale Shire
ENVIRONMENTAL ASSESSMENT
SERPENTINE TOWNSITE

Drawn: J. Hams	Date: 28 Nov 2013
Job: 10154 Rpt: 2013-110	Revision: A

SITE LOCATION

Figure 1

PINPOINT CARTOGRAPHICS (08) 9562 7136 2013-110-f02.dgn QCM275 3/12/15

N

0 50 100 150 200m

SCALE 1 : 5 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Easement Boundary
- Topographic Contour

RICHARDSON ROAD
SERPENTINE RIVER
KARNUP ROAD
MAXWELL STREET
WELLARD STREET
TONKIN STREET
LEFROY STREET
RUDALL STREET
HARDEY ROAD
LESLIE STREET
ARNOLD ROAD

6 419 500mN
6 419 000mN
6 418 500mN
6 418 000mN
403 500mE
404 000mE
404 500mE

CADASTRAL SOURCE: Landgate, November 2013.
CONTOUR SOURCE: Landgate 1:50 000 Topographic Mapping.
AERIAL PHOTOGRAPHY SOURCE: Landgate, flown January 2013.

pgv ENVIRONMENTAL

Serpentine Jarrahdale Shire
ENVIRONMENTAL ASSESSMENT
SERPENTINE TOWNSITE

Drawn: J. Hams | Date: 28 Nov 2013
Job: 10154 Rpt: 2013-110 | Revision: A

SITE BOUNDARY

Figure 2

N

0 50 100 150 200m

SCALE 1 : 5 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Easement Boundary
- Soil Type Boundary
- 213Pj Soil Type

Soils

213Fo__F2b - Moderately deep to deep, gravelly acidic yellow duplex soils and rare laterite.

213Pj__B1 - Deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at generally > 2m.

213Pj__B2 - Deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.

213Pj__B3 - Moderately deep bleached sands with an iron-organic pan, or clay subsoil. Surfaces are dark grey sand.

213Pj__P1a - Deep acidic mottled yellow duplex soils. Shallow pale sand to sandy loam over clay.

213Pj__P1b - Deep acidic mottled yellow duplex (or effective duplex) soils. Moderately deep pale sand to loamy sand over clay.

213Pj__P1d - Deep acidic mottled yellow duplex soils. Shallow pale sand to sandy loam over clay.

213Pj__P3 - Deep acidic gradational yellow or grey-brown earths and mottled yellow duplex soils, with loam to clay loam surface horizons.

213Pj__P4 - Moderately deep to deep black, olive grey and some yellowish brown cracking clays and less commonly non-cracking friable clays with generally acidic.

213Pj__P8 - Moderately deep to deep sands over mottled clays. These may be acidic or less commonly alkaline gley and yellow duplex soils to uniform bleached.

213PjSWP10 - Deep well drained uniform brownish sands or loams.

213PjSWP6a - Deep moderately well to well drained acidic red and yellow duplex and less commonly, gradational soils.

CADASTRAL SOURCE: Landgate, November 2013.
SOILS SOURCE: Department of Agriculture, November 2004.
AERIAL PHOTOGRAPH SOURCE: Landgate, flown January 2013.

pgv ENVIRONMENTAL

Serpentine Jarrahdale Shire
ENVIRONMENTAL ASSESSMENT
SERPENTINE TOWNSITE

Drawn: J. Hams | Date: 28 Nov 2013
Job: 10154 Rpt: 2013-110 | Revision: A

SOIL MAPPING

Figure 3

ASS SOURCE: DEC, January 2010.
CADASTRAL SOURCE: Landgate, November 2013.
AERIAL PHOTOGRAPH SOURCE: Landgate, flown January 2013.

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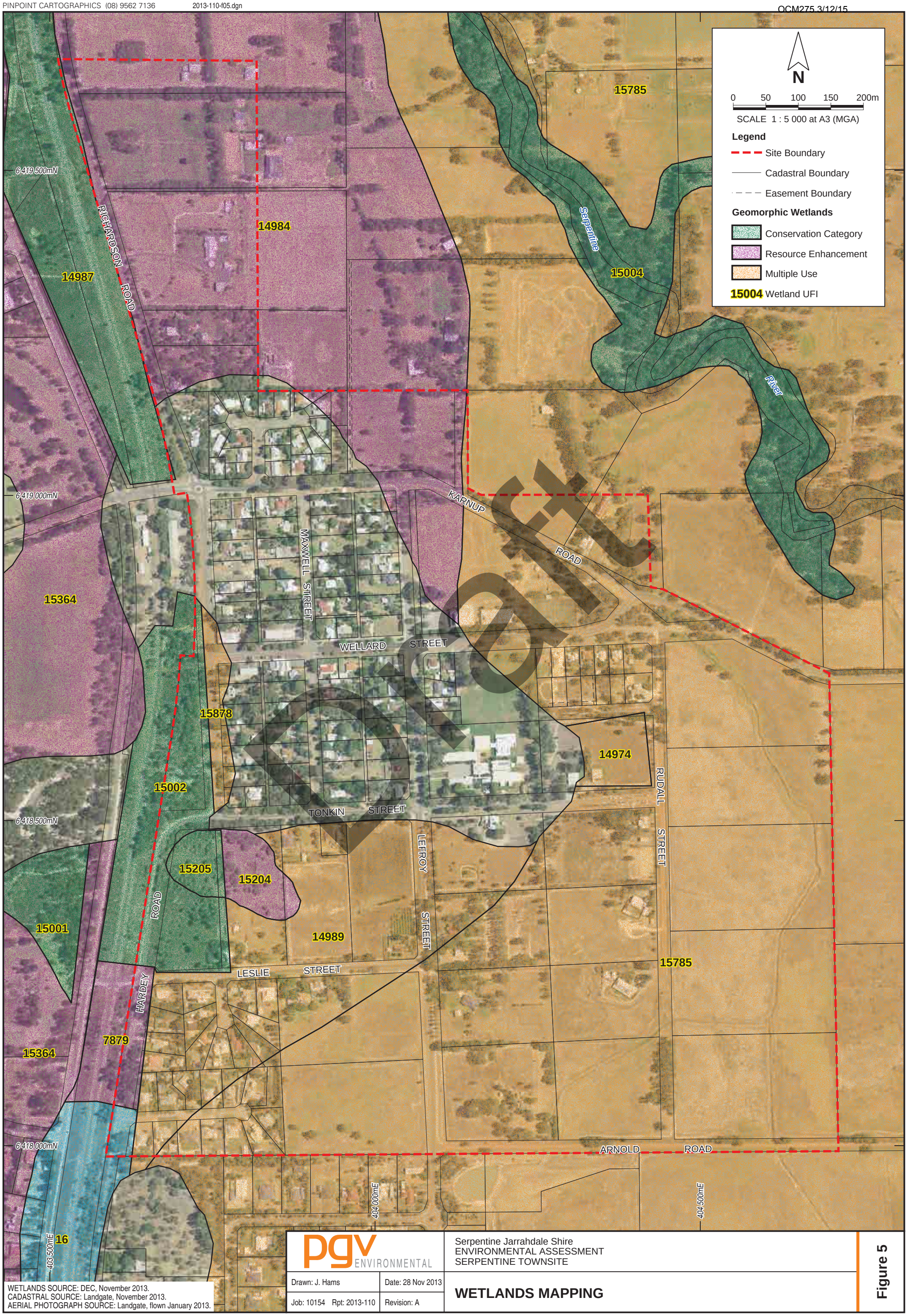
Serpentine Jarrahdale Shire
ENVIRONMENTAL ASSESSMENT
SERPENTINE TOWNSITE

ACID SULPHATE SOILS RISK MAPPING

Figure 4

PINPOINT CARTOGRAPHICS (08) 9562 7136 2013-110-f05.dgn QCM275 3/12/15



WETLANDS SOURCE: DEC, November 2013.
CADASTRAL SOURCE: Landgate, November 2013.
AERIAL PHOTOGRAPH SOURCE: Landgate, flown January 2013.

pgv ENVIRONMENTAL

Serpentine Jarrahdale Shire
ENVIRONMENTAL ASSESSMENT
SERPENTINE TOWNSITE

Drawn: J. Hams	Date: 28 Nov 2013
Job: 10154 Rpt: 2013-110	Revision: A

WETLANDS MAPPING

Figure 5

N

0 50 100 150 200m

SCALE 1 : 5 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Easement Boundary
- Bush Forever Site
- 371 Bush Forever Site Number

6 419 500mN
6 419 000mN
6 418 500mN
6 418 000mN
403 500mE
404 000mE
404 500mE

RICHARDSON ROAD
365
371
Serpentine River
KARNUP ROAD
MAXWELL STREET
WELLARD STREET
TONKIN STREET
LEFROY STREET
RUDALL STREET
375
HARDEY ROAD
LESLIE STREET
ARNOLD ROAD

BUSH FOREVER SOURCE: DoP, 2007.
CADASTRAL SOURCE: Landgate, November 2013.
AERIAL PHOTOGRAPH SOURCE: Landgate, flown January 2013.

pgv ENVIRONMENTAL

Drawn: J. Hams | Date: 28 Nov 2013
Job: 10154 Rpt: 2013-110 | Revision: A

Serpentine Jarrahdale Shire
ENVIRONMENTAL ASSESSMENT
SERPENTINE TOWNSITE

BUSH FOREVER SITES

Figure 6

APPENDIX 1

DPI Proposed Local Structure Plan

3.1 Main Land Uses

Figure 9: Land Use Plan.

APPENDIX 2

Vegetation Mapping – Coffey Environments (2009)

PRINTED: Thu 28 May 09 CHECKED: BL 28-05-09 DRAWN: CR 28-05-09 DATUM: MGA zn50 ENVI/PERT/00643AA/EPBC Act Assessment/EP2009-050F03.dgn

VEGETATION ASSESSMENT - LOTS 6-10 TURNER STREET, SERPENTINE

coffey environments
SPECIALISTS IN LIVING AND WORKING PLACES

LOCATION OF SIMILAR HABITAT IN THE SERPENTINE TOWNSITE

FIGURE 3

APPENDIX 3

TEC/PEC Database Search (04-0913EC)

BDY_ID	OCC_UNIQUE	COM_ID	COM_NAME	CT_DESC	S_ID_COUNT	FIRST_S_ID	LAST_S_ID	BUFFER	OCC_CONFID
370	757	SCP3a	Eucalyptus calophylla - Kingia australis woodlands on heavy soils, Swan Coastal Plain	Critically Endangered	2	FHALL01	HALL05	500	No
372	113	SCP3a	Eucalyptus calophylla - Kingia australis woodlands on heavy soils, Swan Coastal Plain	Critically Endangered	1	PUNR02		500	No
1325	3239	SCP3a	Eucalyptus calophylla - Kingia australis woodlands on heavy soils, Swan Coastal Plain	Critically Endangered	2	Turner01	Turner03	500	No
359	510	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered	1	MYBYFORD01		500	No
0	5067	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered	1	BYFrail07		500	No
0	4043	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered	1	RAPID05		500	No
367	754	SCP10a	Shrublands on dry clay flats	Endangered	1	HALL02		500	No
369	756	SCP10a	Shrublands on dry clay flats	Endangered	1	HALL04		500	No
371	761	SCP10a	Shrublands on dry clay flats	Endangered	1	PUNR03		500	No
0	5069	SCP10a	Shrublands on dry clay flats	Endangered	1	BYFrail09		500	No
366	753	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	HALL01		500	No
368	755	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	HALL03		500	No
382	750	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	PAUL06		500	No
383	733	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	PAUL01		500	No
386	751	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	xLamb02		500	No
391	752	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	xLamb01		500	No
0	4041	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	RAPID01		500	No
0	4044	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	RAPID06		500	No
0	5106	SCP1a	Eucalyptus haematoxylon - E. marginata woodlands on Whicher foothills	Priority 3	1	WattleRd01		500	No
0	4042	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	RAPID02		500	No
373	760	SCP07	Herb rich saline shrublands in clay pans	Vulnerable	1	PUNR01		500	No
374	762	SCP07	Herb rich saline shrublands in clay pans	Vulnerable	1	PUNR04		500	No
381	740	SCP07	Herb rich saline shrublands in clay pans	Vulnerable	1	PAUL04		500	No
379	749	SCP08	Herb rich shrublands in clay pans	Vulnerable	1	PAUL05		500	No
384	734	SCP3b	Eucalyptus calophylla - Eucalyptus marginata woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	1	PAUL02		500	No
390	735	SCP3b	Eucalyptus calophylla - Eucalyptus marginata woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	1	PAUL03		500	No
404	451	SCP3b	Eucalyptus calophylla - Eucalyptus marginata woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	5	MYSERP01	serp04	500	No
599	457	SCP3b	Eucalyptus calophylla - Eucalyptus marginata woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	2	MYTRANSPLOT1	MYTRANS01	500	No
0	5068	SCP3b	Eucalyptus calophylla - Eucalyptus marginata woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	1	BYFrail08		500	No
0	5196	SCP3b	Eucalyptus calophylla - Eucalyptus marginata woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	1	WattleRd01Serp		500	No

APPENDIX 4

Conservation Codes

Western Australian and Commonwealth of Australia Conservation Codes

Flora

Definitions of the Conservation Codes for the Status of Flora under the Wildlife Conservation Act 1950 follow:

T: Threatened Flora (Declared Rare Flora — Extant)

Taxa1 which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such (Schedule 1 under the Wildlife Conservation Act 1950).

Threatened Flora (Schedule 1) are further ranked by the Department according to their level of threat using IUCN Red List criteria:

CR: Critically Endangered

Considered to be facing an extremely high risk of extinction in the wild

EN: Endangered

Considered to be facing a very high risk of extinction in the wild

VU: Vulnerable

Considered to be facing a high risk of extinction in the wild.

X: Presumed Extinct Flora (Declared Rare Flora — Extinct)

Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such (Schedule 2 under the Wildlife Conservation Act 1950).

Taxa that have not yet been adequately surveyed to be listed under Schedule 1 or 2 are added to the Priority Flora List 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. Taxa that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Conservation Dependent species are placed in Priority 5.

Priority One: Poorly-known taxa

Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or

more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.

Priority Two: Poorly-known taxa

Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.

Priority Three: Poorly-known taxa

Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.

Priority Four: Rare, Near Threatened and other taxa in need of monitoring

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.

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.

Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Priority Five: Conservation Dependent taxa

Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxon becoming threatened within five years.

Vegetation

Definitions and criteria for presumed totally destroyed, critically endangered, endangered and vulnerable ecological communities are outlined below.

Presumed Totally Destroyed (PD)

An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence

of it is likely to recover its species composition and/or structure in the foreseeable future.

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.

Possible threatened ecological communities that do not meet survey criteria are added to DEC's Priority Ecological Community Lists under Priorities 1, 2 and 3. Ecological Communities that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or 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.

Priority One: 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 ≤ 100ha). 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 Two: Poorly-known ecological communities

Communities that are known from few occurrences with a restricted distribution (generally ≤10 occurrences or a total area of ≤200ha). 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.

Priority Three: Poorly known ecological communities

(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:

(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;

(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.

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.

Priority Four: 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.

(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.

(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.

(iii) Ecological communities that have been removed from the list of threatened communities during the past five years.

Priority Five: Conservation Dependent ecological communities

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.

Fauna

In Western Australia, all native fauna species are protected under the *Wildlife Conservation Act 1950-1979*. Fauna species that are considered rare, threatened with extinction or have a high conservation value are specially protected under the Act. In addition, some species of fauna are covered under the 1991 ANZECC convention, while certain birds are listed under the Japan and Australian Migratory Bird Agreement (JAMBA) and the China and Australian Migratory Bird Agreement (CAMBA). In addition to the above classification, DEC also classify fauna under five different Priority codes and rare and endangered fauna are classified under the Wildlife Conservation (Specially Protected Fauna) Notice 2006 into four schedules of taxa.

Schedule 1

Fauna which are rare or likely to become extinct and are declared to be fauna in need of special protection.

Schedule 2

Fauna which are presumed to be extinct and are declared to be fauna in need of special protection.

Schedule 3

Birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction which are declared to be fauna in need of special protection.

Schedule 4

Fauna that are in need of special protection, otherwise than for the reasons mentioned in Schedule 1, 2 or 3.

In addition to the above classification, the DEC also classifies fauna under five different priority codes:

Priority One: Taxa with few, poorly known populations on threatened lands

Taxa which are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority Two: Taxa with few, poorly known populations on conservation lands

Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority Three: Taxa with several, poorly known populations, some on conservation lands

Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority Four: Taxa in need of monitoring

Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which 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.

Priority Five: Taxa in need of monitoring (conservation dependent)

Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Commonwealth of Australia Conservation Codes

The Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* has the following nine conservation codes for Flora and Fauna.

Extinct

Taxa not definitely located in the wild during the past 50 years

Extinct in the Wild

Taxa known to survive only in captivity

Critically Endangered

Taxa facing an extremely high risk of extinction in the wild in the immediate future

Endangered

Taxa facing a very high risk of extinction in the wild in the near future

Vulnerable

Taxa facing a high risk of extinction in the wild in the medium-term

Near Threatened

Taxa that risk becoming Vulnerable in the wild

Conservation Dependent

Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classified as Vulnerable or more severely threatened.

Data Deficient (Insufficiently Known)

Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.

Least Concern

Taxa that are not considered Threatened

APPENDIX 5

DPaW Flora Database Searches

Taxon	Status	Rank	IUCN Criteria	EPBC	DECRegion	DECDistrict	Distribution	Flowering Period	Recovery Plan
Acacia horridula	3				SWAN	PERTH HILLS	Helena Valley - Serpentine	May-Aug	
Acacia lasiocarpa var. bracteolata long peduncle variant (G.J. Keighery 5026)	1				SWAN	PERTH HILLS,SWAN COASTAL	North Dandalup, Mundijong, Gosnells, Jandakot, Serpentine, Mundijong	My,Aug	
Acacia oncinophylla subsp. oncinophylla	3				MWST,SWAN ,WARR	PERTH HILLS,DONNELLY,MOORA	Mogumber, Mundaring, John Forrest NP, Serpentine, Mt Lennard, Dwellingup, Winnejup		
Dillwynia dillwynioides	3				SWAN	SWAN COASTAL	Harvey, Pinjarrah, Yunderup, Gingin, Perth, Karnup, Mundijong, Serpentine	Aug-Oct	
Eryngium pinnatifidum subsp. Palustre (G.J. Keighery 13459) PN	3				SWAN	SWAN COASTAL	Serpentine, Kenwick, Upper Swan, Gingin, Forrestdale, Bullsbrook, Mandurah, Arrowsmith, Capel	-	
Eucalyptus rudis subsp. cratyantha	4				SWAN,SWST	SWAN COASTAL,BLACKWOOD	Yallingup, Eagle Bay, Mandurah, Cape Naturaliste, Meelup, Busselton, Serpentine	-	
Johnsonia pubescens subsp. cygnorum	2				SWAN	SWAN COASTAL	Serpentine, Cardup, Lowlands	Sep-Nov	
Lasiopetalum pterocarpum	T	CR	Ba1b(iii) +2ab(iii); C2a(i,ii); D	EN	SWAN	PERTH HILLS	Serpentine Falls	Aug	IRP
Parsonsia diaphanophleba	4				SWAN	PERTH HILLS,SWAN COASTAL	Murray River, Coolup, Serpentine	Jan-Feb,May-	
Stachystemon sp. Keysbrook (R. Archer 17/11/99)	1				SWAN	SWAN COASTAL	Keysbrook, Whiteman	Oct	
Stylidium ireneae	4				SWAN,SWST	SWAN COASTAL,BLACKWOOD,WELL INGTON	Waroona, Lane Poole, Serpentine Dam, North Dandalup, Augusta, Kwinana	Oct-Nov	
Synaphea odocoileops	1				SWAN,SWST	PERTH HILLS,SWAN COASTAL,BLACKWOOD	Serpentine, Elgin, Byford, Wagerup	Aug-Oct	
Synaphea sp. Pinjarra Plain (A.S. George 17182)	1				SWAN	SWAN COASTAL	Mundijong, Serpentine	Oct	IRP
Synaphea sp. Serpentine (G.R. Brand 103)	3				SWAN,SWST	SWAN COASTAL,WELLINGTON	Serpentine, Mundijong, Byford, Yarloop	Aug-Nov	
Tetraria australiensis	T	VU	B1ab(iii)	VU	SWAN,SWST	PERTH HILLS,SWAN COASTAL,BLACKWOOD	Mundijong, Busselton, (Cannington, Serpentine River)	Dec	
Verticordia lindleyi subsp. lindleyi	4				MWST,SWAN	PERTH HILLS,SWAN COASTAL,MOORA	Gillingarra-Forrestdale, Cannington, Guildford, Muchea, Gingin, Murray River, Moore River, Serpentine	Nov-Jan	
Verticordia plumosa var. ananeotes	T	CR	B1ab(iii,v)+2ab(iii, v)	EN	SWAN,SWST	SWAN COASTAL,BLACKWOOD	Busselton, Serpentine - Blackwood	Dec	IRP

FID_	PopId	Nameid	Taxon	ConsStatus	WARank	PopNumber	SubPopCode	Vesting	Purpose1	Purpose2	CountDate
	86383	3373	Acacia horridula	3		1		LGA	VER		7/12/1976 0:00
	98539	3373	Acacia horridula	3		4	A	LGA	VER		12/06/1996 0:00
	98540	3373	Acacia horridula	3		4	B	CC	NPK		12/06/1996 0:00
	98541	3373	Acacia horridula	3		4	C	CC	NPK		13/06/1996 0:00
	98542	3373	Acacia horridula	3		4	D	CC	NPK		14/06/1996 0:00
	98543	3373	Acacia horridula	3		4	E	CC	NPK		20/06/1996 0:00
	98544	3373	Acacia horridula	3		4	F	CC	NPK		20/06/1996 0:00
	98545	3373	Acacia horridula	3		4	G	CC	NPK		25/06/1996 0:00
	98546	3373	Acacia horridula	3		4	H	CC	NPK		8/07/1996 0:00
	98547	3373	Acacia horridula	3		4	I	CC	NPK		13/11/1996 0:00
	86389	3373	Acacia horridula	3		5		LGA	VER		2/07/1991 0:00
	91850	14129	Acacia oncinophylla subsp. oncinophylla	3		1		UNKNOWN			18/07/1976 0:00
	84967	1596	Caladenia huegelii	T	CR	75		PRI			23/09/2010 0:00
	101638	13191	Drosera occidentalis subsp. occidentalis	4		20	A	RAI	RRE		27/11/1990 0:00
	101639	13191	Drosera occidentalis subsp. occidentalis	4		20	B	LGA	VER		27/11/1990 0:00
	101641	13191	Drosera occidentalis subsp. occidentalis	4		22	A	LGA	VER		27/11/1990 0:00
	101642	13191	Drosera occidentalis subsp. occidentalis	4		22	B	RAI	RRE		27/11/1990 0:00
	94661	19272	Johnsonia pubescens subsp. cygnorum	2		3		RAI	RRE		19/10/1983 0:00
	103518	17000	Lasiopetalum pterocarpum	T	CR	1	A	CC	NPK		30/11/2007 0:00
	103519	17000	Lasiopetalum pterocarpum	T	CR	1	B	CC	NPK		30/11/2007 0:00
	103520	17000	Lasiopetalum pterocarpum	T	CR	1	C	CC	NPK		19/12/2000 0:00
	103521	17000	Lasiopetalum pterocarpum	T	CR	1	D	CC	NPK		8/10/2003 0:00
	103522	17000	Lasiopetalum pterocarpum	T	CR	1	E	CC	NPK		5/04/2006 0:00
	103523	17000	Lasiopetalum pterocarpum	T	CR	1	F	CC	NPK		30/11/2007 0:00
	93503	16865	Synaphea odocoileops	1		3		UNKNOWN	UNKNOWN		21/09/1998 0:00
	103965	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	A	RAI	RRE		16/09/2010 0:00
	103966	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	B	RAI	RRE		16/09/2010 0:00
	103967	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	C	RAI	RRE		21/09/2010 0:00
	103968	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	D	RAI	RRE		21/09/2010 0:00
	103969	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	E	RAI	RRE		21/09/2010 0:00
	107083	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	F	LGA	VER		16/09/2010 0:00

FID_	PopId	Nameid	Taxon	ConsStatus	WARank	PopNumber	SubPopCode	Vesting	Purpose1	Purpose2	CountDate
	107084	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	G	LGA	VER		21/09/2010 0:00
	107086	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	H	LGA	VER		21/09/2010 0:00
	103971	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	6	A	CC	CFF		11/10/2010 0:00
	103972	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	6	B	LGA	VER		11/10/2010 0:00
	103973	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	6	C	LGA	VER		11/10/2010 0:00
	107453	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		6	A	RAI	RRE		5/10/2012 0:00
	107455	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		6	B	LGA	VER		5/10/2012 0:00
	107456	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		7	A	CC	NRE		8/10/2012 0:00
	107458	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		7	B	LGA	VER		8/10/2012 0:00
	107459	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		7	C	RAI	RRE		8/10/2012 0:00
	107462	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		8	A	LGA	VER		8/11/2011 0:00
	107464	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		8	B	RAI	RRE		9/10/2012 0:00
	107465	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		9		RAI	RRE		9/10/2012 0:00
	96982	1033	Tetraria australiensis	T	VU	7	A	CC	CFF		26/10/2009 0:00
	96983	1033	Tetraria australiensis	T	VU	7	B	NON	UCL		26/10/2009 0:00
	96984	1033	Tetraria australiensis	T	VU	7	C	LGA	VER		26/10/2009 0:00
	96985	1033	Tetraria australiensis	T	VU	7	D	RAI	RRE		26/10/2009 0:00
	96973	1033	Tetraria australiensis	T	VU	11	A	LGA	REC		26/08/2009 0:00
	96974	1033	Tetraria australiensis	T	VU	11	B	LGA	VER		1/11/2009 0:00
	84541	1033	Tetraria australiensis	T	VU	14		PRI			19/10/2010 0:00
	106361	1033	Tetraria australiensis	T	VU	15		RAI	RRE		29/09/2011 0:00
	92652	14714	Verticordia lindleyi subsp. lindleyi	4		10		LGA	VER	DRA	27/12/1988 0:00
	92666	14714	Verticordia lindleyi subsp. lindleyi	4		25		LGA	VER		9/11/1995 0:00
	90083	12452	Verticordia plumosa var. pleiobotrya	T	VU	4		LGA	OTH		24/11/1999 0:00

FID_	Sheet_no	Taxon	Cons_code	Site	Vegetation	Locality	Geocode_me	Prec	Coll_Date
	PERTH 01188445	Acacia horridula	3	Red soil over granite.	Wandoo-Marri overstorey, Hakea sp. and Blackboy midstorey, Hibbertia, Grevillea sp. understorey.	700 m East on Scrivner Road on verge and extending into National Park	MAN	4	09 07 1990
	PERTH 04366263	Acacia horridula	3	WSW aspect. Slope. Dry brown/yellow sand/clay/gravel over granite.	With Eucalyptus calophylla, E. wandoo, E. marginata, Hakea trifurcata, H. cristata, H. lissocarpa, Blackboys, Dryandra nivea, Eucalyptus laeliae, Zamia, Hibbertia sp., Acacia pulchella, Daviesia sp.	Serpentine National Park	MAN	0	12 06 1996
	PERTH 04366220	Acacia horridula	3	Dry brown sand/clay/gravel. WNW aspect. Slope.	Very open vegetation with scattered Marri saplings, Hakea trifurcata, H. cristata, Blackboys, Dryandra armata, D. nivea, Calothamnus sp.	Serpentine National Park	MAN	0	25 06 1996
	PERTH 126179	Acacia horridula	3	Among granite rocks on hillside.	Low dense sclerophyll scrub.	Serpentine, Spring Valley Road	MAN	3	18 07 1976
	PERTH 04366255	Acacia horridula	3	WNW aspect. Slope. Dry brown/yellow sand/clay/gravel.	Very open vegetation with Eucalyptus laeliea, E. calophylla, Hakea trifurcata, H. lissocarpha, H. cristata, H. stenocarpa, Blackboys, Dryandra armata, D. nivea, Calothamnus sp.	Serpentine National Park	MAN	0	20 06 1996
	PERTH 04366212	Acacia horridula	3	WSW aspect. Slope. Dry yellow sand/clay/gravel over sheet boulder/granite with quartz rubble.	Very open vegetation with stunted Jarrah and Nuytsia floribunda, Hakea trifurcata, H. cristata, Blackboys, Lambertia multiflora, Dryandra nivea, Calothamnus sp., Hibbertia hypericoides.	Serpentine National Park	GPS	1	08 07 1996
	PERTH 05114209	Acacia horridula	3	Grey-brown gritty clay loam, with surface gravel and granitic cobbels, on a steep western lower slope.	Eucalyptus lane-poolei Low Woodland, over Kingia australis Open Low Scrub, over Xanthorrhoea acanthostachya Dwarf Scrub, over Melaleuca scabra Low Heath, over Neurachne alopecuroidea Very Open Low Grass.	Serpentine National Park, on NE corner of crossroads about 400 m ESE from Chatfield Rd. (Plot-SERP01)	GPS	1	13 11 1996
	PERTH 04366247	Acacia horridula	3	Westerly aspect. Slope. Dry light brown sand/clay/gravel over granite boulder/ dolerite and quartz rubble.	Very open vegetation with stunted Eucalyptus calophylla, E. marginata, Hakea trifurcata, H. cristata, H. lissocarpa, Blackboys, Dryandra armata, D. nivea, Eucalyptus laeliea, Hibbertia sp.	Serpentine National Park	GPS	1	13 06 1996
	PERTH 04366271	Acacia horridula	3	WNW aspect. Slope. Dry red/brown loam over granite boulder.	Open vegetation but very scrubby site with Eucalyptus laeliae, Hakea trifurcata, H. lissocarpha, H. cristata, H. stenocarpa, Acacia pulchella, A. marginata, Dryandra armata, D. nivea, Grevillea bipinnatifida.	Serpentine National Park	GPS	1	20 06 1996
	PERTH 04366239	Acacia horridula	3	Dry brown/yellow sand/clay/gravel over granite boulder/dolerite and quartz rubble. Westerly aspect. Slope.	Open vegetation with Eucalyptus laeliea, E. calophylla, E. marginata, Hakea trifurcata, H. cristata, H. lissocarpha, Blackboys, Zamia, Dryandra armata, D. nivea, Isopogon sp., Hibbertia sp., Calothamnus sp.	Serpentine National Park	GPS	1	14 06 1996
	PERTH 126195	Acacia horridula	3			About 1 km E of South West Highway on Scrivener Road (S of Serpentine)	MAN	2	07 12 1976
	PERTH 00607487	Acacia oncinophylla subsp. oncinophylla	3			Serpentine, Spring Valley Road	AUTO	3	18 07 1976
	PERTH 05811929	Drosera occidentalis subsp. occidentalis	4	Low lying flat. Grey sandy clay. Disturbed.	In Low Heath C of Kunzea micrantha over Leptocarpus sp., low sedges.	250 m N of Karnup Road on Hall Road, Serpentine, between Hall Road and railway,	MAN	3	27 11 1990
	PERTH 05811961	Drosera occidentalis subsp. occidentalis	4	Damp flat. Grey brown clayey sand.	Edge of Pericalymma ellipticum Low Heath C.	400 m S of Karnup Road on Hall Road, Serpentine, between Hall Road and railway,	MAN	3	27 11 1990
	PERTH 06428304	Eryngium pinnatifidum subsp. Palustre (G.J. Keighery 13459)	3	Dry Flat, brown sand, well drained.	Associated species: Eucalyptus calophylla.	Karnup Road Reserve just to SW of intersection with Rapids Road in Karnup Road Bushland (Bush Forever Site 74), Peel Estate, in System 6 Update quadrat punr02	GPS	1	09 11 1995

FID_	Sheet_no	Taxon	Cons_code	Site	Vegetation	Locality	Geocode_me	Prec	Coll_Date
	PERTH 03418731	Isopogon drummondii	3			Serpentine	AUTO	3	02 1901
	PERTH 08470944	Isopogon drummondii	3	Sand slope of yellow colluvial sand.	Banksia low woodland. Associated vegetation Banksia attenuata and B. menziesii.	Paul Robertson Reserve, Serpentine	GPS	1	26 02 2003
	PERTH 04781643	Johnsonia pubescens subsp. cygnorum	2	Flat site, rather low lying; recently burnt; grey sand.	Low woodland of Eucalyptus marginata and Coymbia calophylla with Kingia and Xanthorrhoea.	Between Tonkin Road and railway in SW corner of Serpentine townsite,	MAN	0	19 10 1983
	PERTH 01969501	Johnsonia pubescens subsp. cygnorum	2	Grey sand.	Open Banksia - Casuarina woodland.	2 km W of Serpentine	AUTO	3	29 09 1982
	PERTH 07319193	Lasiopetalum pterocarpum	T	In gently undulating area.	In an open woodland with Eucalyptus calophylla, Darwinia, Lepidosperma, Acacia.	Off the first track W of the Serpentine Falls, ca 150 m from the carpark	GPS	1	26 10 2005
	PERTH 05118379	Lasiopetalum pterocarpum	T	Dark brown loam, with dolerite cobbels at surface, on a creekline.	Eucalyptus rudis, E. calophylla Low Forest, over Trymalium floribundum, Grevillea manglesii spp manglesii Thicket, over Watsonia meriana Open Herbs, over Baumea vaginalis Open Tall Sedges.	Serpentine National Park, to SE of Falls Rd Car Park, on S side of creek. (Plot-SERP15)	GPS	1	08 12 1996
	PERTH 07220200	Lasiopetalum pterocarpum	T	Dark brown sandy clay over granite. 5 m from creek.	With riparian vegetation of open woodland and tall shrubs. Eucalyptus rudis, E. calophylla, Acacia sp., Lepidosperma sp., Agonis sp.	On track verge, in fence area approximately 160 m from the Serpentine Falls carpark, walking towards the Falls on N bank of creek	GPS	1	12 05 2006
	PERTH 05414172	Lasiopetalum pterocarpum	T	Riverbank. Organic litter cover. Brown clay-sand over granite.	Woodland over Heath A. Associated species: Eucalyptus rudis, Acacia alata (<2 m), A. saligna, Grevillea ?diversifolia, Blackberry (Rubus ulmifolius), Watsonia.	Serpentine National Park, E of Serpentine Falls following river course,	GPS	1	24 09 1999
	PERTH 04930363	Lasiopetalum pterocarpum	T	Valley. Northerly aspect. Moist, dark brown loam.	M.LA.c. S.SA.SB.SC.c.i. Eucalyptus calophylla/rudis overstorey. Associated with Agonis linearifolia, Acacia urophylla, Darwinia citriodora, Trymalium floribundum, Blackberry and Watsonia.	Serpentine National Park, situated 35 m E from the junction of the large water pipeline and the first walk trail that parallels the River	GPS	1	30 07 1997
	PERTH 2715031	Lasiopetalum pterocarpum	T		In shade amongst thick shrub layer with overhanging trees.	Near base of Serpentine Falls	AUTO	2	05 08 1972
	PERTH 07220219	Lasiopetalum pterocarpum	T	Dark brown sandy clay over granite. Gently undulating area near the base of the falls.	Riparian vegetation with Eucalyptus rudis, Acacia sp., Lepidosperma sp., Agonis sp.	Approximately 160 m from the Serpentine Falls carpark walking towards the Falls, near a small track to Falls	GPS	1	26 09 2004
	PERTH 05409624	Lasiopetalum pterocarpum	T	Moist, brown loam over granite. Riverbank.	Woodland over Heath A. Associated species: Dense Grevillea diversifolia, Eucalyptus calophylla, Darwinia citriodora, Acacia nervosa, Eucalyptus rudis, Lasiopetalum floribundum, Hemigenia sp., Watsonia.	ca 100 m W of Serpentine Falls car park, ca 5 m N of N bank of Serpentine River, Serpentine National Park,	MAN	2	07 09 1999
	PERTH 07968825	Lasiopetalum pterocarpum	T	Unburnt site with open area and deep leaf litter. Brown clayey sand over granite.		Site 3 DEC report. Behind ticket entry box Serpentine Falls National Park	GPS	1	06 05 2006
	PERTH 07968833	Lasiopetalum pterocarpum	T	Creek bank with dark brown, sandy clay over granite.	With riparian vegetation of open woodland and tall shrubs. Eucalyptus rudis, E. calophylla, Acacia sp, Lepidosperma sp and Agonis sp.	Over pipe Bridge near Serpentine Falls carpark, walking towards the Falls on S bank of creek. Site 4 DEC report	GPS	1	11 2004
	PERTH 03017656	Parsonsia diaphanophleba	4	Light brown sandy clay, river edge.		Lowlands, Mardella, N side of Serpentine River, NE of old house	AUTO	3	31 05 1993
	PERTH 06739016	Senecio leucoglossus	4			Serpentine	MAN	3	24 09 1899
	PERTH 06739024	Senecio leucoglossus	4			Serpentine	MAN	3	22 10 1899
	PERTH 05424585	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Flat. Road-rail reserve. Moist, liiter. Grey sandy clay. Pinjarra plain.	Heath, scattered Marri.	Hall Road, 200 m N of Utley Road-Rail Reserve, Serpentine,	MAN	0	15 09 1999

FID_	Sheet_no	Taxon	Cons_code	Site	Vegetation	Locality	Geocode_me	Prec	Coll_Date
	PERTH 07469195	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Winter wet railway reserve. Light brown red gravelley clay loam.	Open Pericalymma sp., Leptospermum shrubland with Leschenaultia biloba, Allocasuarina humilis, Briza sp., Watsonia sp., grasses and scattered emergent Eucalyptus sp.	200 m N of Utley road on Hall road, S of Serpentine	TOPO	3	26 10 1999
	PERTH 07469225	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Rail Reserve. Compacted light brown clayey sand.	Pericalymma ellipticum low shrubland with Adenanthos meisneri, Synaphea charisma ms., Leptospermum sp., Hakea spp. and Watsonia bulbillifera weed invasion.	1.1 km S of Karnup road on Hall road, S of Serpentine, E side of road in rail reserve	GPS	1	10 10 2003
	PERTH 07469233	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Rail Reserve. Grey clayey sand with areas of compacted grey to red - brown clay.	Kunzea recurva shrubland with Hypocalymma angustifolium, Leschenaultia biloba, Mesomelaena tetragona, Synaphea petiolaris, Synaphea xela ms., Grevillea sp., and scattered emergent Corymbia calophylla as well as Neurachne allopecuroidea and Watsonia bulbi	3.85 km S of Karnup road on Hall road, S of Serpentine, E side of road in rail reserve	GPS	1	22 10 2003
	PERTH 07469241	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Rail Reserve. Grey clayey sand with areas of compacted grey to red - brown clay.	Kunzea recurva shrubland with Hypocalymma angustifolium, Leschenaultia biloba, Mesomelaena tetragona, Synaphea petiolaris, Synaphea xela ms., Grevillea sp., and scattered emergent Corymbia calophylla as well as Neurachne allopecuroidea and Watsonia bulbi	3.85 km S of Karnup road on Hall road, S of Serpentine, E side of road in rail reserve	GPS	1	22 10 2003
	PERTH 07463642	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Rail reserve. Grey clayey sand with areas of compacted grey to red-brown clay.	Kunzea recurva shrubland with Hypocalymma angustifolium, Leschenaultia biloba, Mesomelaena tetragona, Synaphea petiolaris, S. sp. Pinjarra Plain (A.S. George 17182), Grevillea sp. and scattered emergent Corymbia calophylla, as well as Neurachne alopecuro	3.85 km S of Karnup Road on Hall Road, S of Serpentine; E side of road in rail reserve	GPS	1	22 10 2003
	PERTH 07463650	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Rail reserve. Compacted light brown sandy loam with lateritic gravel.	Kunzea recurva thicket with some Pericalymma ellipticum over Adenanthos meisneri Mesomelaena tetragona, Synaphea sp. Serpentine (G.R. Brand 103), Synaphea sp. (RB 1082) and Leschenaultia biloba with Watsonia meriana var. bulbillifera, Ehrharta calycina a	2.2 km S of Karnup Road on Hall Road, S of Serpentine; E side of road in rail reserve	GPS	1	18 10 2003
	PERTH 07463669	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Rail reserve. Compacted light brown clayey sand.	Pericalymma ellipticum low shrubland with Adenanthos meisneri, Synaphea sp. Serpentine (G.R. Brand 103), Leptospermum sp., Hakea spp. and Watsonia meriana var. bulbillifera weed invasion.	0.9 km S of Karnup Road on Hall Road, S of Serpentine; E side of road in rail reserve	GPS	1	10 10 2003
	PERTH 07463677	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Compacted pinkish-light brown clayey sand with lateritic gravel over grey-light brown sandy loam. The earth was distubed with a large number of small mounds and dips.	Very sparse, open Kunzea recurva shrubland with Adenanthos meisneri, Leschenaultia biloba and Synahea gracillima (1 plant near railway line). Weeds included Watsonia meriana var. bulbillifera, Briza maxima, Eragrostis curvula and other grasses.	3.1 km S of Karnup Road on Hall Road, S of Serpentine; E side of road in rail reserve	GPS	1	22 10 2003
	PERTH 05427452	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Flat. Moist, grey, sandy clay. Pinjarra Plain?	Heath. Characteristic species: Marri, other Synaphea.	Hall Road, Serpentine	MAN	0	01 09 1999
	PERTH 07463685	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Degraded railway reserve. Grey, moist clay/sand.	Scattered Marri and Nuytsia floribunda with Eremaea, Mesomelaena tetragona and Xanthorrhoea preissii.	Ca 50 m N of roundabout at Serpentine, rail reserve, E side of line	TOPO	3	26 10 1999
	PERTH 07463707	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Rail/road reserve with grey sand and lateritic gravel.	Shrubland. Leptospermum, Leschenaultia and weeds - Eragrostis curvula, Watsonia bulbillifera and Briza spp.	100 m N of Utley Road on Hall Road, S of Serpentine	TOPO	3	26 10 1999
	PERTH 07463715	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Degraded railway reserve. Grey, moist clay/sand.	Scattered Marri and Nuytsia floribunda with Eremaea, Mesomelaena tetragona and Xanthorrhoea preissii.	Ca 50 m N of roundabout at Serpentine, rail reserve, E side of line	GPS	3	26 10 1999

FID_	Sheet_no	Taxon	Cons_code	Site	Vegetation	Locality	Geocode_me	Prec	Coll_Date
	PERTH 07463766	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Reserve between road and rail. Greyish clay.	Low shrubland of Pericalymma ellipticum and Kunzea, with Hakea spp., Synaphea sp. Serpentine (G.R. Brand 103), Adenanthos and Watsonia meriana var. bubillifera.	600 m S of Karnup Road on Hall Road, E side of road, S of Serpentine	GPS	3	10 10 2003
	PERTH 07463847	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Rail reserve. Compacted greyish red-brown clay.	Kunzea shrubland with some Hypocalymma angustifolium, Lechenaultia biloba, Mesomelaena tetragona, Allocasuarina, Grevillea, Neurachne alopecuroidea, some Watsonia meriana var. bulbillifera, Synaphea petiolaris and S. sp. Fairbridge Farm (D. Papenfus DP 6	3.9 km S along Hall Road from Karnup Road, E side of road; S of Serpentine	GPS	1	22 10 2003
	PERTH 07463731	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Area between road and rail. Light yellow-pinkish brown gravelly clay-sand with lateritic gravel, over light brown clayey sand.	Corymbia calophylla and Eucalyptus sp. woodland remnant with Synaphea petiolaris Xanthorrhoea preissii, Kunzea and Watsonia meriana var. bulbillifera and grass weeds.	4 km S of Karnup Road on Hall Road, E side of road; S of Serpentine	GPS	3	22 10 2003
	PERTH 08187479	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Flat adjacent to wetland area. Brown loam.	Hakea sp., Kingia, Melaleuca sp., Nuytsia floribunda, Stirlingia latifolia. Occurs with Synaphea sp. Serpentine.	Within Lambkin Nature Reserve, Serpentine. Plants occur on the E side of Tonkin Street (also Hardey Street). Beside fencing	GPS	1	23 12 2008
	PERTH 05251400	Synaphea sp. Serpentine (G.R. Brand 103)	3	Flat, wet grey sandy clay. Pinjarra plain.	Heath. Marri adjacent. Dodder.	Serpentine, Hall Road, .5 km S of Karnup Road on E side of road and into rail reserve	MAN	0	06 09 1998
	PERTH 05251397	Synaphea sp. Serpentine (G.R. Brand 103)	3	Flat, winter wetland. Wet grey sandy clay.	Heathland, Marri adjacent.	Serpentine,	MAN	0	06 09 1998
	PERTH 05298865	Synaphea sp. Serpentine (G.R. Brand 103)	3	Brown loam. Swamp.		Serpentine, 3.3 km along Karnup Road from Hall Road,	GPS	1	24 09 1998
	PERTH 05298881	Synaphea sp. Serpentine (G.R. Brand 103)	3	Brown loam. Swamp.		Serpentine, N along Richardson Road from Karnup	GPS	1	21 09 1998
	PERTH 05297192	Synaphea sp. Serpentine (G.R. Brand 103)	3	Swamp. Brown loam.	Pericalymma.	Serpentine, 100 m S along Hall Road from Egerton Road	GPS	1	21 09 1998
	PERTH 05297206	Synaphea sp. Serpentine (G.R. Brand 103)	3	Swamp. Brown loam.		Serpentine, Lambkin Reserve at junction of Richardson Road and Tonkin Road	GPS	1	21 09 1998
	PERTH 05298903	Synaphea sp. Serpentine (G.R. Brand 103)	3	Brown loam. Swamp.	Eragrostis curvula, Watsonia.	Serpentine, 2.8 km along Karnup Road from Hall Road	GPS	1	24 09 1998
	PERTH 05427487	Synaphea sp. Serpentine (G.R. Brand 103)	3	Flat. Wet, grey sand clay. Pinjarra Plain?	Heath. Characteristic species: Marri, Synaphea petiolaris?	Hall Road, Serpentine,	MAN	0	01 09 1999
	PERTH 05055911	Synaphea sp. Serpentine (G.R. Brand 103)	3	Winter wetland, flat, sand/clay.	Heathland.	Lot 783, 0.5 km from Karnup Road along Hall Road, Serpentine	AUTO	3	17 09 1994
	PERTH 06982387	Synaphea sp. Serpentine (G.R. Brand 103)	3	Coastal plain, edge of winter wet site. Seasonally damp. Grey loamy sand.	Open Marri woodland. With Viminaria juncea, Xanthorrhoea preissii, Mesomelaena tetragona.	Southern boundary of Bradby Nature Reserve off Hall Road, Serpentine	GPS	1	28 11 2003
	PERTH 4263308	Synaphea sp. Serpentine (G.R. Brand 103)	3			Cockburn Sound: Serpentine	AUTO	3	12 1900
	PERTH 07469098	Synaphea sp. Serpentine (G.R. Brand 103)	3	Embankment. Brown sandy loam.	Small patch of remnant bush. Corymbia calophylla open woodland with very low shrub layer.	Embankment in front of the Serpentine Tractor Museum, Serpentine	GPS	1	19 09 2003
	PERTH 07469128	Synaphea sp. Serpentine (G.R. Brand 103)	3	Compacted light brown clayey sand.	Pericalymma ellipticum low shrubland with Adenanthos meisneri, Synaphea selenae ms., Leptospermum sp., Hakea sp., and Watsonia bulbillifera weed invasion.	900 m S of Karnup road, E of side of road, S of Serpentine	GPS	1	10 10 2003

FID_	Sheet_no	Taxon	Cons_code	Site	Vegetation	Locality	Geocode_me	Prec	Coll_Date
	PERTH 07469136	Synaphea sp. Serpentine (G.R. Brand 103)	3	Rail reserve. Yellow - grey to grey clayey sand.	Open Corymbia calophylla woodland remnant with Dryandra nivea, Kingia australis, Xanthorrhoea preissii, Kenedia prostrata, Hakea prostrata, Hypocalymma angustifolium, Synaphea petiolaris, Dampiera sp., Poaceae sp., Restionaceae sp., Watsonia bulbillifera	6.8 km S along Richardson road from rail crossing at Watkins road, E of railway line, Serpentine	GPS	1	09 10 2003
	PERTH 07469144	Synaphea sp. Serpentine (G.R. Brand 103)	3	Degraded railway reserve. Grey moist clay sand.	Scattered Marri and Nuytsia floribunda with Eremaea sp., Mesomelaena tetragona, and Xanthorrhoea preissii.	Ca 50 km N of roundabout at Serpentine. Rail reserve E side of line	TOPO	3	26 10 1999
	PERTH 07469152	Synaphea sp. Serpentine (G.R. Brand 103)	3	Degraded rail reserve. Compacted grey clay sand with gravel.	Degraded shrubland. Macrozamia sp., Synaphea xela, Eragrostis curvula, Watsonia bulbillifera, Stipa sp.	Hall road, opposite entrance to Paul Robinson Reserve, ca 100 m N of Leslie st, S of Serpentine	TOPO	3	26 10 1999
	PERTH 07469160	Synaphea sp. Serpentine (G.R. Brand 103)	3	Seasonally wet rail reserve.	Edge of Pericalymma ellipticum, Leptospermum sp., Adenanthos low shrubland with Synaphea ? petiolaris (RB 1061).	800 m S of Karnup road on Hall road, E side of road, S of Serpentine	GPS	1	10 10 2003
	PERTH 07463596	Synaphea sp. Serpentine (G.R. Brand 103)	3	Rail reserve. Brown loam.	Low shrubland of Pericalymma ellipticum, Leptospermum, Adenanthos, Hakea prostrata, Synaphea ?sp. Pinjarra Plain (A.S. George 17182), Grevillea sp., Drosera sp., Watsonia meriana var. bulbillifera.	600 m S of Karnup Road on Hall Road, E side of road, S of Serpentine	GPS	1	10 10 2003
	PERTH 07469101	Synaphea sp. Serpentine (G.R. Brand 103)	3	Very degraded rail reserve. Compacted grey clayey - sand with gravel.	Degraded shrubland of Macrozamia sp., Synaphea xela, Eragrostis curvula, Watsonia bulbillifera, Stipa sp.	Hall road, opposite entrance to Paul Robinson Reserve, ca 100 m N of Leslie street, S of Serpentine	TOPO	3	26 10 1999
	PERTH 05298873	Synaphea sp. Serpentine (G.R. Brand 103)	3	Swamp. Brown loam.	Pericalymma.	S of Serpentine at junction of Hall Road and Bate Road	GPS	1	21 09 1998
	PERTH 07469187	Synaphea sp. Serpentine (G.R. Brand 103)	3	Winter wet rail reserve. Compacted light brown sandy loam with lateritic gravel.	Kunzea recurva thicket with some Pericalymma ellipticum over Adenanthos meisneri, Mesomelaena tetragona, Synaphea selenae, Synaphea sp. (RB 1082) and Leschenaultia biloba, Watsonia bulbillifera, Ehrharta calycina and Eragrostis curvula weed invasion.	2.25 km S of Karnup road on Hall road, E side of road, S of Serpentine	GPS	1	18 10 2003
	PERTH 08187487	Synaphea sp. Serpentine (G.R. Brand 103)	3	Flat, gentle slope to wetland. Yellow/brown sand.	Grevillea sp., Haemodorum sp., Hakea prostrata, Kingia, Nuytsia floribunda, Stirlingia.	Within Lambkin Nature Reserve, Serpentine. Population is off Tonkin Street (or could be Hardey Road), E of the railway	GPS	1	07 01 2009
	PERTH 04528913	Tetraria australiensis	T	Grey sand over clay.	Eucalyptus calophylla woodland.	Lambkin Reserve, Serpentine,	MAN	0	21 04 1996
	PERTH 08321000	Tetraria australiensis	T	Well drained. Flat. Moist grey sandy loam/light clay. Boundary of Ridge Hill Shelf and Guildford Clay.	20% cover Corymbia calophylla, 25% cover grasses: Neurachne allopecuroidea, 30% cover sedges: Tetraria australis, Lomandra spp. Associated species: Corymbia calophylla, Kingia australis, Tricoryne elatior, Xanthorrhoea preissii, Burchardia congesta, Tetr	E side of Byford to Serpentine Rail Line; ca 80 m S of gravel 'parking area' at S end of Hardey Road, Serpentine (Quadrat Byford 08)	GPS	1	29 09 2011
	PERTH 06428312	Verticordia lindleyi subsp. lindleyi	4	Wet Flat, orange brown sandy clay, poor drainage, wet during winter/spring.	Associated species: Viminaria juncea.	Karnup Road Reserve just to SW of intersection with Rapids Road in Karnup Road Bushland (Bush Forever Site 74), Peel Estate, in System 6 Update quadrat punr03	GPS	1	09 11 1995
	PERTH 1894196	Verticordia lindleyi subsp. lindleyi	4	On clay flat near drain.	In open scrub.	Near junction of Karnup Road and Punrack Road, W of Serpentine	MAN	0	27 12 1988
	PERTH 1026526	Verticordia plumosa var. ananeotes	T			Serpentine, between Perth and Pinjarra.	MAN	3	11 1900
	PERTH 1026518	Verticordia plumosa var. ananeotes	T			Cockburn Sound, Serpentine District	MAN	3	12 1900

APPENDIX 6

Naturemap Report

NatureMap Species Report

Created By Jackalyn Hams on 15/10/2013

Current Names Only Yes
Core Datasets Only Yes
Method 'By Circle'
Centre 115°58' 41" E,32°21' 48" S
Buffer 5km
Group By Conservation Status

Conservation Status	Species	Records
Rare or likely to become extinct	10	77
Other specially protected fauna	1	1
Priority 1	2	17
Priority 2	1	3
Priority 3	5	50
Priority 4	5	16
Priority 5	1	13
Non-conservation taxon	573	2753
TOTAL	**598**	**2930**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Rare or likely to become extinct					
1.	1596	*Caladenia huegelii (Grand Spider Orchid)*		T	
2.	24731	*Calyptorhynchus banksii subsp. naso (Forest Red-tailed Black-Cockatoo)*		T	
3.	24733	*Calyptorhynchus baudinii (Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo)*		T	
4.	24734	*Calyptorhynchus latirostris (Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo)*		T	
5.	24092	*Dasyurus geoffroii (Chuditch, Western Quoll)*		T	
6.	17000	*Lasiopetalum pterocarpum*		T	
7.	24099	*Phascogale tapoatafa subsp. tapoatafa (Southern Brush-tailed Phascogale, Wambenger)*		T	
8.	18590	*Synaphea sp. Fairbridge Farm (D. Papenfus 696)*		T	
9.	1033	*Tetraria australiensis*		T	
10.	12448	*Verticordia plumosa var. ananeotes*		T	
Other specially protected fauna					
11.	24475	*Falco peregrinus subsp. macropus (Australian Peregrine Falcon)*		S	
Priority 1					
12.	16865	*Synaphea odocoileops*		P1	
13.	30751	*Synaphea sp. Pinjarra Plain (A.S. George 17182)*		P1	
Priority 2					
14.	19272	*Johnsonia pubescens subsp. cygnorum*		P2	
Priority 3					
15.	3373	*Acacia horridula*		P3	
16.	14129	*Acacia oncinophylla subsp. oncinophylla*		P3	
17.	41801	*Eryngium pinnatifidum subsp. Palustre (G.J. Keighery 13459)*		P3	
18.	2228	*Isopogon drummondii*		P3	
19.	28354	*Synaphea sp. Serpentine (G.R. Brand 103)*		P3	
Priority 4					
20.	13191	*Drosera occidentalis subsp. occidentalis*		P4	
21.	6573	*Parsonsia diaphanophleba*		P4	
22.	8212	*Senecio leucoglossus*		P4	
23.	14714	*Verticordia lindleyi subsp. lindleyi*		P4	
24.	34113	*Westralunio carteri (Carter's Freshwater Mussel)*		P4	
Priority 5					
25.	24153	*Isoodon obesulus subsp. fusciventer (Quenda, Southern Brown Bandicoot)*		P5	
Non-conservation taxon					
26.	-13853	*? ?*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
27.	15429	*Acacia alata var. alata*			
28.	3294	*Acacia dentifera*			
29.	11192	*Acacia drummondii subsp. elegans*			
30.	3382	*Acacia incrassata*			
31.	3383	*Acacia incurva*			
32.	3410	*Acacia lateriticola*			
33.	3454	*Acacia nervosa (Rib Wattle)*			
34.	3464	*Acacia obovata*			
35.	3502	*Acacia pulchella (Prickly Moses)*			
36.	15483	*Acacia pulchella var. pulchella*			
37.	3527	*Acacia saligna (Orange Wattle, Kudjong)*			
38.	30032	*Acacia saligna subsp. saligna*			
39.	3541	*Acacia sessilis*			
40.	3557	*Acacia stenoptera (Narrow Winged Wattle)*			
41.	3574	*Acacia teretifolia*			
42.	3591	*Acacia urophylla*			
43.	24260	*Acanthiza apicalis (Broad-tailed Thornbill, Inland Thornbill)*			
44.	24261	*Acanthiza chrysorrhoa (Yellow-rumped Thornbill)*			
45.	24262	*Acanthiza inornata (Western Thornbill)*			
46.	1205	*Acanthocarpus canaliculatus*			
47.	1208	*Acanthocarpus preissii*			
48.	24560	*Acanthorhynchus superciliosus (Western Spinebill)*			
49.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
50.	25536	*Accipiter fasciatus (Brown Goshawk)*			
51.	6205	*Actinotus leucocephalus (Flannel Flower)*			
52.	14970	*Adenanthos barbiger*			
53.	1790	*Adenanthos meisneri*			
54.	23474	*Agrostocrinum hirsutum*			
55.	1261	*Agrostocrinum scabrum (Blue Grass Lily)*			
56.	184	*Aira caryophyllea (Silvery Hairgrass)*	Y		
57.	1731	*Allocasuarina huegeliana (Rock Sheoak, Kwowl)*			
58.	1732	*Allocasuarina humilis (Dwarf Sheoak)*			
59.	-11863	*Allothereua maculata*			
60.	13380	*Amphibromus nervosus*			
61.	197	*Amphipogon debilis*			
62.	20184	*Amphipogon laguroides subsp. laguroides*			
63.	199	*Amphipogon strictus (Greybeard Grass)*			
64.	200	*Amphipogon turbinatus*			
65.	-12196	*Aname mainae*			
66.	24312	*Anas gracilis (Grey Teal)*			
67.	24316	*Anas superciliosa (Pacific Black Duck)*			
68.	6300	*Andersonia aristata (Rice Flower)*			
69.	6314	*Andersonia lehmanniana*			
70.	7833	*Angianthus preissianus*			
71.	1411	*Anigozanthos manglesii (Mangles Kangaroo Paw, Kurulbrang)*			
72.	1416	*Anigozanthos viridis (Green Kangaroo Paw, Kurulbardang)*			
73.	11566	*Anigozanthos viridis subsp. viridis*			
74.	24561	*Anthochaera carunculata (Red Wattlebird)*			
75.	24562	*Anthochaera lunulata (Western Little Wattlebird)*			
76.	12724	*Anthotium junciforme*			
77.	-12101	*Antichiropus variabilis*			
78.	24285	*Aquila audax (Wedge-tailed Eagle)*			
79.	-12899	*Araneus senicaudatus*			
80.	7838	*Arctotheca calendula (Cape Weed)*	Y		
81.	24341	*Ardea pacifica (White-necked Heron)*			
82.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
83.	24353	*Artamus cyanopterus (Dusky Woodswallow)*			
84.	20350	*Astartea affinis*			
85.	20249	*Astartea leptophylla*			
86.	6323	*Astroloma ciliatum (Candle Cranberry)*			
87.	6334	*Astroloma pallidum (Kick Bush)*			
88.	-12131	*Australotiphys barmutai*			
89.	17233	*Austrostipa campylachne*			
90.	17234	*Austrostipa compressa*			
91.	233	*Avena barbata (Bearded Oat)*	Y		
92.	36441	*Babingtonia camphorosmae (Camphor Myrtle)*			
93.	1800	*Banksia attenuata (Slender Banksia, Piara)*			
94.	1852	*Banksia telmatiaea (Swamp Fox Banksia)*			
95.	32054	*Banksia undata var. undata*			
96.	32315	*Barbula calycina*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
97.	32321	*Bartramia breutelii*			
98.	32323	*Bartramia pseudostricta*			
99.	15037	*Bartsia trixago*	Y		
100.	743	*Baumea juncea (Bare Twigrush)*			
101.	745	*Baumea preissii*			
102.	748	*Baumea vaginalis (Sheath Twigrush)*			
103.	4598	*Beyeria lechenaultii (Pale Turpentine Bush)*			
104.	25788	*Billardiera fraseri (Elegant Pronaya)*			
105.	1417	*Blancoa canescens (Winter Bell)*			
106.	11503	*Boronia crenulata var. crenulata*			
107.	4429	*Boronia molloyae (Tall Boronia)*			
108.	11564	*Boronia ramosa subsp. ramosa*			
109.	1273	*Borya sphaerocephala (Pincushions)*			
110.	14396	*Bossiaea aquifolium subsp. aquifolium*			
111.	3710	*Bossiaea eriocarpa (Common Brown Pea)*			
112.	3714	*Bossiaea ornata (Broad Leaved Brown Pea)*			
113.	3718	*Bossiaea rufa*			
114.	18497	*Bossiaea sp. Waroona (B.J. Keighery & N. Gibson 229)*			
115.	-15786	*Bostockia porosa*			
116.	8661	*Brachypodium distachyon (False Brome)*	Y		
117.	7871	*Brachyscome ciliaris*			
118.	32327	*Breutelia affinis*			
119.	244	*Briza maxima (Blowfly Grass)*	Y		
120.	245	*Briza minor (Shivery Grass)*	Y		
121.	247	*Bromus arenarius (Sand Brome)*			
122.	250	*Bromus hordeaceus (Soft Brome)*	Y		
123.	12770	*Burchardia congesta*			
124.	1385	*Burchardia multiflora (Dwarf Burchardia)*			
125.	25716	*Cacatua sanguinea (Little Corella)*			
126.	25598	*Cacomantis flabelliformis (Fan-tailed Cuckoo)*			
127.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			
128.	1276	*Caesia micrantha (Pale Grass Lily)*			
129.	1277	*Caesia occidentalis*			
130.	1590	*Caladenia ferruginea (Rusty Spider Orchid)*			
131.	1592	*Caladenia flava (Cowslip Orchid)*			
132.	1605	*Caladenia marginata (White Fairy Orchid)*			
133.	16365	*Calandrinia sp. Kenwick (G.J. Keighery 10905)*			
134.	19307	*Calectasia grandiflora subsp. grandiflora*			
135.	4717	*Callitriche stagnalis (Common Starwort)*	Y		
136.	36600	*Callitris pyramidalis (Swamp Cypress)*			
137.	5431	*Calothamnus torulosus*			
138.	25717	*Calyptorhynchus banksii (Red-tailed Black-Cockatoo)*			
139.	5437	*Calytrix acutifolia*			
140.	2952	*Cassytha glabella (Tangled Dodder Laurel)*			
141.	2956	*Cassytha pomiformis (Dodder Laurel)*			
142.	2957	*Cassytha racemosa (Dodder Laurel)*			
143.	6539	*Centaurium erythraea (Common Centaury)*	Y		
144.	1121	*Centrolepis aristata (Pointed Centrolepis)*			
145.	1125	*Centrolepis drummondiana*			
146.	1134	*Centrolepis polygyna (Wiry Centrolepis)*			
147.	-12810	*Cercophonius sulcatus*			
148.	1280	*Chamaescilla corymbosa (Blue Squill)*			
149.	31	*Cheilanthes austrotenuifolia*			
150.	24321	*Chenonetta jubata (Australian Wood Duck, Wood Duck)*			
151.	8971	*Chorizema cordatum*			
152.	3753	*Chorizema dicksonii (Yellow-eyed Flame Pea)*			
153.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
154.	4550	*Comesperma calymega (Blue-spike Milkwort)*			
155.	4551	*Comesperma ciliatum*			
156.	4564	*Comesperma virgatum (Milkwort)*			
157.	1875	*Conospermum huegelii (Slender Smokebush)*			
158.	1882	*Conospermum stoechadis (Common Smokebush)*			
159.	15611	*Conospermum stoechadis subsp. stoechadis (Common Smokebush)*			
160.	12109	*Conostylis aculeata subsp. preissii*			
161.	1454	*Conostylis setigera (Bristly Cottonhead)*			
162.	1455	*Conostylis setosa (White Cottonhead)*			
163.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
164.	-1758	*Cormocephalus aurantiipes*			
165.	-1711	*Cormocephalus turneri*			
166.	25592	*Corvus coronoides (Australian Raven)*			

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167.	17104	*Corymbia calophylla (Marri)*			
168.	7947	*Cotula turbinata (Funnel Weed)*	Y		
169.	25595	*Cracticus tibicen (Australian Magpie)*			
170.	24422	*Cracticus tibicen subsp. dorsalis (White-backed Magpie)*			
171.	25596	*Cracticus torquatus (Grey Butcherbird)*			
172.	13354	*Craspedia variabilis*			
173.	29054	*Crepis foetida subsp. foetida*	Y		
174.	25398	*Crinia georgiana (Quacking Frog)*			
175.	25401	*Crinia pseudinsignifera (Bleating Froglet)*			
176.	35838	*Cristonia biloba subsp. biloba*			
177.	30893	*Cryptoblepharus buchananii*			
178.	24883	*Ctenophorus ornatus (Ornate Crevice-Dragon)*			
179.	25049	*Ctenotus labillardieri*			
180.	6663	*Cuscuta epithymum (Lesser Dodder, Greater Dodder)*	Y		
181.	768	*Cyathochaeta avenacea*			
182.	815	*Cyperus tenellus (Tiny Flatsedge)*	Y		
183.	17692	*Cytogonidium leptocarpoides*			
184.	30901	*Dacelo novaeguineae (Laughing Kookaburra)*	Y		
185.	7420	*Dampiera alata (Winged-stem Dampiera)*			
186.	7454	*Dampiera linearis (Common Dampiera)*			
187.	25673	*Daphoenositta chrysoptera (Varied Sittella)*			
188.	5508	*Darwinia citriodora (Lemon-scented Darwinia)*			
189.	5531	*Darwinia thymoides*			
190.	1218	*Dasypogon bromeliifolius (Pineapple Bush)*			
191.	6960	*Datura ferox (Fierce Thornapple)*	Y		
192.	6218	*Daucus glochidiatus (Australian Carrot)*			
193.	15656	*Daviesia brachyphylla*			
194.	16579	*Daviesia decipiens*			
195.	3805	*Daviesia decurrens (Prickly Bitter-pea)*			
196.	3815	*Daviesia horrida (Prickly Bitter-pea)*			
197.	3835	*Daviesia preissii*			
198.	38782	*Dermocybe globuliformis*			
199.	17663	*Desmocladus asper*			
200.	15831	*Desmocladus castaneus*			
201.	17691	*Desmocladus fasciculatus*			
202.	11636	*Dianella revoluta var. divaricata*			
203.	25607	*Dicaeum hirundinaceum (Mistletoebird)*			
204.	306	*Dichelachne crinita (Longhair Plumegrass)*			
205.	1287	*Dichopogon capillipes*			
206.	17838	*Dielsia stenostachya*			
207.	-11742	*Dinocambala ingens*			
208.	1509	*Dioscorea hastifolia (Warrine, Wararn)*			
209.	24939	*Diplodactylus polyophthalmus*			
210.	18589	*Diplopeltis huegelii subsp. lehmannii*			
211.	4757	*Dodonaea ceratocarpa*			
212.	24470	*Dromaius novaehollandiae (Emu)*			
213.	3095	*Drosera erythrorhiza (Red Ink Sundew)*			
214.	3106	*Drosera macrantha (Bridal Rainbow)*			
215.	12243	*Drosera mannii*			
216.	3109	*Drosera menziesii (Pink Rainbow)*			
217.	13216	*Drosera menziesii subsp. penicillaris*			
218.	3118	*Drosera pallida (Pale Rainbow)*			
219.	8911	*Drosera rosulata*			
220.	3131	*Drosera stolonifera (Leafy Sundew)*			
221.	25096	*Egernia kingii (King's Skink)*			
222.	349	*Ehrharta longiflora (Annual Veldt Grass)*	Y		
223.	25250	*Elapognathus coronatus (Crowned Snake)*			
224.	1643	*Elythranthera brunonis (Purple Enamel Orchid)*			
225.	24652	*Eopsaltria georgiana (White-breasted Robin)*			
226.	379	*Eragrostis elongata (Clustered Lovegrass)*			
227.	6219	*Eryngium pinnatifidum (Blue Devils)*			
228.	15446	*Eryngium pinnatifidum subsp. pinnatifidum*			
229.	5616	*Eucalyptus decurva (Slender Mallee)*			
230.	5688	*Eucalyptus laeliae (Darling Range Ghost Gum)*			
231.	5690	*Eucalyptus lane-poolei (Salmon White Gum)*			
232.	5708	*Eucalyptus marginata (Jarrah, Djara)*			
233.	13547	*Eucalyptus marginata subsp. marginata (Jarrah)*			
234.	5763	*Eucalyptus rudis (Flooded Gum, Kulurda)*			
235.	13511	*Eucalyptus rudis subsp. rudis*			
236.	5797	*Eucalyptus wandoo (Wandoo, Wondu)*			

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237.	12906	*Eucalyptus wandoo subsp. wandoo*			
238.	3872	*Euchilopsis linearis (Swamp Pea)*			
239.	-12122	*Eucyrtops latior*			
240.	4627	*Euphorbia helioscopia (Sun Spurge)*	Y		
241.	4648	*Euphorbia terracina (Geraldton Carnation Weed)*	Y		
242.	3880	*Eutaxia virgata*			
243.	25621	*Falco berigora (Brown Falcon)*			
244.	25622	*Falco cenchroides (Australian Kestrel)*			
245.	1747	*Ficus carica (Common Fig)*	Y		
246.	32365	*Fissidens leptocladus*			
247.	32367	*Fissidens megalotis*			
248.	32469	*Fissidens taylorii var. taylorii*			
249.	2969	*Fumaria capreolata (Whiteflower Fumitory)*	Y		
250.	34028	*Galaxias occidentalis (Western Minnow)*			
251.	7321	*Galium divaricatum*	Y		
252.	7323	*Galium murale (Small Goosegrass)*	Y		
253.	20513	*Gastrolobium dilatatum*			
254.	20473	*Gastrolobium ebracteolatum*			
255.	3924	*Gastrolobium spinosum (Prickly Poison)*			
256.	32383	*Gemmabryum sullivanii*			
257.	25404	*Geocrinia leai (Ticking Frog)*			
258.	25530	*Gerygone fusca (Western Gerygone)*			
259.	1524	*Gladiolus undulatus (Wild Gladiolus)*	Y		
260.	3945	*Gompholobium aristatum*			
261.	10909	*Gompholobium confertum*			
262.	3950	*Gompholobium knightianum*			
263.	3951	*Gompholobium marginatum*			
264.	3954	*Gompholobium polymorphum*			
265.	6149	*Gonocarpus cordiger*			
266.	29362	*Goodenia coerulea*			
267.	24443	*Grallina cyanoleuca (Magpie-lark)*			
268.	1964	*Grevillea bipinnatifida (Fuchsia Grevillea)*			
269.	19628	*Grevillea bipinnatifida subsp. bipinnatifida*			
270.	13429	*Grevillea diversifolia subsp. diversifolia*			
271.	1997	*Grevillea endlicheriana (Spindly Grevillea)*			
272.	13450	*Grevillea manglesii subsp. manglesii*			
273.	2066	*Grevillea pilulifera (Woolly-flowered Grevillea)*			
274.	2122	*Grevillea wilsonii (Native Fuchsia)*			
275.	32473	*Grimmia pulvinata var. africana*			
276.	1465	*Haemodorum discolor*			
277.	1468	*Haemodorum laxum*			
278.	1472	*Haemodorum simplex*			
279.	1474	*Haemodorum sparsiflorum*			
280.	2128	*Hakea amplexicaulis (Prickly Hakea)*			
281.	2137	*Hakea ceratophylla (Horned Leaf Hakea)*			
282.	2152	*Hakea cyclocarpa (Ramshorn)*			
283.	2166	*Hakea incrassata (Marble Hakea)*			
284.	2175	*Hakea lissocarpha (Honey Bush)*			
285.	2203	*Hakea ruscifolia (Candle Hakea)*			
286.	2206	*Hakea stenocarpa (Narrow-fruited Hakea)*			
287.	2212	*Hakea sulcata (Furrowed Hakea)*			
288.	2214	*Hakea trifurcata (Two-leaf Hakea)*			
289.	2215	*Hakea undulata (Wavy-leaved Hakea)*			
290.	32392	*Hedwigidium integrifolium*			
291.	439	*Hemarthria uncinata (Matgrass)*			
292.	25115	*Hemiergis initialis subsp. initialis*			
293.	6856	*Hemigenia incana (Silky Hemigenia)*			
294.	-11740	*Henicops dentatus*			
295.	1293	*Hensmania turbinata*			
296.	5108	*Hibbertia acerosa (Needle Leaved Guinea Flower)*			
297.	5114	*Hibbertia commutata*			
298.	5135	*Hibbertia hypericoides (Yellow Buttercups)*			
299.	5148	*Hibbertia mylnei*			
300.	5150	*Hibbertia nymphaea*			
301.	5155	*Hibbertia pilosa (Hairy Guinea Flower)*			
302.	5169	*Hibbertia serrata (Serrate Leaved Guinea Flower)*			
303.	11481	*Hibbertia spicata subsp. spicata*			
304.	5173	*Hibbertia subvaginata*			
305.	24491	*Hirundo neoxena (Welcome Swallow)*			
306.	6222	*Homalosciadium homalocarpum*			

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307.	3964	*Hovea chorizemifolia (Holly-leaved Hovea)*			
308.	3966	*Hovea pungens (Devil's Pins, Puyenak)*			
309.	3968	*Hovea trisperma (Common Hovea)*			
310.	12741	*Hyalosperma cotula*			
311.	12007	*Hybanthus floribundus subsp. floribundus*			
312.	6226	*Hydrocotyle callicarpa (Small Pennywort)*			
313.	5817	*Hypocalymma angustifolium (White Myrtle, Kudjid)*			
314.	5825	*Hypocalymma robustum (Swan River Myrtle)*			
315.	8086	*Hypochaeris glabra (Smooth Catsear)*	Y		
316.	9352	*Hypochaeris radicata (Flat Weed)*	Y		
317.	1070	*Hypolaena exsulca*			
318.	-13273	*Idiommata blackwalli*			
319.	20200	*Isolepis cernua var. setiformis*			
320.	917	*Isolepis marginata (Coarse Club-rush)*	Y		
321.	919	*Isolepis oldfieldiana*			
322.	-1666	*Isometroides vescus*			
323.	-12192	*Isopeda leishmanni*			
324.	2221	*Isopogon asper*			
325.	7396	*Isotoma hypocrateriformis (Woodbridge Poison)*			
326.	4018	*Jacksonia lehmannii*			
327.	4025	*Jacksonia restioides*			
328.	1180	*Juncus capitatus (Capitate Rush)*	Y		
329.	11922	*Juncus kraussii subsp. australiensis*			
330.	1196	*Juncus usitatus (Common Rush)*	Y		
331.	-12097	*Karaops ellenae*			
332.	4037	*Kennedia coccinea (Coral Vine)*			
333.	4045	*Kennedia stirlingii (Bushy Kennedia)*			
334.	1221	*Kingia australis (Kingia, Pulonok)*			
335.	5835	*Kunzea micrantha*			
336.	17461	*Kunzea micrantha subsp. micrantha*			
337.	3667	*Labichea lanceolata (Tall Labichea)*			
338.	11289	*Labichea lanceolata subsp. lanceolata*			
339.	3669	*Labichea punctata (Lance-leaved Cassia)*			
340.	18585	*Lagenophora huegelii*			
341.	14083	*Lambertia multiflora var. darlingensis*			
342.	11911	*Laxmannia ramosa subsp. ramosa*			
343.	1309	*Laxmannia squarrosa*			
344.	7568	*Lechenaultia biloba (Blue Leschenaultia)*			
345.	41620	*Lepidosperma asperatum*			
346.	936	*Lepidosperma leptostachyum*			
347.	940	*Lepidosperma pubisquameum*			
348.	29141	*Lepidosperma sp. Gosnells (A. Markey 1145)*			
349.	29150	*Lepidosperma sp. Margaret River (B.J. Lepschi 1841)*			
350.	949	*Lepidosperma tuberculatum*			
351.	2342	*Leptomeria cunninghamii*			
352.	1085	*Lepyrodia glauca*			
353.	25131	*Lerista distinguenda*			
354.	6367	*Leucopogon capitellatus*			
355.	6400	*Leucopogon gracillimus*			
356.	6436	*Leucopogon propinquus*			
357.	6439	*Leucopogon pulchellus (Beard-heath)*			
358.	6447	*Leucopogon strictus*			
359.	7676	*Levenhookia pusilla (Midget Stylewort)*			
360.	7677	*Levenhookia stipitata (Common Stylewort)*			
361.	25661	*Lichmera indistincta (Brown Honeyeater)*			
362.	4363	*Linum trigynum (French Flax)*	Y		
363.	9289	*Lobelia anceps (Angled Lobelia)*			
364.	7402	*Lobelia gibbosa (Tall Lobelia)*			
365.	7403	*Lobelia heterophylla (Wing-seeded Lobelia)*			
366.	478	*Lolium rigidum (Wimmera Ryegrass)*	Y		
367.	1222	*Lomandra brittanii*			
368.	1223	*Lomandra caespitosa (Tufted Mat Rush)*			
369.	1228	*Lomandra hermaphrodita*			
370.	1229	*Lomandra integra*			
371.	1232	*Lomandra micrantha (Small-flower Mat-rush)*			
372.	14542	*Lomandra micrantha subsp. micrantha*			
373.	1234	*Lomandra nigricans*			
374.	1236	*Lomandra odora (Tiered Matrush)*			
375.	1239	*Lomandra preissii*			
376.	1240	*Lomandra purpurea (Purple Mat Rush)*			

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377.	1243	*Lomandra sericea (Silky Mat Rush)*			
378.	1244	*Lomandra sonderi*			
379.	1245	*Lomandra spartea*			
380.	4059	*Lotus angustissimus (Narrowleaf Trefoil)*	Y		
381.	8564	*Lotus subbiflorus*	Y		
382.	85	*Macrozamia riedlei (Zamia, Djiridji)*			
383.	25650	*Malurus elegans (Red-winged Fairy-wren)*			
384.	25654	*Malurus splendens (Splendid Fairy-wren)*			
385.	17630	*Marianthus tenuis*			
386.	17747	*Meeboldina decipiens*			
387.	18394	*Melaleuca parviceps*			
388.	5958	*Melaleuca radula (Graceful Honeymyrtle)*			
389.	5959	*Melaleuca rhaphiophylla (Swamp Paperbark)*			
390.	5964	*Melaleuca seriata*			
391.	5983	*Melaleuca trichophylla*			
392.	13280	*Melaleuca viminea subsp. viminea*			
393.	953	*Mesomelaena graciliceps*			
394.	955	*Mesomelaena pseudostygia*			
395.	11473	*Mesomelaena stygia subsp. stygia*			
396.	957	*Mesomelaena tetragona (Semaphore Sedge)*			
397.	485	*Microlaena stipoides (Weeping Grass)*			
398.	11747	*Microlaena stipoides var. stipoides*			
399.	15419	*Microtis media subsp. media*			
400.	14344	*Millotia tenuifolia var. tenuifolia (Soft Millotia)*			
401.	4090	*Mirbelia dilatata (Holly-leaved Mirbelia)*			
402.	4091	*Mirbelia floribunda (Purple Mirbelia)*			
403.	4100	*Mirbelia spinosa*			
404.	37440	*Monopsis debilis var. depressa*	Y		
405.	24738	*Neophema elegans (Elegant Parrot)*			
406.	-15725	*Neosilurus hyrtlii*			
407.	492	*Neurachne alopecuroidea (Foxtail Mulga Grass)*			
408.	25252	*Notechis scutatus (Tiger Snake)*			
409.	-12530	*Nunciella aspera*			
410.	-12547	*Occiperipatoides gilesii*			
411.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
412.	2365	*Olax benthamiana*			
413.	8143	*Olearia paucidentata (Autumn Scrub Daisy)*			
414.	18254	*Opercularia apiciflora*			
415.	7346	*Opercularia echinocephala (Bristly Headed Stink Weed)*			
416.	18255	*Opercularia vaginata (Dog Weed)*			
417.	11749	*Orthrosanthus laxus var. laxus (Morning Iris)*			
418.	24085	*Oryctolagus cuniculus (Rabbit)*	Y		
419.	4355	*Oxalis perennans*			
420.	25679	*Pachycephala pectoralis (Golden Whistler)*			
421.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
422.	25253	*Parasuta gouldii*			
423.	25681	*Pardalotus punctatus (Spotted Pardalote)*			
424.	25682	*Pardalotus striatus (Striated Pardalote)*			
425.	7089	*Parentucellia latifolia (Common Bartsia)*	Y		
426.	7090	*Parentucellia viscosa (Sticky Bartsia)*	Y		
427.	27922	*Parmotrema chinense*			
428.	527	*Paspalum dilatatum*	Y		
429.	1542	*Patersonia babianoides*			
430.	1550	*Patersonia occidentalis (Purple Flag, Koma)*			
431.	1551	*Patersonia pygmaea (Pygmy Patersonia)*			
432.	11550	*Patersonia umbrosa var. xanthina (Yellow Flags)*			
433.	6245	*Pentapeltis peltigera*			
434.	39058	*Perichaena depressa*			
435.	2267	*Persoonia longifolia (Snottygobble)*			
436.	2273	*Persoonia saccata (Snottygobble)*			
437.	2284	*Petrophile biloba (Granite Petrophile)*			
438.	2312	*Petrophile striata*			
439.	24409	*Phaps chalcoptera (Common Bronzewing)*			
440.	32409	*Philonotis australiensis*			
441.	18529	*Philotheca spicata (Pepper and Salt)*			
442.	1173	*Philydrella pygmaea (Butterfly Flowers)*			
443.	24596	*Phylidonyris novaehollandiae (New Holland Honeyeater)*			
444.	16177	*Phyllangium paradoxum*			
445.	4675	*Phyllanthus calycinus (False Boronia)*			
446.		*Phytophthora cinnamomi*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
447.	11667	*Pimelea brevistyla subsp. brevistyla*			
448.	5251	*Pimelea imbricata*			
449.	11402	*Pimelea imbricata var. piligera*			
450.	5259	*Pimelea preissii*			
451.	12041	*Pimelea suaveolens subsp. suaveolens*			
452.	8165	*Pithocarpa pulchella (Beautiful Pithocarpa)*			
453.	25720	*Platycercus icterotis (Western Rosella)*			
454.	6253	*Platysace filiformis*			
455.	32413	*Pleuridium ecklonii*			
456.	573	*Poa drummondiana (Knotted Poa)*			
457.	8175	*Podolepis gracilis (Slender Podolepis)*			
458.	-13158	*Poecilipta smaragdinea*			
459.	2419	*Polygonum aviculare (Wireweed)*	Y		
460.	25722	*Polytelis anthopeplus (Regent Parrot)*			
461.	4691	*Poranthera microphylla (Small Poranthera)*			
462.	1677	*Prasophyllum macrostachyum (Laughing Leek Orchid)*			
463.	10853	*Prasophyllum plumiforme*			
464.	25259	*Pseudonaja affinis subsp. affinis (Dugite)*			
465.	25433	*Pseudophryne guentheri (Crawling Toadlet)*			
466.	13255	*Pterochaeta paniculata*			
467.	24173	*Pteropus scapulatus (Little Red Flying-fox)*			
468.	2742	*Ptilotus manglesii (Pom Poms, Mulamula)*			
469.	32480	*Racopilum cuspidigerum var. convolutaceum*			
470.	25285	*Ramphotyphlops pinguis*			
471.	-12205	*Raveniella cirrata*			
472.	6012	*Regelia ciliata*			
473.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
474.	15035	*Rhodanthe corymbosa*			
475.	13234	*Rhodanthe manglesii*			
476.	1556	*Romulea rosea (Guildford Grass)*	Y		
477.	20506	*Rubus anglocandicans*	Y		
478.	23990	*Rubus ulmifolius var. ulmifolius*	Y		
479.	2433	*Rumex crispus (Curled Dock)*	Y		
480.	40427	*Rytidosperma setaceum*			
481.	7602	*Scaevola calliptera*			
482.	7613	*Scaevola glandulifera (Viscid Hand-flower)*			
483.	7635	*Scaevola pilosa (Hairy Fan-flower)*			
484.	6263	*Schoenolaena juncea*			
485.	975	*Schoenus bifidus*			
486.	978	*Schoenus brevisetis*			
487.	979	*Schoenus caespititius*			
488.	991	*Schoenus grammatophyllus*			
489.	1002	*Schoenus nanus (Tiny Bog Rush)*			
490.	17614	*Schoenus plumosus*			
491.	1013	*Schoenus sculptus (Gimlet Bog-rush)*			
492.	18164	*Schoenus sp. smooth culms (K.R. Newbey 7823)*			
493.	1023	*Schoenus tenellus*			
494.	1026	*Schoenus unispiculatus*			
495.	17409	*Schoenus variicellae*			
496.	-1669	*Scolopendra laeta*			
497.	32433	*Sematophyllum homomallum*			
498.	8203	*Senecio diaschides*	Y		
499.	20663	*Senecio multicaulis subsp. multicaulis*			
500.	25534	*Sericornis frontalis (White-browed Scrubwren)*			
501.	8225	*Siloxerus humifusus (Procumbent Siloxerus)*			
502.	30948	*Smicrornis brevirostris (Weebill)*			
503.	8231	*Sonchus oleraceus (Common Sowthistle)*	Y		
504.	617	*Sorghum halepense (Johnson Grass)*	Y		
505.	1312	*Sowerbaea laxiflora (Purple Tassels)*			
506.	4207	*Sphaerolobium medium*			
507.	41623	*Sphaeromorphaea australis*			
508.	4716	*Stachystemon vermicularis*			
509.	4733	*Stackhousia monogyna*			
510.	24645	*Stagonopleura oculata (Red-eared Firetail)*			
511.	39083	*Stemonitis fusca*			
512.	2316	*Stirlingia latifolia (Blueboy)*			
513.	25597	*Strepera versicolor (Grey Currawong)*			
514.	25590	*Streptopelia senegalensis (Laughing Turtle-Dove)*	Y		
515.	7693	*Stylidium brunonianum (Pink Fountain Triggerplant)*			
516.	7694	*Stylidium bulbiferum (Circus Triggerplant)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
517.	7696	*Stylidium calcaratum (Book Triggerplant)*			
518.	7699	*Stylidium carnosum (Fleshy-leaved Triggerplant)*			
519.	7721	*Stylidium emarginatum (Biddy-four-legs)*			
520.	7736	*Stylidium hispidum (White Butterfly Triggerplant)*			
521.	7745	*Stylidium junceum (Reed Triggerplant)*			
522.	7783	*Stylidium pycnostachyum (Downy Triggerplant)*			
523.	33106	*Stylidium recurvum*			
524.	7790	*Stylidium roseoalatum (Pink-wing Triggerplant)*			
525.	25806	*Stylidium scariosum*			
526.	25830	*Stylidium sp. Darling Range (H. Bowler 371)*			
527.	23511	*Stylidium thesioides (Delicate Triggerplant)*			
528.	7806	*Stylidium utricularioides (Pink Fan Triggerplant)*			
529.	1260	*Stypandra glauca (Blind Grass)*			
530.	6476	*Styphelia tenuiflora (Common Pinheath)*			
531.	2323	*Synaphea gracillima*			
532.	2324	*Synaphea petiolaris (Synaphea)*			
533.	-13287	*Synsphyronus mimulus*			
534.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
535.	24331	*Tadorna tadornoides (Australian Shelduck, Mountain Duck)*			
536.	-16332	*Tandanus bostocki*			
537.	24167	*Tarsipes rostratus (Honey Possum, Noolbenger)*			
538.	20135	*Taxandria linearifolia*			
539.	-11829	*Tetragnatha maeandrata*			Y
540.	1034	*Tetraria capillaris (Hair Sedge)*			
541.	1036	*Tetraria octandra*			
542.	667	*Tetrarrhena laevis (Forrest Ricegrass)*			
543.	4535	*Tetratheca hirsuta (Black Eyed Susan)*			
544.	4537	*Tetratheca nuda*			
545.	1705	*Thelymitra crinita (Blue Lady Orchid)*			
546.	1707	*Thelymitra flexuosa (Twisted Sun Orchid)*			
547.	11053	*Thelymitra macrophylla*			
548.	1715	*Thelymitra spiralis (Curlylocks)*			
549.	5080	*Thomasia foliosa*			
550.	5083	*Thomasia glutinosa (Sticky Thomasia)*			
551.	11194	*Thomasia glutinosa var. latifolia*			
552.	24844	*Threskiornis molucca (Australian White Ibis)*			
553.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
554.	32486	*Thuidium sparsum var. hastatum*			
555.	1328	*Thysanotus dichotomus (Branching Fringe Lily)*			
556.	1338	*Thysanotus manglesianus (Fringed Lily)*			
557.	1351	*Thysanotus sparteus*			
558.	1354	*Thysanotus tenellus*			
559.	1357	*Thysanotus thyrsoideus*			
560.	1358	*Thysanotus triandrus*			
561.	25207	*Tiliqua rugosa subsp. rugosa*			
562.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
563.	8248	*Tolpis barbata (Yellow Hawkweed)*	Y		
564.	19041	*Trachymene coerulea subsp. coerulea*			
565.	6280	*Trachymene pilosa (Native Parsnip)*			
566.	1482	*Tribonanthes brachypetala*			
567.	39098	*Trichia favoginea*			
568.	8251	*Trichocline spathulata (Native Gerbera)*			
569.	24158	*Trichosurus vulpecula subsp. vulpecula (Common Brushtail Possum)*			
570.	1361	*Tricoryne elatior (Yellow Autumn Lily)*			
571.	4292	*Trifolium campestre (Hop Clover)*	Y		
572.	4293	*Trifolium cernuum (Drooping Flower Clover)*	Y		
573.	4304	*Trifolium ornithopodioides (Birdsfoot Fenugreek)*	Y		
574.	4737	*Tripterococcus brunonis (Winged Stackhousia)*			
575.	13479	*Trymalium ledifolium var. rosmarinifolium*			
576.	33418	*Trymalium odoratissimum subsp. odoratissimum*			
577.	-12778	*Urodacus novaehollandiae*			
578.	-12796	*Urodacus planimanus*			
579.	8255	*Ursinia anthemoides (Ursinia)*	Y		
580.	12411	*Verticordia densiflora var. cespitosa*			
581.	6107	*Verticordia pennigera*			
582.	12449	*Verticordia plumosa var. brachyphylla*			
583.	4325	*Viminaria juncea (Swishbush, Koweda)*			
584.	722	*Vulpia bromoides (Squirrel Tail Fescue)*	Y		
585.	724	*Vulpia myuros (Rat's Tail Fescue)*	Y		
586.	7389	*Wahlenbergia preissii*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
587.	1567	*Watsonia meriana (Bulbil Watsonia)*	Y		
588.	18108	*Watsonia meriana var. bulbillifera*	Y		
589.	32456	*Weissia rutilans*			
590.	-11697	*Wheenyoides cooki*			
591.	1394	*Wurmbea dioica (Early Nancy)*			
592.	12072	*Wurmbea dioica subsp. alba*			
593.	1249	*Xanthorrhoea acanthostachya*			
594.	1253	*Xanthorrhoea gracilis (Graceful Grass Tree, Mimidi)*			
595.	1256	*Xanthorrhoea preissii (Grass tree, Palga)*			
596.	6284	*Xanthosia candida*			
597.	6289	*Xanthosia huegelii*			
598.	25765	*Zosterops lateralis (Grey-breasted White-eye, Silvereye)*			

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 wholely 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.

APPENDIX 7

Protected Matters Search Tool Report

Australian Government

Department of Sustainability, Environment, Water, Population and Communities

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: 15/10/13 13:07:50

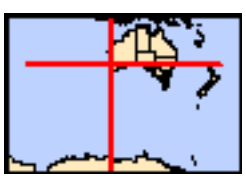
Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

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:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	24
Listed Migratory Species:	7

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 and the heritage values of a place on the Register of the National Estate.

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.

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:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	7
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine	None

Extra Information

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

Place on the RNE:	3
State and Territory Reserves:	4
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
Peel-yalgorup system	Upstream from Ramsar

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
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
Claypans of the Swan Coastal Plain	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo [67034]	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus baudinii Baudin's Black-Cockatoo, Long-billed Black-Cockatoo [769]	Vulnerable	Roosting known to occur within area
Calyptorhynchus latirostris Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Breeding likely to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
[Pseudocheirus occidentalis](#) Western Ringtail Possum [25911]	Vulnerable	Species or species habitat likely to occur within area
[Setonix brachyurus](#) Quokka [229]	Vulnerable	Species or species habitat may 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 likely to occur within area
[Caladenia huegelii](#) King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat known to occur within area
[Centrolepis caespitosa](#) [6393]	Endangered	Species or species habitat likely to occur within area
[Darwinia foetida](#) Muchea Bell [83190]	Critically 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-leafed Hammer-orchid, Praying Virgin [16753]	Endangered	Species or species habitat likely to occur within area
[Drakaea micrantha](#) Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
[Eucalyptus balanites](#) Cadda Road Mallee, Cadda Mallee [24264]	Endangered	Species or species habitat likely to occur within area
[Lasiopetalum pterocarpum](#) Wing-fruited Lasiopetalum [64922]	Endangered	Species or species habitat known to occur within area
[Synaphea sp. Fairbridge Farm (D.Papenfus 696)](#) Selena's Synaphea [82881]	Critically Endangered	Species or species habitat known to occur within area
[Thelymitra manginii K.Dixon & Batty ms.](#) [67443]	Endangered	Species or species habitat may occur within area
[Thelymitra stellata](#) Star Sun-orchid [7060]	Endangered	Species or species habitat may occur within area
[Verticordia fimbrilepis subsp. fimbrilepis](#) Shy Featherflower [24631]	Endangered	Species or species habitat may occur within area
[Villarsia calthifolia](#) Mountain Villarsia [10886]	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		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
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 likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -

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		
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 likely to 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

Name	Threatened	Type of Presence
Pandion haliaetus		
Osprey [952]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	State	Status
Natural		
Karnet Nature Reserve	WA	Registered
Serpentine National Park	WA	Registered
Historic		
Turner Cottage	WA	Indicative Place

State and Territory Reserves [Resource Information]

Name	State
Karnet	WA
Lambkin	WA
Serpentine	WA
Unnamed WA46587	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 Resouces 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
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

Name	Status	Type of Presence
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
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

Name	Status	Type of Presence
		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

Coordinates

-32.36599 115.97914

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 Heritage and Register of National Estate properties, Wetlands of International 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.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

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.

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:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA 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, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-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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APPENDIX 8

DPaW Fauna Database Search Results

NAME	SOURCE_CODE	SOURCE_ID	NAME_ID	FAMILY	GENUS	SPECIES	INFRARANK	INFRANAME	AUTHOR	VERNACULAR	KINGDOM	CONSV_CODE	CLASS	SITE_NAME	DAY	MONTH	YEAR	LOCALITY_NAME
Calyptorhynchus banksii subsp. naso	WAM_BIRDS	urn:lsid:taxonomy.org.au:AVIF:38464	24731	Psittacidae	Calyptorhynchus	banksii	subsp.	naso	Gould	Forest Red-tailed Black-Cockatoo	Animalia	T	BIRD	Serpentine	19	09	2012	SERPENTINE
Calyptorhynchus baudinii	BIRDATLAS2	430818|266	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	08	04	2004	SERPENTINE
Calyptorhynchus baudinii	BIRDATLAS2	218474|266	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo	Animalia	T	BIRD	Serpentine Sports Reserve	17	03	2004	SERPENTINE
Calyptorhynchus baudinii	BIRDATLAS2	751645|266	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo	Animalia	T	BIRD	Serpentine	13	10	2008	SERPENTINE
Calyptorhynchus baudinii	TFAUNA	12198	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo	Animalia	T	BIRD	Serpentine	01	01	2005	SERPENTINE
Calyptorhynchus baudinii	BIRDATLAS2	18709|266	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	11	06	1999	SERPENTINE
Calyptorhynchus baudinii	BIRDATLAS2	454853|266	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	11	07	2005	SERPENTINE
Calyptorhynchus baudinii	BIRDATLAS2	18699|266	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo	Animalia	T	BIRD	State Forest, Serpentine	16	05	1999	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	18700|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	16	05	1999	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	754818|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Serpentine Nat Park	22	01	2009	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	489847|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	03	08	2007	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	487068|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	14	01	2007	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	489877|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	15	11	2007	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	218474|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Serpentine Sports Reserve	17	03	2004	SERPENTINE
Calyptorhynchus latirostris	WAM_BIRDS	urn:lsid:taxonomy.org.au:AVIF:35753	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Serpentine	05	10	2003	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	487083|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	17	03	2007	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	5013375|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	John's house	23	04	2007	JARRAHDALE
Dasyurus geoffroii	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M1291	24092	Dasyuridae	Dasyurus	geoffroii			Gould	Chuditch, Western Quoll	Animalia	T	MAMMAL					SERPENTINE
Dasyurus geoffroii	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M1326	24092	Dasyuridae	Dasyurus	geoffroii			Gould	Chuditch, Western Quoll	Animalia	T	MAMMAL					SERPENTINE
Dasyurus geoffroii	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M1736	24092	Dasyuridae	Dasyurus	geoffroii			Gould	Chuditch, Western Quoll	Animalia	T	MAMMAL					SERPENTINE
Dasyurus geoffroii	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M1234	24092	Dasyuridae	Dasyurus	geoffroii			Gould	Chuditch, Western Quoll	Animalia	T	MAMMAL					SERPENTINE
Phascogale tapoatafa subsp. tapoatafa	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M48842	24099	Dasyuridae	Phascogale	tapoatafa	subsp.	tapoatafa	(Meyer)	Southern Brush-tailed Phascogale, Wambenger	Animalia	T	MAMMAL	HOPELANDS RD	17	12	2000	SERPENTINE
Phascogale tapoatafa subsp. tapoatafa	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M11954	24099	Dasyuridae	Phascogale	tapoatafa	subsp.	tapoatafa	(Meyer)	Southern Brush-tailed Phascogale, Wambenger	Animalia	T	MAMMAL	POST OFFICE	13	12	1972	SERPENTINE
Phascogale tapoatafa subsp. tapoatafa	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M48843	24099	Dasyuridae	Phascogale	tapoatafa	subsp.	tapoatafa	(Meyer)	Southern Brush-tailed Phascogale, Wambenger	Animalia	T	MAMMAL	MANNING ROAD	22	03	2001	SERPENTINE
Phascogale tapoatafa subsp. tapoatafa	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M49942	24099	Dasyuridae	Phascogale	tapoatafa	subsp.	tapoatafa	(Meyer)	Southern Brush-tailed Phascogale, Wambenger	Animalia	T	MAMMAL	MANNING ROAD		02	2002	SERPENTINE
Falco peregrinus subsp. macropus	TFAUNA	9798	24475	Falconidae	Falco	peregrinus	subsp.	macropus	Swainson	Australian Peregrine Falcon	Animalia	S	BIRD	Serpentine	01	01	1975	SERPENTINE
Westralunio carteri	FAUNASURVEY	138703	34113	Hyriidae	Westralunio	carteri				Carter's Freshwater Mussel	Animalia	4	INVERT	Serpentine Falls	15	12	2009	SERPENTINE
Westralunio carteri	FAUNASURVEY	432561	34113	Hyriidae	Westralunio	carteri				Carter's Freshwater Mussel	Animalia	4	INVERT	Serpentine River	17	03	2011	SERPENTINE

NAME	SOURCE_CODE	SOURCE_ID	NAME_ID	FAMILY	GENUS	SPECIES	INFRARANK	INFRANAME	AUTHOR	VERNACULAR	KINGDOM	CONSV_CODE	CLASS	SITE_NAME	DAY	MONTH	YEAR	LOCALITY_NAME
Westralunio carteri	FAUNASURVEY	432674	34113	Hyriidae	Westralunio	carteri				Carter's Freshwater Mussel	Animalia	4	INVERT	Serpentine River	23	11	2010	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6579	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	07	12	2001	SERPENTINE
Isoodon obesulus subsp. fusciventer	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M34374	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	SW HIGHWAY SERPENTINE	13	04	1990	SERPENTINE
Isoodon obesulus subsp. fusciventer	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M8445	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	GARDEN	09	03	1970	SERPENTINE
Isoodon obesulus subsp. fusciventer	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M12185	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	FALLS RD/S.W.H`WAY,POST OFFICE	30	05	1972	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6576	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	01	06	2001	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6578	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	04	12	2001	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	7290	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	South Western Hwy, <100m N of the Mundjedal Brook bridge	26	07	2003	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6582	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	19	04	2002	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6577	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	21	05	2001	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6580	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	16	04	2002	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	5563	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine. West of Hall Road.	15	11	2000	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6575	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	29	05	2001	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6581	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	18	04	2002	SERPENTINE

APPENDIX 9

Aboriginal Heritage Inquiry System Report

Search Criteria

1 Registered Aboriginal Sites in Custom search area (2); 403496.8mE, 6417826.06mN (zone 50) : 404754.47mE, 6419407.69mN (zone 50)

Disclaimer

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

Copyright

Coordinate Accuracy

Accuracy is shown as a code in brackets following the site coordinates.

Terminology (NB that some terminology has varied over the life of the legislation)

ID/Site ID: This a unique ID assigned by the Department of Aboriginal Affairs to the place

Status:

- **Registered Site**: The place has been assessed as meeting Section 5 of the *Aboriginal Heritage Act 1972*
- **Other Heritage Place which includes:**
  - **Stored Data:** The place has been assessed as not meeting Section 5 of the *Aboriginal Heritage Act 1972*
  - **Insufficient Information:** There is not enough information presented to determine if the place meets Section 5 of the *Aboriginal Heritage Act 1972*
  - **Lodged:** Information has been received in relation to the place, but an assessment has not been completed at this stage to determine if it meets Section 5 of the *Aboriginal Heritage Act 1972*

Access and Restrictions:

- **Open:** Availability of information that the Department of Aboriginal Affairs holds in relation to the place is not restricted in any way.
- **Closed:** Some of the information that the Department of Aboriginal Affairs holds in relation to the place is restricted if it is considered culturally sensitive. This information will only be made available if the Department of Aboriginal Affairs receives written approval from the informants who provided the information. Download the Request to Access Restricted Information letter and form.
  The Department of Aboriginal Affairs maps the locations of all sites and heritage places, including Closed sites, as accurately as the information lodged with the Registrar allows. However, to preserve the confidentiality of Closed sites their locations are published in reports from the Register and displayed on the Aboriginal Heritage Inquiry System within one or more two-kilometre-square boxes. These 2 km boxes act as indicators for the presence of sites or heritage places rather than the exact location of the place.
- **Restriction:**
  - **No Restrictions:** Anyone can view the information.
  - **Male Access Only:** Only males can view restricted information.
  - **Female Access Only:** Only females can view restricted information

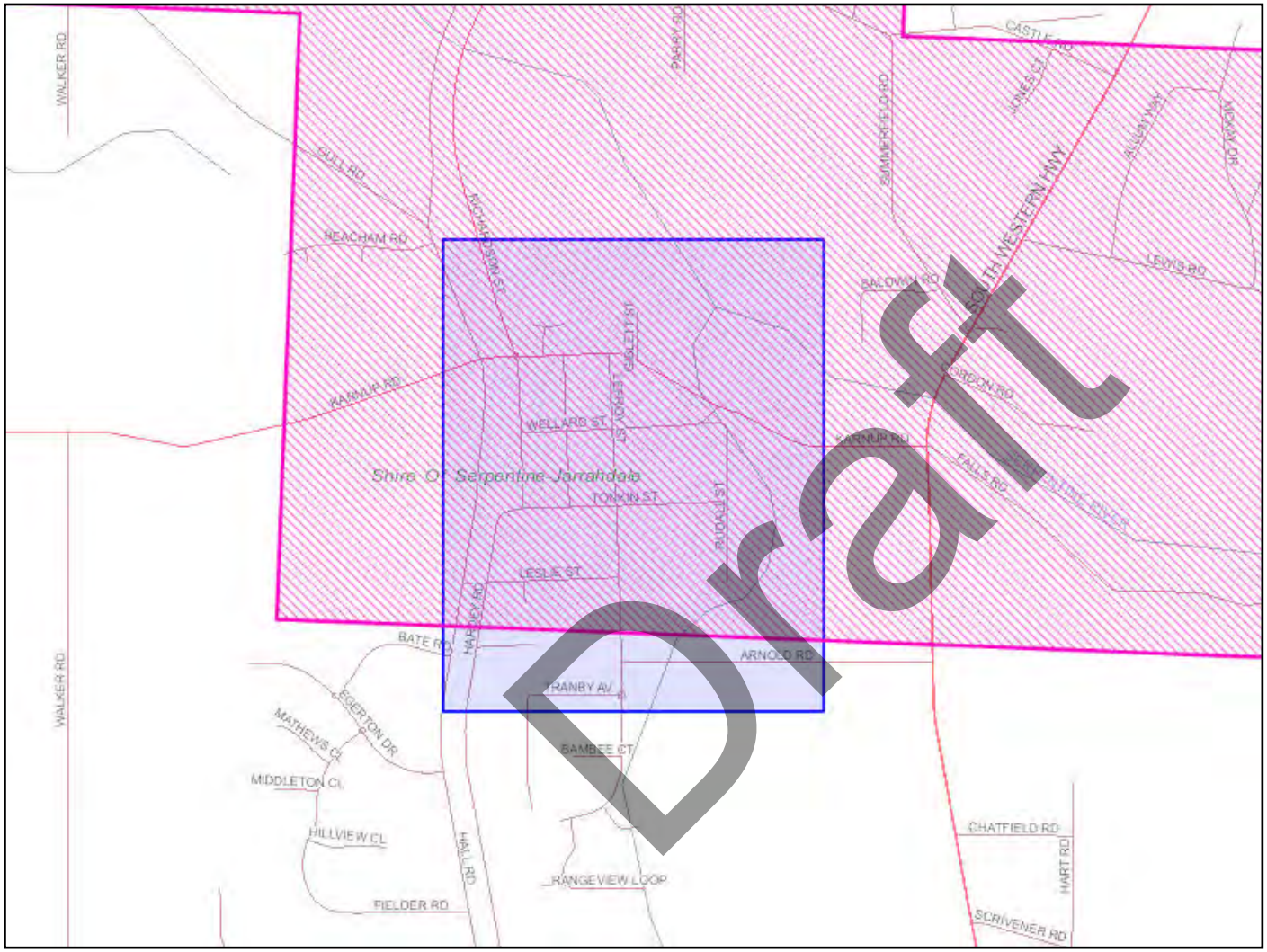
Reliability:

- **Reliable:** The spatial information recorded about the place is deemed to be reliable, due to methods of capture.
- **Unreliable:** The spatial information recorded about the place is deemed to be unreliable due to errors of spatial data capture and/or quality of spatial information recorded.

Number/No./Site No: This is the former unique number that the former Department of Aboriginal Sites assigned to the place. This has been replaced by the ID/SiteID

List of Registered Aboriginal Sites with Map

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
3582	Registered Site	Closed	No Gender Restrictions	SERPENTINE RIVER	Ceremonial, Mythological		*Registered Informant names available from DAA	Not available for closed Sites	S02407



Legend

Selected Heritage Sites

- Registered Sites
- Aboriginal Community Occupied
- Aboriginal Community Unoccupied
- Town
- Search Area

Search Criteria

1 Survey Areas in Custom search area (3); 403867.68mE, 6418957.78mN (zone 50) : 403867.68mE, 6418957.78mN (zone 50)

Disclaimer

Heritage Surveys have been mapped using information from the reports and / or other relevant data sources. Heritage Surveys consisting of small discrete areas may not be visible except at large scales. Reports shown may not be held at DAA. Please consult report holder for more information. Refer to www.daa.wa.gov.au/heritage for information on requesting reports held by DAA.

Copyright

Legend

Access

Some reports are restricted. The type of restriction is shown as a code in brackets following the catalogue number. No code indicates an unrestricted report.

[CLOSED]	Closed
[OWE]	Open with exception
[TBD]	To be determined
[RESTRICTED PENDING]	Restricted pending

Spatial Accuracy

The following legend strictly applies to the spatial accuracy of heritage survey boundaries as captured by DIA.

Very Good	Boundaries captured from surveyed titles, GPS (2001 onwards) submitted maps georeferenced to within 20m accuracy.
Good	Boundaries captured from GPS (pre 2001) submitted maps georeferenced to within 250m accuracy.
Moderate	
Unreliable	Boundaries captured from submitted maps georeferenced to an accuracy exceeding 250m.
Indeterminate	Surveys submitted with insufficient information to allow boundary capture.

Survey 2274

Project The Perth Area.

Start Date Wednesday, April 01, 1970

Proponents University of Western Australia

Consultants University of Western Australia

Survey Types Archaeological, Archaeological and Ethnographic

Aboriginal People Consulted? No

Related Reports for Survey 2274

Report ID	Catalogue Number	Title	Recorders	Held at
104023		An Archaeological Survey Project. The Perth Arch. Area. Western Australia Report no.4 April 1971.	Unknown H. Polach	DAA
103564	HSR MW 1972 UWA	An Archaeological Survey Project: The Perth Area, Western Australia. Apr 1972.	Unknown H. Polach	DAA

Related Survey Areas for Survey 2274

Area Number	Survey Type	Area Description	Survey Methodology	Spatial Accuracy	Field / Desktop
1	Archaeological	The Perth Area. 103 site locations in 67 site groups were investigated.	Site Identification	Indeterminate	Field and Desktop
2	Archaeological	The Perth Area. Sites included id's 3350, 4404, 3846	Site Identification	Unreliable	Field and Desktop
3	Archaeological and Ethnographic	The Perth Area. Closed site id 2887	Site Identification	Indeterminate	Field and Desktop

Legend

Selected Heritage Surveys

- Heritage Survey
- Aboriginal Community Occupied
- Aboriginal Community Unoccupied
- Town
- Search Area