Native Vegetation Clearing Permit Application [Area Permit] - Supporting Documentation

Dunland Property Pty Ltd

Prepared for
Dunland Property Pty Ltd (Cedar Wood)
by Strategen

May 2018

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ENVIRONMENTAL

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May 2018

Limitations

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Client: Dunland Property Pty Ltd (Cedar Wood)

Report Version	Revision No.	Purpose	Strategen author/reviewer	Submitted to Client	
				Form	Date
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Final	**O**	**DWER submission**	**K Cooper**	**Electronic**	**28/05/2018**

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1. Introduction

1.1 Overview

Dunland Property Pty Ltd (Cedar Woods) is currently developing the Bushmead residential development (Lot 9000 Midland Road Bushmead (the site) (Figure 1), in accordance with approved Local Structure Plan (LSP) (Appendix 1) and subdivision. The site is located approximately 16 km north east of the Perth CBD and is within the City of Swan.

The Bushmead development includes two development cells, the Northern cell and Southern cell. Development of Stages 1, 2 and 3 have already commenced and are nearing completion. Stage 6a has recently received Western Australian Planning Commission (WAPC) subdivision approval (WAPC Application No. 155962), with site works scheduled to commence in the coming months (Appendix 1).

A portion of the Bushmead Northern cell subject to this clearing application has recently being rezoned (Amendment 13374/27, Appendix 2) is currently zoned 'Urban' under the Metropolitan Region Scheme (MRS) and in the process of being rezoned 'Special Use' under the City's Local Planning Scheme No. 17 (LPS No.2). A Structure Plan amendment for this area (including Stages 4, 5 and 6b) has been submitted and currently out for public comments. WAPC feedback is expected in early June 2018. The Subdivision approval for Stages 4, 5 and 6b is expected to be November/December 2018 (refer to Appendix 1, Figure 1).

1.2 Proposed clearing

Dunland Property Pty Ltd (Cedar Woods) is proposing to clear approximately 8.75 ha comprising of native vegetation (CcEm) in Completely Degraded condition for the purpose for earthworks and establishing engineering infrastructure (Figure 2), within Stages 4, 5 and 6b prior to subdivision approval which is expected in November/December 2018.

1.3 Existing environmental Approvals

1.3.1 Environment Protection Biodiversity and Conservation Act 1999

The Bushmead development was referred to the Department of Environment and Energy under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) which included the clearing of approximately 50 ha of potential Black-Cockatoo foraging and breeding habitat within the Development Area. Where possible viable habitat trees will be maintained within the Northern and Southern cells.

The project received EPBC approval (EPBC 2015/7414) with conditions, refer to Appendix 3. The proposed clearing area which is subject of the application is within the Northern cell and within the EPBC approval area. To compensate for the loss of approximately 50 hectares (ha) of black cockatoo habitat, a Conservation Management Plan (CMP) (RPS 2016) (Appendix 4) which included the Bushmead Conservation Masterplan has been developed and approved with a subsequent Restrictive Covenant: Deed of Covenant for the Conservation of Land with is between Dunland Property Pty Ltd and Department of Parks and Wildlife (now Department of Biodiversity Conservation and Attractions-DBCA) (Appendix 5).

The CMP outlines key management plan which have been completed to the satisfaction of DBCA, which include a Construction Management Plan (CoMP) and Revegetation, Stream Restoration and Weed Management Plan (Tranen 2017).

Construction Management Plan

A Construction Management Plan (CoMP) (Strategen 2017) has been prepared to satisfy the requirement to prepare and 'implement a Construction Management Plan to the satisfaction of DPaW', as stated in the Conservation Management Plan (CMP), in accordance with condition 9 of the EPBC Act Project approval (EPBC 2015/7414). The CoMP should be read in conjunction with the CMP prepared for this Project. The scope of the CoMP is to manage clearing and construction activities to be undertaken to develop the Project. In particular the plan addresses:

- the protection of flora and vegetation during construction
- the protection of fauna during construction
- dust control
- dieback and hygiene management (Appendix 6).

Revegetation Stream Restoration and Weed Management Plan

A Revegetation, Stream Restoration and Weed Management Plan (Tranen 2017) which has been approved by the DBCA has several key components for the Conservation Area:

- retention and management of existing vegetation, including TECs
- management of problematic weed species
- revegetation to increase plant density and species diversity in degraded areas
- weed management and stream restoration for degraded sections of the Kadina Brook.

A total of 41.3 ha has been identified for revegetation, with the remaining land in the Conservation Area (148 ha) managed to reduce weed loads. The strategy for the site has been developed based on the following geographical designations (refer to Appendix 8 for a map of the areas):

- Conservation Area A, which includes four revegetation sites, a TEC (FCT 20a) and remnant vegetation
- Conservation Area B, which includes five revegetation sites, a TEC (FCT 20c) and remnant vegetation
- Conservation Area C, which includes two broad revegetation areas and remnant vegetation
- Conservation Area D, which is the Kadina Brook and its buffer area.

The completion targets for all areas managed under this plan have been designed based on a six-year implementation plan, which includes at least one year of site preparation, planting and / or seeding, and a five-year management period. Following these works, the whole conservation estate will be handed over to DBCA for management, assuming the completion criteria have been met (Tranen 2017).

The strategy for weed management and revegetation works will be adaptable over the management period, based on learnings from the on-going revegetation works across the site. Variations to the management strategies will be agreed with DBCA prior to implementation (Tranen 2017).

1.3.2 Environmental Protection Act 1986

An MRS Amendment was referred to the Environmental Protection Authority (EPA) in 2013, resulting in MRS rezoning of Lot 911 from 'Public Purposes: Commonwealth Government' to the following:

1. 91.81 ha is zoned 'Urban' or 'Urban Deferred' (later reduced to 85.8 ha).
2. The remaining 180.07 ha (later increased to 186.7 ha) is zoned 'Parks and Recreation' and will be ceded to the State's conservation estate. The 'Parks and Recreation' zoning forms the amended boundary for Bush Forever Site No. 213 and a Conservation Covenant with Parks and Wildlife (as addition levels of planning and management protection).

A Local Structure Plan was lodged and approved by the City of Swan.

The EPA assigned the Bushmead Amendment an assessment level of "Not assessed – advice given" on the basis that the following key agreed environmental outcomes (from the relevant environmental agencies) were adopted:

1. The 'development' areas (or 'Urban' zoned areas) are focused on historically cleared or impacted sites. The areas of vegetation and fauna habitat identified and agreed by the relevant agencies as being locally and regionally significant are to be ceded to the State for conservation purposes. The key outcome of defining the Development Area has meant:
    - approximately 85.8 ha (or 31%) of the total landholding will be developed for urban uses
    - approximately 186.7 ha (or 69%) of the land will be ceded to the state free of cost and reserved as 'Parks and Recreation' reserve for conservation purposes
    - the retention and management of substantial tracts of vegetation and habitats in Good to Very Good condition
    - unbroken habitat linkages and ecological transition zones between stream zone and upland habitats within Lot 911 and ensuring links to adjacent land
    - managing and rehabilitating (approximately 38.3 ha) portions of the Conservation Area.
2. The Bushmead MRS Amendment finalises the agreed Bush Forever and Conservation Covenant boundary consistent with the conservation areas defined in the MRS Amendment and the Bushmead LSP as 'Parks and Recreation'.

A Conservation Management Plan (RPS 2016) was prepared, in consultation with Parks and Wildlife, to provide a framework to ensure appropriate ongoing management of the Conservation Area consistent with the Conservation Covenant management guidelines (Refer to Section 1.3.1).

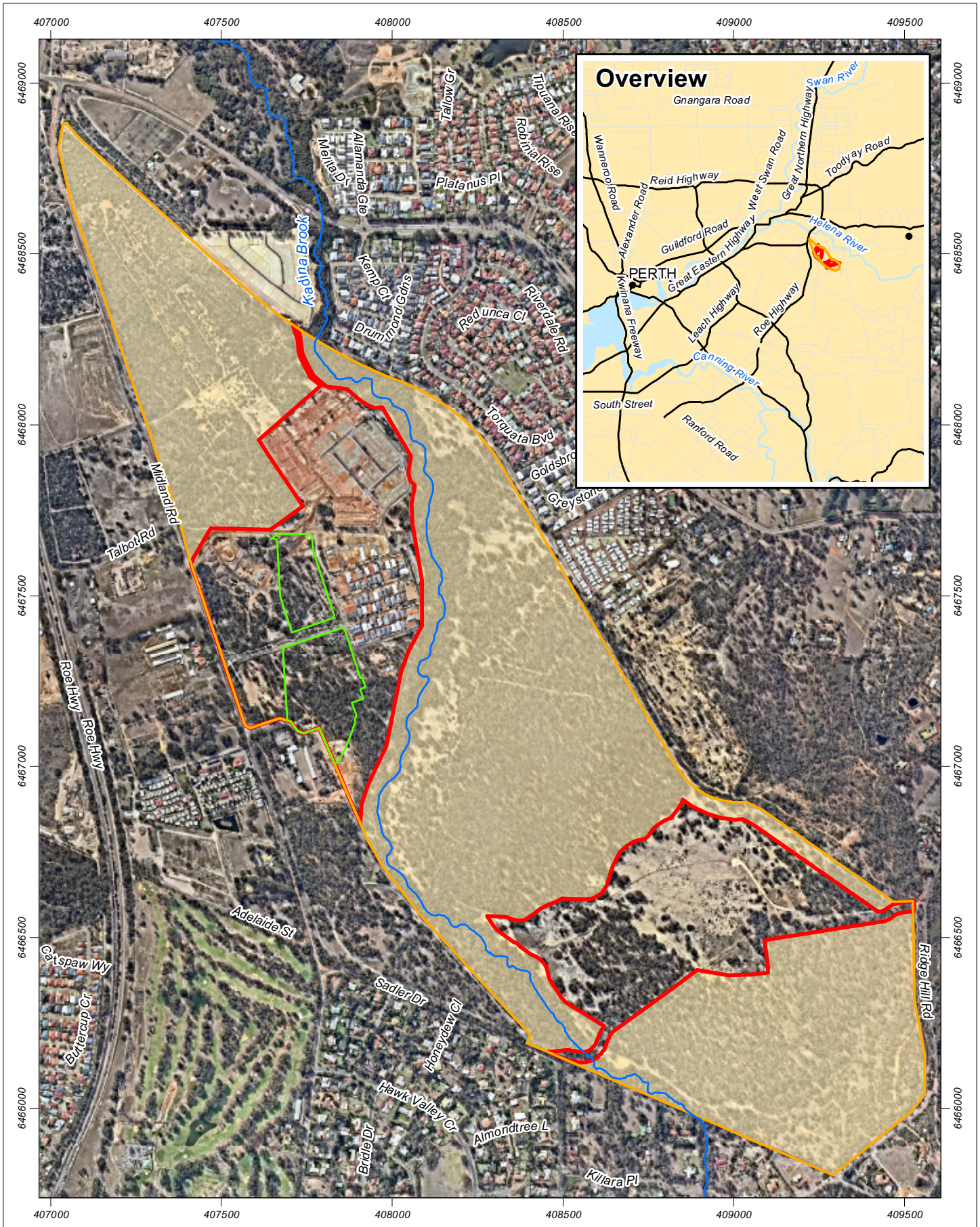

Figure 1: Site location and clearing area

Scale 1:15,000 at A4

0 100 200 300 400 500 m

Coordinate System: GDA 1994 MGA Zone 50

Note that positional errors may occur in some areas

Date: 16/05/2018

Author: JCrute

Source: Aerial image: Nearmap, flown 04/2018.

Development area: Client 2014. Clearing boundary: Client 05/2018.

Path: Q:\Consult\2018\CED\CED18227\01_GIS_documents\ArcMap_documents\CED18227_G001_RevA.mxd

Legend

- Clearing boundary
- Lot 911
- Development area
- Conservation area

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2. Overview of existing environment

2.1 Surrounding Land uses

The Northern cell (which includes the proposed clearing area) is within an urban area, where development has commenced in accordance with approved LSP and Subdivision approval. Bushforever site 213 is located north, east and south of the cell while an existing poultry farm and urban development located west of the site.

2.2 Geology and topography

Regional Environmental Geology mapping indicates that the clearing area consists of the geology unit Sand (S8) which is characterised by – very light grey at the surface and yellow at depth fine to medium grained Bassendean Sand and Sand (S10) – S8 sand overlying clay from the Guildford Formation (Gozzard, 1986). Predevelopment topography on site ranges from approximately 28mAHD to 35mAHD (Strategen 2014).

2.3 Hydrology

A review of the Perth Groundwater Atlas (DWER) indicates that the direction of groundwater flow at Lot 911 is in a northwest direction towards the Helena and Swan River, depth to groundwater across Lot 911 ranges from 2 mbgl to 13.5 mbgl (RPS 2012). Kadina Brook is primarily sourced from direct runoff and groundwater baseflow, if present, is not expected to be a significant contributor to flow in the stream (Strategen 2014).

Surface runoff is negligible for the flat, well drained portions of Lot 911 but is associated with the silt, clay and gravel lateritic soils of the site (ERM 2007). Surface water from these areas flows into Kadina Brook (Figure 1) on a seasonal basis (ERM 2007). Kadina Brook is an ephemeral stream that transfers surface water run-off from the Darling Scarp to the Coastal Plain (Strategen 2014).

The proposed clearing area is approximately 150 to 350m west of the Kadina Brook.

2.4 Vegetation and flora

Vegetation occurring within the region was initially mapped at a broad scale (1: 1 000 000) by Beard during the 1970s. The site is located within the Beard Vegetation Association 3 (Medium forest; jarrah-marri) and 1001 (described as Medium very sparse woodland; jarrah, with low woodland; banksia & casuarina).

Based on regional vegetation complex mapping (Heddle et al, 1980) the site consists of Forrestfield Complex (Ridge Hill Shelf, Darling Plateau) ranges from open forest of Marri - Corymbia calophylla, Wandoo - Eucalyptus wandoo, Jarrah - Eucalyptus marginata to open forest of Marri, Jarrah, Sheoak - Allocasuarina fraseriana - Banksia species.

A flora and vegetation survey of the site was undertaken by RPS in 2012 (RPS 2012a). Environmental surveys have confirmed that neither *Corymbia calophylla – Kingia australis* woodlands on heavy soils of the Swan Coastal Plain or Claypans of the Swan Coastal Plain occur within Lot 911.

Shrublands and Woodlands of the eastern Swan Coastal Plain have been identified on Lot 911. However, the full extent of this Threatened Ecological Community is located within the Conservation Area (Bushforever site 213) which is under conservation covenant. The proposed clearing area does not impact the mapped TEC (Strategen 2014).

The clearing area consists of vegetation type *CcEm: *Corymbia calophylla* and *Eucalyptus marginata* over weed species which is in Completely Degraded condition (RPS 2012a) (Figure 2 and Appendix 7).

An assessment of the likelihood of occurrence of each of the flora species identified by the EPBC Act Protected Matters and Nature Map database search is presented in Table 1. All of the identified species are unlikely to occur within Lot 911 (and within the proposed clearing area) based on flora and vegetation surveys undertaken, and the condition of the understory within the Development cells.

Table 1: EPBC and WC Act -listed flora species likelihood of occurrence

Species name	Likelihood of occurrence	Comment
*Andersonia gracilis (*Slender Andersonia)	Unlikely	Not recorded on Lot 911 during flora and vegetation survey.
*Calytrix brevisete subsp. Breviseta (*Swamp Starflower)	Unlikely	
*Conospermum undulatum (*Wavy Leaved Smokebush)	Unlikely	
*Eucalyptus balanites (*Cadda Road Mallee)	Unlikely	
*Lepidosperma rostratum (*Beaked Lepidosperma)	Unlikely	
*Synaphea sp. Fairbridge Farm (*Selenas Synaphea)	Unlikely	
Diuris micrantha (Dwarf Bee-orchid)	Unlikely	Considered very unlikely to occur due to preference for damp/wetland sites and the predominantly degraded condition of the vegetation.
Diuris purdiei (Purdie's Donkey-orchid)	Unlikely	Considered very unlikely to occur due to preference for damp/wetland sites and the predominantly degraded condition of the vegetation.
Drakaea elastica (Glossy-leafed Hammer-orchid, Praying Virgin)	Unlikely	
Drakaea micrantha (Dwarf Hammer-orchid)	Unlikely	Considered very unlikely to occur due to preference for damp/wetland sites and the predominantly degraded condition of the vegetation.
Isopogon drummondii Jacques	Unlikely	Considered very unlikely to occur due to predominantly degraded condition of the vegetation.
Thelymitra dedmaniarum (Cinnamon Sun Orchid)	Unlikely	Known from three populations northeast of Perth (two northwest of Gidgegannup and one northwest of Gingin). Grows in Eucalyptus wandoo (wandoo) and *E. accedens* (powderbark wandoo) woodlands on red-brown sandy-loam soil associated with dolerite and granite outcrops.
Thelymitra stellata (Star Sun-orchid)	Unlikely	Considered very unlikely to occur due to preference for damp/wetland sites and the predominantly degraded condition of the vegetation.

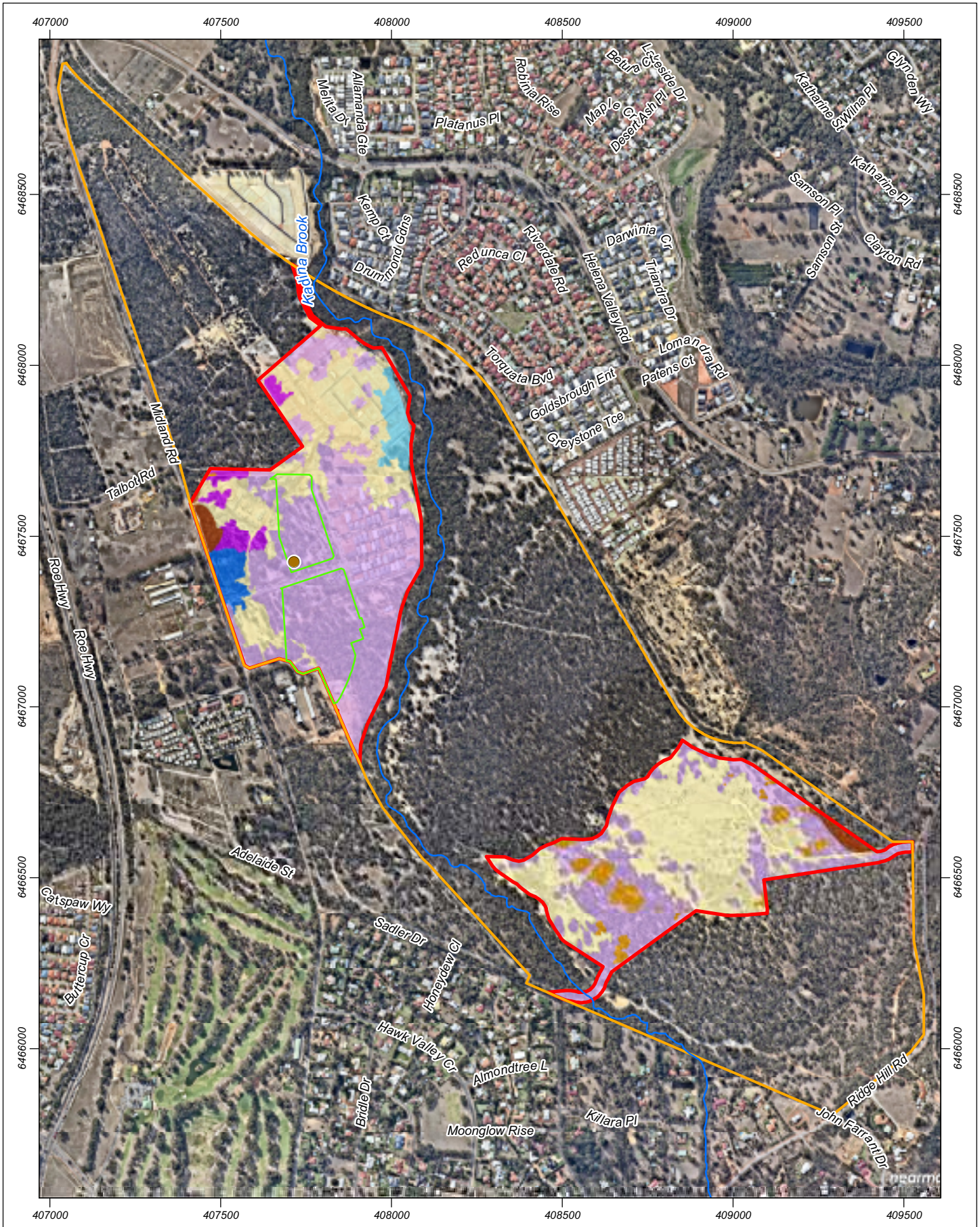

Figure 2: Vegetation type and clearing area

Scale 1:15,000 at A4

0 100 200 300 400 500 m

N

Coordinate System: GDA 1994 MGA Zone 50

Note that positional errors may occur in some areas

Date: 17/05/2018

Author: JCrute

Source: Aerial image: Nearmap, flown 04/2018.

Development area: Client 2014. Clearing boundary: Client 05/2018.

Path: Q:\Consult\2018\CED\CED18227\01_GIS_documents\ArcMap_documents\CED18227_G002_RevB.mxd

Legend

- Black cockatoo tree with hollow (Jarrah)
- Clearing boundary
- Lot 911
- Development area

Vegetation type

- *CcEm
- *CcEr
- *TSTOSAcCuMn
- OFEmLWCcAf
- OWEmTOSBs
- WEmCcOSXp
- WLOWEmCcAfBaE
- *C

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2.5 Fauna and habitat

Database searches of NatureMap and the DoEE protected matters database were undertaken to determine the likelihood of any Threatened or Priority fauna species within the vicinity of the site. The desktop survey identified the Carnaby's Black-Cockatoo (CBC) (*Calyptorhynchus latirostris*), Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*), Baudin's Cockatoo, Long-billed Black-Cockatoo, (*Calyptorhynchus baudinii*), Chuditch, Western Quoll (*Dasyurus geoffroii), Isoodon fusciventer (*Quenda, southwestern brown bandicoot).

Of these species, three are likely to occur and three are unlikely to occur within Lot 911 based on their known range distribution and habitat, refer to Table 2.

Table 2: Significant listed fauna species likelihood of occurrence

Species name	Likelihood of occurrence	Habitat Description and Distribution	Comment
Birds			
Calidris ferruginea (Curlew Sandpiper)	Low	Widespread around coastal and sub-coastal plains from Cape Arid to south-west Kimberley. Habitat associated with intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast.	Preferred habitat not within Lot 911 or within the proposal clearing area.
Calyptorhynchus banksii naso(Forest Red-tailed Black-Cockatoo)	High	Eucalypt forests. Feeds on seeding *Corymbia calophylla* (Marri), *Eucalyptus marginata* (Jarrah), *Eucalyptus todtiana* (Blackbutt), *Eucalyptus diversicolor* (Karri), *Allocasuarina fraseriana* (Sheoak) and *Persoonia micranthera* (Snottygobble) (Johnstone & Storr 1998). This subspecies occurs in the humid and subhumid south west, mainly in hilly interior, north to Gingin (formerly to Dandaragan) and east to Mt Helena (formerly to Toodyay), Christmas Tree Well, North Bannister (formerly to Wandering), Mt Saddleback (formerly to Kojonup), Rocky Gully and the upper King River. It is endemic to Western Australia (Johnstone & Storr 1998).	Recorded during Level 1 Fauna Survey (RPS 2012b). Observed during Black-Cockatoo Habitat Assessment (Bamford 2014).
*Calyptorhynchus baudinii (*Baudin's Black Cockatoo)	High	Baudin's Black-Cockatoo occurs in forests dominated by Marri (*Corymbia calophylla*) and *Eucalyptus* species, especially Karri (*E. diversicolor*) and Jarrah (*E. marginata*). However, it also occurs in woodlands of Wandoo (*E. wandoo*), Blackbutt (*E. patens*), Flooded Gum (*E. rudis*), Yate (*E. cornuta*) (DotE 2014a).	Lot 911 contains potential habitat; however, Baudin's Black Cockatoo was not recorded during the Level 1 Fauna Assessment undertaken by RPS (RPS 2012b). Not observed during Black-Cockatoo Habitat Assessment (Bamford 2014).

Species name	Likelihood of occurrence	Habitat Description and Distribution	Comment
Calyptorhynchus latirostris(Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo)	High	Woodlands and scrubs of semiarid interior of Western Australia, in non-breeding season wandering in flocks to coastal areas, especially pine plantations. Food includes seeds of Banksia species, Dryandra species, Hakea species, Eucalyptus species, Grevillea species and Pinus species; also fruiting almonds (Johnstone & Storr 1998). Occurs in south-west of Western Australia with a range that extends from Cape Arid to Kalbarri, and inland to Hatter Hill, Gibb Rock, Narembeen, Noongar, Wongan Hills, Nugadong, near Perenjori, Wilroy and Nabawa. Other records include north to the lower Murchison River and east to Waadi Forest, Nugadong, Manmanning, Durokoppin, Lake Cronin, Ravensthorpe Range, head of Oldfield River, 20 km east-southeast of Coondingup. Occasional sightings occur on Rottnest Island (DotE 2014b).	Recorded during Level 1 Fauna Survey (RPS 2012b). Observed during Black-Cockatoo Habitat Assessment (Bamford 2014).
*Leipoa ocellata (*Malleefowl)	Unlikely	Malleefowl are known to occur in shrublands and low woodlands that are dominated by mallee vegetation and eucalypt or native pine vegetation such as *Callitris* woodlands, acacia shrublands, Broombush *Melaleuca uncinata* vegetation or coastal heathlands (DotE 2014c).	Lot 911 does not contain specific plant species usually associated with Malleefowl habitat.
Rostratula australis (Australian Painted Snipe)	Unlikely	The Australian Painted Snipe prefers shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. The Australian Painted Snipe feeds on vegetation, seeds, insects, worms and molluscs, crustaceans and other invertebrates (DotE 2014d).	This species was not recorded during the Level 1 fauna assessment. While there is a seasonal creek within the adjacent land, its habitats do not resemble the preferred habitat for the species. The proposed clearing area is 150m to 350m west of the Kadina Brook, no wetland habitats within the clearing area.

Species name	Likelihood of occurrence	Habitat Description and Distribution	Comment
Mammals			
Dasyurus geoffroii (Chuditch, Western Quoll)	Unlikely	Chuditch are known to have occupied a wide range of habitats from woodlands, dry sclerophyll (leafy) forests, riparian vegetation, beaches and deserts (DotE 2014e). The Chuditch now has a patchy distribution through the *Eucalyptus marginata* (Jarrah) forest and mixed *Eucalyptus diversicolor* (Karri)/*Corymbia calophylla* (Marri)/Jarrah forest of southwest Western Australia. In Jarrah forest, Chuditch populations occur in both moist, densely vegetated, steeply sloping forest and drier, open, gently sloping forest (DotE 2014e).	Lot 911 contains *Eucalyptus marginata;* however, this species was not recorded during the Level 1 Fauna Survey.

Two Black-Cockatoo species have been recorded within Lot 911 (Table 2); Forest Red-Tailed Black-Cockatoo and Carnaby's Black-Cockatoo. Vegetation type *CcEm: *Corymbia calophylla* and *Eucalyptus marginata* over weed species which is in Completely Degraded condition which consists of low/medium Carnaby's black cockatoo foraging habitat and medium/good foraging habitat for Forest Red-tailed Black-Cockatoo and Baudin's Black Cockatoo. There is one potential black cockatoo nesting habitat tree (with suitable hollow) (Tree with large, suitable hollow bearing chew-marks in 2015) that may be cleared, subject to finalisation of the subdivision design (refer to Figure 2).

3. Assessment against ten clearing principles

An assessment of the proposed clearing against the ten clearing principles outlined in Schedule 5 of the EP Act 1986 is provided in Table 3. The following assessment demonstrates that the proposed removal and/or thinning of native vegetation, planted introduced species and weed species is not at a significant variance with the clearing principles.

Table 3: Assessment against clearing principles

Principle	Assessment	Conclusion
Native vegetation should not be cleared if it comprises a high level of biological diversity.	The Vegetation type within the proposed clearing area consists of *CcEm: *Corymbia calophylla* and *Eucalyptus marginata* over weed species which is in Completely Degraded condition. Environmental surveys have not recorded any TEC/PEC or DRF within the proposed clearing area. Refer to Section 2.4.	Not at variance with the principle.
Native vegetation should not be cleared if it comprises the whole or part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.	The Level 1 fauna assessment (RPS, 2012a) and Black Cockatoo follow-up Survey (Bamford, 2015) confirmed that the site contains foraging habitat and potential habitat trees. Most of the area to be cleared Poor to Moderate quality foraging habitat. There for one habitat tree (No. 4), a Jarrah tree with large, suitable hollow bearing recent chew-marks potential habitat trees which is located just outside of the proposed clearing area (stage 4) and will not be impacted with proposed works. The removal of 8.57ha of Poor to Good quality foraging habitat was considered as part of EPBC referral (EPBC 2015/7414) of clearing approximately 50ha of black cockatoo habitat. It is noted that part of the EPBC referral and approval that 186.7 ha of bushland, comprising 175.5 ha of Black Cockatoo habitat (including 38.3 ha to be revegetated) within Lot 911 was ceded to the Conservation Commission which is reserved as conservation estate (Bush Forever Site 231) and to be managed by the DBCA once the revegetation program has been completed (Appendix 8). A conservation covenant has been registered on the title of the land (Appendix 5). While the local extent of foraging habitat will be reduced, the proposed clearing will not lead to a reduction in the area of occupancy of the species. Based in 2014 mapping data, extensive areas of Black-Cockatoo habitat are located in the vicinity of Lot 911 within protected areas such as local reserves, Bush Forever Sites and Parks and Wildlife managed estates (Appendix 9). Within 15 km of Lot 911, approximately 22,000 ha of protected Black Cockatoo habitat is available. (Strategen 2014). There is one potential black cockatoo nesting habitat tree (with suitable hollow) (Tree with large, suitable hollow bearing chew-marks in 2015) that may be cleared, subject to finalisation of the subdivision design (refer to Figure 2). As per EPBC approval 2015/7414 Condition 12, should the potential breeding habitat tree be removed “the person taking the action will compensate for their loss by installing at least three (3) artificial nesting hollows for black cockatoos within the Conservation Area, for every potential nesting tree cleared. The design, placement and method used to install the artificial nesting hollows must be in accordance with relevant artificial hollow guidance material”.	The size of habitat in regard to other available habitat within the vicinity of the site will not lead to a reduction of species occupancy on site. Therefore, not considered to be at variance with this principle.
Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.	The Vegetation type within the proposed clearing area consists of *CcEm: *Corymbia calophylla* and *Eucalyptus marginata* over weed species which is in Completely Degraded condition. Environmental surveys have not recorded any TEC/PEC or DRF within the proposed clearing area. Refer to Section 2.4.	It is unlikely that the priority or rare flora will be impacted and the proposed action is not a variance with this principle.

Principle	Assessment	Conclusion
Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community.	The Vegetation type within the proposed clearing area consists of *CcEm: *Corymbia calophylla* and *Eucalyptus marginata* over weed species which is in Completely Degraded condition. Environmental surveys have not recorded any TEC/PEC or DRF within the proposed clearing area. Refer to Section 2.4.	Not at variance with the principle
Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.	The area to be cleared (within the Northern cell) is within an existing EPBC approval (EPBC 2015/7414) area. Development of Stages 1, 2 and 3 have already commenced and are nearing completion. Stage 6a has recently received Western Australian Planning Commission (WAPC) subdivision approval (WAPC Application No. 155962), with site works scheduled to commence in the coming months. The area to be cleared (Stages 4, 5 and 6B) are in accordance with the amended Structure Plan (currently with the WAPC). The proposed area which consists of the vegetation type within the *CcEm: *Corymbia calophylla* and *Eucalyptus marginata* over weed species which is in Completely Degraded condition and does not consist of any recorded TEC/PEC. This area is not considered a significant remnant and is located in close proximately to the conservation area which includes the preservation and enhancement of areas in accordance with the Revegetation Stream Restoration and Weed Management Plan (Tranen, 2017). The conservation area is part of Bush Forever Site 213.	Removal of vegetation within the project area is not considered to be at variance with this principle as it will not result in the removal of significant remnant of vegetation compared to the surrounding area.
Native vegetation should not be cleared if it is growing in or in association with a watercourse or wetland.	There are no mapped geomorphic wetlands within the proposed cleared area. The proposed clearing area is approximately 150 to 350m west of the Kadina Brook. There is no vegetation on site which is growing in or associated with a watercourse or wetland.	Not at variance with the principle.
Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.	The proposed clearing is located in the centre of the Northern cell with urban development currently being developed on the eastern area of the cell. Land degradation processes such as erosion and weed encroachment on site are managed through the implementation of the CoMP (Appendix 6).	Removal of vegetation within the site (Northern cell) is not considered to be at variance with this principle.
Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.	The proposed clearing area (Stages 4, 5 and 6b) is situated within the middle of the Northern development cell. Development has already commenced and approved for Stages 1, 2, 3and 6a which is situated along the interface with Bushforever site 231. The clearing of Completely Degraded vegetation within the clearing area is unlikely to have a significant impact on environmental values and will not directly impact the Bushforever site No. 231 as there is no interface with the Bushforever site and Stages 4, 5 and 6b. Construction on site will also be undertaken in accordance with the Bushmead Construction Management Plan (Appendix 7)	The proposed action is not at variance with this principle.

Principle	Assessment	Conclusion
Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.	There is an approved Local Water Management Strategy (LWMS) (JDA, 2015) for the Bushmead development which includes the Northern Cell (Appendix 10). The LWMS addresses the LSP area and provides a refinement of the flood modelling, surface water management and groundwater management presented in the DWMS. This LWMS is consistent with water sensitive urban design practises as described in the Stormwater Management Manual of WA. AS discussed in the LWMS (JDA, 2015:22) due to the natural occurrence of elevated levels of nutrients in the groundwater, dewatering will be managed on-site or discharged through the sewer to prevent untreated discharge to drains or surface water bodies. Structural treatment measures (infiltration storages, bio-retention/treatment structures sized to minimum 2% of connected impervious area), and Non-structural measures (i.e. Local native plants to make up a minimum 80% of the planted areas and streetscape treatments. Any non-local species will be selected for drought tolerance and low fertiliser requirements) to reduce nutrient loads are also discussed within the LWMS. A subsequent Urban Water Management Plan (UWMP) will be developed in accordance with WAPC subdivision conditions. The urban development within Stages 4, 5 and 6b will be connected to reticulated sewerage.	The proposed action is not at variance with this principle.
Native vegetation should not be cleared if the clearing of the vegetation is likely to cause, or exacerbate, the intensity of flooding.	There are no mapped geomorphic wetlands within the proposed cleared area. The proposed clearing area is approximately 150 to 350m west of the Kadina Brook. The site is not within a floodway. There is an approved LWMS (JDA, 2015) for the Bushmead development which includes the Northern Cell (Appendix 10). The LWMS addresses the LSP area and provides a refinement of the surface water modelling (1 year:1hour and 100year ARI critical storm events, surface water management and groundwater management presented in the DWMS. This LWMS is consistent with water sensitive urban design practises as described in the Stormwater Management Manual of WA. A subsequent Urban Water Management Plan (UWMP) will be developed in accordance with WAPC subdivision condition. Clearing vegetation within the proposed area will not cause, or exacerbate, the intensity of flooding, in the area or Kadina Brook. The LWMS included the proposed clearing areas within the major and minor drainage system/design strategy which is consistent with the objectives provided within the District Water Management Strategy and the approved Conservation Management Plan (Appendix 4).	Removal of vegetation within the proposed area is not considered to be at variance with this principle, as the clearing is not expected to cause or exacerbate flooding in the area.

4. References

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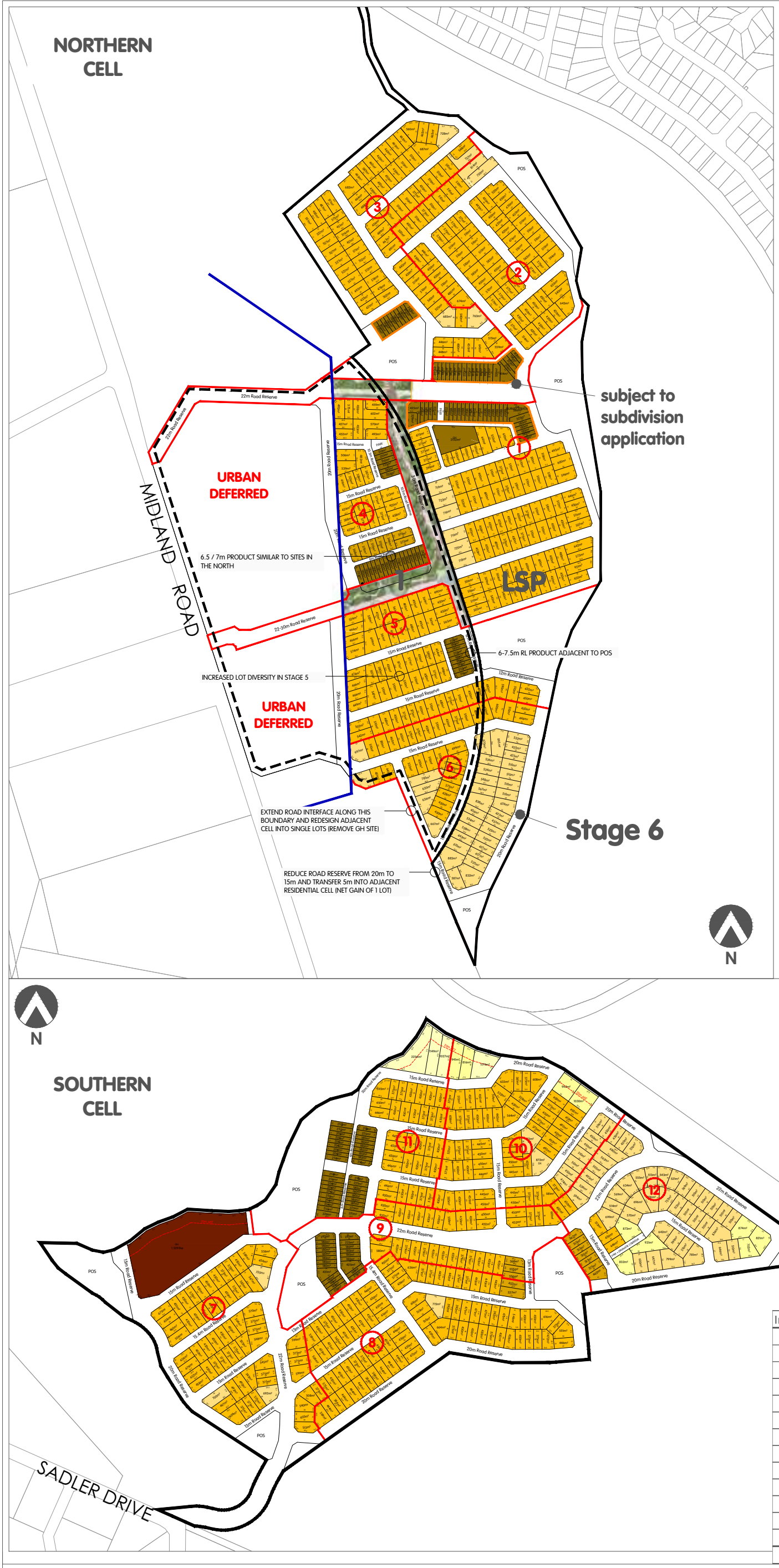
Appendix 1
Local Structure Plan



LEGEND

- STRUCTURE PLAN AREA
- URBAN DEFFERED
- RECOMMENDED POULTRY FARM BUFFER

NORTHERN CELL (LSP) APPROVED SUBDIVISION

	R 20	12 Lots
	R 25	218 Lots
	R 40	1 GH site
	TOTAL	230 Lots + 1 GH site

NORTHERN CELL (LSP) SUBJECT TO SUBDIVISION APPLICATION

	R 40	58 Lots
	TOTAL	58 Lots

NORTHERN CELL (LSP) STAGE 6 - INDICATIVE DENSITES

	R 20	30 Lots
	R 25	10 Lots
	TOTAL	40 Lots

NORTHERN CELL 1 (PROPOSED LIFTING OF URBAN DEFERRED AREA) - INDICATIVE DENSITIES

	R 20	6 Lots
	R 25	111 Lots
	R 30	7 Lots
	R 40	32 Lots
	TOTAL	156 Lots

SOUTHERN CELL - INDICATIVE DENSITIES

	R 10	4 Lots
	R 17.5	10 Lots
	R 20	55 Lots
	R 25	279 Lots
	R 30	12 Lots
	R 40	59 Lots
	R 60	1 GH site
	TOTAL	419 Lots + 1 GH site
	TOTAL	**903 Lots + 2 GH sites**

Indicative Yield Table for Plan 040 P			
Stage	Yield (Lots)	Yield (GH Sites)	Average Lot Size (m²)
1	115	1	430
2	89		421
3	83		468
4	59		365
5	70		447
6	67		519
7	70	1	461
8	90		451
9	56		353
10	72		505
11	73		367
12	59		575
Total	**903**	**2**	

great places_
robertsday.com.au
planning·design·place

CADASTRAL INFORMATION
SOURCE: LANDGATE
YYMMDD:
DWG REF:
PROJECTION: MGA94

SIZE A3
NOT TO SCALE

REVISED STRUCTURE PLAN BASE
Lot 911 Midland Road, Bushmead
City of Swan

REF NO.	DRAW NO.	REV.
CWP BUS	**RD1 040**	**P**

DISCLAIMER: ISSUED FOR DESIGN INTENT ONLY. ALL AREAS AND DIMENSIONS ARE SUBJECT TO DETAIL DESIGN AND SURVEY

Appendix 2
MRS Amendment 1337/27

Western Australian Planning Commission

Our Ref: 812-2-21-31 (RLS/0685/1)
Enquiries: Andrew Thomas (6551 9615)

Dunland Property Pty Ltd
c/- Cedar Woods Properties Pty Ltd
PO Box 788
WEST PERTH WA 6872

Dear Sir/Madam

Metropolitan Region Scheme Amendment 1337/27
Lot 9000 Bushmead Road, Hazelmere

I wish to advise that the Metropolitan Region Scheme has been amended by the Western Australian Planning Commission, and that the regional zoning of your land is now urban.

The attached plan number 4.1646 shows the extent of the area rezoned. The land had previously been identified as urban deferred in the Metropolitan Region Scheme. This was to allow detailed planning issues and constraints to urban development to be addressed.

Notice of the resolution will be published in the *Government Gazette* on Friday 19 January 2018 in accordance with the provision of Clause 27 of the Metropolitan Region Scheme.

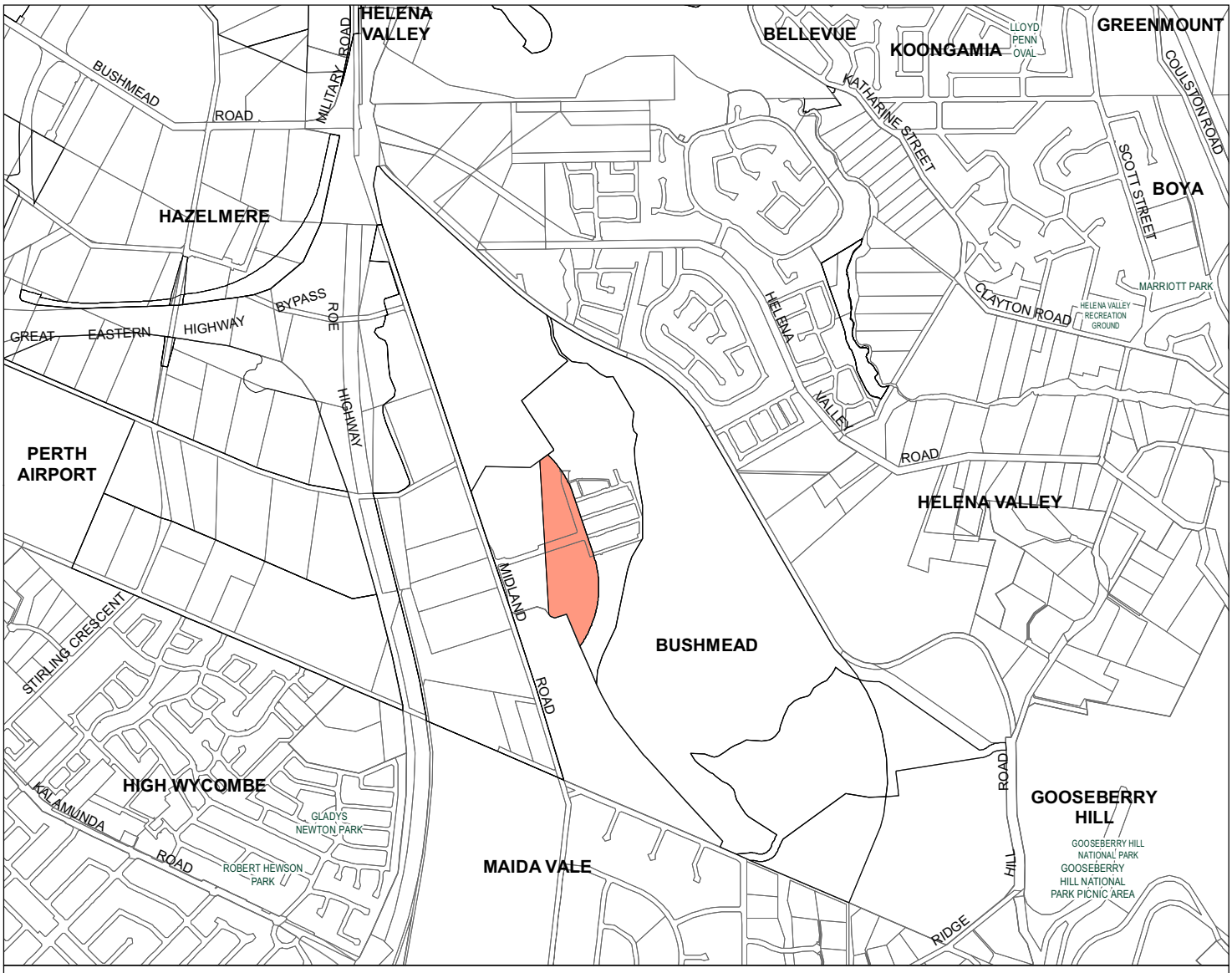
If you have any further queries on this matter, please contact Andrew Thomas at the Department of Planning, Lands and Heritage on 6551 9815.

Yours faithfully

KM Blenkinsop

Kerrine Blenkinsop
Secretary
Western Australian Planning Commission

17 January 2018



Signed for and on behalf of the
Western Australian Planning Commission

_____

An officer duly authorised by the Commission
pursuant to section 24 of the
Planning and Development Act 2005
for that purpose in the presence of :

_____

Witness

_____

Date

Metropolitan Region Scheme

Clause 27 - Transfer of land
from urban deferred zone to urban zone

Amendment No. xxxx /27

Legend

Excluded from urban deferred and included in urban zone

N

0 0.25 0.5 0.75 1
kilometres

Western Australian Planning Commission

Created on date: Wednesday, 15 November 2017
Document Name: MRS_2950_v1_APlan4_1646
Produced by Geospatial Research and Modelling, Department of Planning, Lands and Heritage, Perth WA
Base information supplied by Western Australian Land Information Authority LI 862-2016-1

Program Manager: A. Thomas

Geospatial Officer: J. Ballarotta

Examined: A. Power

Revised:

Version No. 1

Date: WAPC/xxxx
13 December 2017

File number: 812/02/21/0031

Plan reference:
MRS 1:25000 sheet 16
detail plans: 1.6240, 1.6266

Oracle reference no: 2950

Plan Number 4.1646

Appendix 3
EPBC Approval2015/7414

Approval

Bushmead Residential Development, Hazelmere, WA (EPBC 2015/7414)

This decision is made under sections 130(1) and 133 of the *Environment Protection and Biodiversity Conservation Act 1999*.

Proposed action

person to whom the approval is granted	Dunland Property Pty Ltd
proponent's ABN	ABN 34 127 744 656
proposed action	To clear vegetation to undertake a residential development on a portion of Lot 911, Midland Road, Hazelmere, Western Australia [See EPBC Act referral 2015/7414].

Approval decision

Controlling Provision	Decision
Listed threatened species and communities (sections 18 & 18A)	Approved

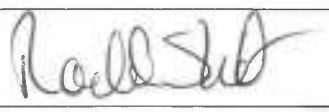
conditions of approval

This approval is subject to the conditions specified below.

expiry date of approval

This approval has effect until 31 December 2025.

Decision-maker

name and position	Rachel Short Acting Assistant Secretary Assessments (WA, SA, NT) and Air Branch
signature	
date of decision	17.6.16

Conditions attached to the approval

Conditions
1. Within 30 days after the **commencement** of the action, the **person taking the action** must advise the **Department** in writing of the actual date of **commencement**.
2. The **person taking the action** must maintain accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement the management plans required by this approval, and make them available upon request to the **Department**. Such records may be subject to audit by the **Department** or an independent auditor in accordance with section 458 of the **EPBC Act**, or used to verify compliance with the conditions of approval. Summaries of audits will be posted on the **Department's** website. The results of audits may also be publicised through the general media.
3. Within three months of every 12 month anniversary of the **commencement** of the action, the **person taking the action** must publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of any management plans as specified in the conditions. Documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of this approval must be provided to the **Department** at the same time as the compliance report is published. Reports must remain on the website for the life of this approval. The **person taking the action** must continue to comply with this condition until such time as agreed to in writing by the **Minister**.
4. Upon the direction of the **Minister**, the **person taking the action** must ensure that an independent audit of compliance with the conditions of approval is conducted and a report submitted to the **Minister**. The independent auditor must be approved by the **Minister** prior to the commencement of the audit. Audit criteria must be agreed to by the **Minister** and the audit report must address the criteria to the satisfaction of the **Minister**.
5. Unless otherwise agreed to in writing by the **Minister**, the **person taking the action** must publish all management plans referred to in these conditions of approval on their website for the duration of this approval. Each management plan must be published on the website within 1 month of this approval or within 1 month of being approved and must remain on the website for the life of this approval.
6. The **person taking the action** must not **clear** more than 50 hectares (ha) of **black cockatoo habitat** within the **project area**.
7. The **person taking the action** must not **clear** any extent of the **EPBC Act** listed endangered **Shrublands and Woodlands of the Eastern Swan Coastal Plain Threatened Ecological Community**, found in the area shown in Attachment 1.
8. To compensate for the loss of approximately 50 hectares (ha) of **black cockatoo habitat**, prior to the **commencement** of the action, the **person taking the action** must protect and manage for conservation the **Conservation Area** identified in Attachment 2. Prior to the **commencement** of the action: a. The **person taking the action** must modify the conservation covenant executed over parts of the **Conservation Area** on 15 June 2009, so that the entire **Conservation Area** is protected by a secure and enduring form of conservation covenant.

b. The modified covenant must be registered on the land title before the commencement of the action and once registered, its provisions must be implemented.

c. The **person taking the action** must provide evidence to the **Department** of the registration of the modified covenant, along with **offset attributes**, **shapefiles** and textual descriptions and maps to clearly define the location and boundaries of the offset site.

9. The **person taking the action** must implement the ***Bushmead Conservation Management Plan*** (Plan), as approved by the **Western Australian Department of Parks and Wildlife**, to compensate for the loss of approximately 50 hectares (ha) of **black cockatoo habitat** and manage the potential indirect impacts of the action on the **EPBC Act** listed endangered **Shrublands and Woodlands of the Eastern Swan Coastal Plain Threatened Ecological Community**. The **person taking the action** must not **commence** the action unless the **Western Australian Department of Parks and Wildlife** has approved the Plan.

10. The **person taking the action** must cede ownership of the **Conservation Area** identified in Attachment 2 to the **Western Australian Department of Parks and Wildlife**, within five (5) years of **commencement** of the action. The proponent must implement the requirements of Condition 9, to improve the quality of habitat within the **Conservation Area** to the satisfaction of the **Western Australia Department of Parks and Wildlife**, before ownership is ceded.

11. If for any reason the **Western Australian Department of Parks and Wildlife** does not take ownership of the **Conservation Area** within five (5) years of the **commencement** of the action, Condition 10 ceases to apply and instead the **person taking the action** must:

    a. notify the **Department** within 30 days of the five (5) year anniversary of **commencement**, that ownership has not been ceded to the **Western Australian Department of Parks and Wildlife**.

    b. provide for the continual protection and management of the **Conservation Area** identified in Attachment 2, for the life of the approval or until such time that ownership is ceded to the **Western Australian Department of Parks and Wildlife**; and

    c. update the Plan referenced in Condition 9 to reflect the proposed changes in the management of the **Conservation Area**. The updated Plan must identify how the future management of the **Conservation Area** will be undertaken and must be submitted for the approval of the **Minister**. Once approved by the **Minister**, the **person taking the action** must implement the Plan.

12. The **person taking the action** has stated their objective to retain all **potential nesting trees** within the **project area**. If any **potential nesting trees** are **cleared**, however, the **person taking the action** will compensate for their loss by installing at least three (3) artificial nesting hollows for **black cockatoos** within the **Conservation Area**, for every **potential nesting tree cleared**. The design, placement and method used to install the artificial nesting hollows must be in accordance with relevant **artificial hollow guidance material**.

13. If **clearing** is to be undertaken during the **black cockatoo breeding season**, the **person taking the action** must investigate all **potential nesting trees** to determine if any **black cockatoos** are utilising these trees for nesting. The investigation must be undertaken by a **suitably qualified and experienced person** and must be undertaken within 7 days prior to **clearing**. If any **black cockatoos** are detected utilising any hollow in any tree, the **person**

taking the action must:

a. clearly identify and mark the tree;

b. not **clear** any such tree or any vegetation within 10 metres of any such tree; and

c. only undertake **clearing** of any such tree when a **suitably qualified and experienced person** has verified that the hollows are no longer being used by **black cockatoos** in that **breeding season**.

14. The **person taking the action** must implement the ***Local Water Management Strategy***, as approved by the **Western Australian Department of Water** to prevent water run-off from the **project area** entering the **EPBC Act** listed **Shrublands and Woodlands of the Eastern Swan Coastal Plain Threatened Ecological Community**.

Definitions:

Artificial hollow guidance material is guidance material prepared by the **Western Australian Department of Parks and Wildlife** on the placement, design and maintenance of artificial nesting hollows for Carnaby's Black Cockatoos (*Calyptorhynchus latirostris*). Found here: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals/208-saving-carnaby-s-cockatoo or as provided by that Department from time to time.

Black Cockatoos are the **EPBC Act** listed endangered Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*), and the **EPBC Act** listed vulnerable Baudin's Black Cockatoo (*Calyptorhynchus baudinii*) and Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*).

Black cockatoo breeding season is the period from 1 July to 31 December of any year.

Black Cockatoo habitat includes foraging and potential breeding habitat as defined in the *EPBC Act Referral Guidelines for three species of Western Australian black cockatoos: Carnaby's Black Cockatoo (Calyptorhynchus latirostris), (Endangered) Baudin's Black Cockatoo (Calyptorhynchus baudinii) (Vulnerable) and Forest Red-tailed Black Cockatoo (Calyptorhynchus banksii naso) (Vulnerable)* (October 2012).

Bushmead Conservation Management Plan is the supplementary document prepared by Dunland Property Pty Ltd in consultation with the **Western Australian Department of Parks and Wildlife** that details the environmental management actions to be implemented within and/or for the **Conservation Area**, prior to the management of the area being transferred to the **Western Australian Department of Parks and Wildlife**.

Clear, **cleared** or **clearing** is the cutting down, felling, thinning, logging, removing, killing, destroying, poisoning, ring-barking, uprooting, mulching or burning of native vegetation.

Commence, commenced or commencement of the action is any preparatory works required to be undertaken including **clearing**, the erection of any fences, signage or on-site temporary structures and the use of construction or excavation equipment on-site for the purpose of breaking the ground for buildings or any other infrastructure.

Conservation Area means the 186.77 ha of land within Lot 911 proposed to the established as a conservation estate, as shown at Attachment 2 of this notice.

Department is the Australian Government Department administering the **EPBC Act**.

EPBC Act is the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

Local Water Management Strategy is the plan prepared by JDA Consultant Hydrologists on behalf of Cedar Woods for Lot 911 Midland Road, Hazelmere and approved by the **Western Australian Department of Water**. The plan details the measures that will be implemented to prevent water run-off from the **project area** entering the **EPBC Act** listed **Shrublands and Woodlands of the Eastern Swan Coastal Plain Threatened Ecological Community**.

Minister is the Minister administering the **EPBC Act** and includes a delegate of the Minister.

Offset attributes is an excel file ('.xls') capturing relevant attributes of the **Offset Area**, including the corresponding **EPBC Act** reference ID number, the physical address of the **Conservation Area**, coordinates of the boundary points in decimal degrees, the **EPBC Act** protected matters that the **Conservation Area** compensates, any additional **EPBC Act** protected matters which benefit from the **Conservation Area**, the size of the **Conservation Area** in hectares and the legal mechanism used to protect and conserve the **Conservation Area**.

Person taking the action is the person to whom the approval is granted, or to whom the approval is transferred under section 145B of the **EPBC Act**.

Potential nesting trees are those ten (10) trees identified in the *Bushmead, Hazelmere Black-Cockatoo Habitat Follow-up Survey 2015* report prepared by Bamford Consulting Ecologist, which showed recent evidence of cockatoo activity and which may contain suitable hollows for **black cockatoo** nesting. The locations of these trees are within the **project area** and are shown in red in Attachment 3.

Project area means the 272.5 ha of land in Lot 911 located off Midland Road, Hazelmere, Western Australia (WA) as shown in Attachment 1 of this notice.

Shapefile is an ESRI shapefile containing '.shp', '.shx' and '.dbf' files and other files capturing attributes of the **Conservation Area**, including the shape, **EPBC Act** reference ID number and **EPBC Act** protected matters present at the relevant site. Attributes should also be captured in '.xls' format.

Shrublands and Woodlands of the Eastern Swan Coastal Plain Threatened Ecological Community is a Threatened Ecological Community listed under the **EPBC Act** and as described in the advice to the Minister for the Environment and Heritage from the Endangered Species Scientific Subcommittee (ESSS) on a proposal to add an ecological community to Schedule 2 of the *Endangered Species Protection Act 1992* (ESP Act). As found on the **Department's** website (currently http://www.environment.gov.au/node/14556 as of April 2016).

Suitably qualified and experienced person is a person with relevant tertiary qualifications and with at least five (5) years experience in surveying for **black cockatoos**.

Western Australian Department of Parks and Wildlife is the Western Australian Government Department with the primary responsibility for managing the state's national parks, marine parks, state forest or other reserves.

Western Australian Department of Water is the Western Australian Government Department with primary responsibility for managing all water resources within Western Australia.

Attachment 1

Figure 5: Threatened Ecological Community (FCT) mapping

Attachment 2

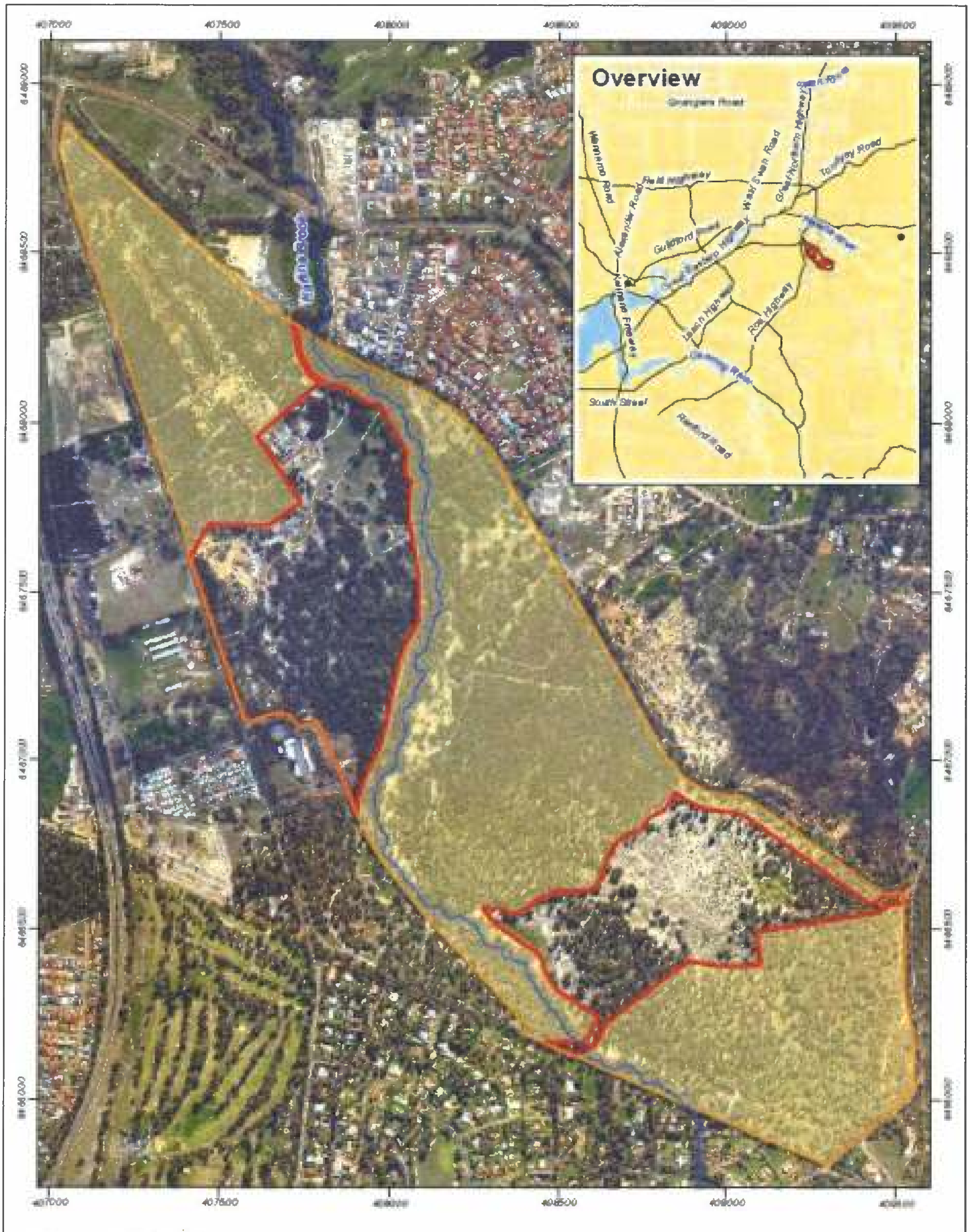


Figure 1: Site location

Legend
Lot 911
Development area
Conservation area

Attachment 3

Figure 2. BC score 2 (red) and 3 (orange) trees in the northern impact area.

Figure 3. BC score 2 (red) and 3 (orange) trees in the southern impact area.

Appendix 4
Bushmead Conservation Management Plan (RPS 2016)

RPS

CONSERVATION MANAGEMENT PLAN

Bushmead

CONSERVATION MANAGEMENT PLAN

Bushmead

Prepared by:

RPS

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Report No: L1010807:2
Version/Date: Rev 2, July 2016

Prepared for:

CEDAR WOODS PROPERTIES LTD

Ground Floor
50 Colin Street
WEST PERTH WA 6005

Document Status

Version	Purpose of Document	Orig	Review	Review Date	Format Review	RPS Release Approval	Issue Date
Draft A	Draft for Client Review	MarBow	JohHal	19.12.15	DC 22.12.15		
Draft B	Draft for Client Review	JohHal	JohHal	02.06.16	SN 02.06.16		
Rev 0	Final for Issue	JohHal	JohHal	12.06.16	DC 20.06.16	J. Halleen	20.06.16
Rev 1	Final for Issue	JohHal	JohHal	08.07.16	SN 08.07.16	J. Halleen	08.07.16
Rev 2	Final for Issue	JohHal	JohHal	13.07.16	DC 14.07.16	J. Halleen	14.07.16

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(contained within report text) **Page**

APPENDICES

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1.0 INTRODUCTION

This Conservation Management Plan (CMP) has been prepared on behalf of Cedar Woods Properties Ltd (Cedar Woods) in liaison with the Department of Parks and Wildlife (DPaW). It provides direction for the 186.77 ha Bushmead "Parks and Recreation" (Conservation) Reserve.

Key directions of the CMP include:

1. Addressing the impacts arising from the proposed urban development cells.
2. Protecting and managing Threatened Ecological Communities (TECs).
   a. FCT20c – Shrublands and woodlands of the eastern Swan Coastal Plain.
   b. FCT 20a – *Banksia attenuata* woodlands over species rich dense shrublands.
3. Controlling invasive weed species.
4. Protecting native fauna.
5. Preventing the spread of plant diseases.
6. Fire management.
7. Ongoing management.
8. Rehabilitating degraded areas in the proposed Conservation Reserve to improve vegetation condition, fauna habitat and the Kadina Brook.
9. Fostering community understanding of, and involvement in, the management of the Conservation Reserve.

The CMP outlines the following key management plans which are to be prepared to the satisfaction of DPaW and/or the appropriate decision making authority:

- Rehabilitation and Revegetation Plan
- Weed Management Plan
- Construction Management Plan – includes Dieback Management Plan
- Fire Management Plan
- Urban Water Management Plan
- Stream Restoration Plan – Kadina Brook.

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2.0 LAND TENURE

The Conservation Reserve is identified as those parts of Lot 911 on Deposited Plan 60213 being comprised in Certificate of Title Volume 2730 Folio 721 that are labelled A1, A2, A3, A4 and A5 on Deposited Plan 403647 (Appendix 2).

Cedar Woods will implement the CMP Actions and subsequently cede the Conservation Reserve to the Conservation Commission as a conservation estate, to be managed by DPaW, as part of the subdivision approval process.

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3.0 ENVIRONMENTAL APPROVALS

In 2009, the Department of Defence and the then state Department of Environment and Conservation entered into a commitment, to establish a Conservation Covenant to protect the conservation values of the Bushmead site. The Conservation Covenant identified a 164 ha area of particular conservation value which warrant retention. It distinctly excluded two areas for urban development purposes.

In July 2010, the Bushmead site was purchased by Cedar Woods from the Department of Defence. At the time of purchase, the majority of the site was zoned "Public Purpose" (Commonwealth Government) with a small portion as "Parks and Recreation".

Between 2010 and 2012, Cedar Woods undertook a technical review of all historical environmental reports available for the site, and commissioned additional site specific flora and vegetation and fauna investigations to be undertaken. Based on an analysis of this information a MRS Amendment 1242/41 was submitted by Cedar Woods in 2013 which proposed rezoning of the Bushmead site from "Public Purpose (Commonwealth Government)" and "Parks and Recreation".

Prior to the amendment, a small area was originally zoned as "Parks and Recreation" Reserve, which contained vegetation that was in completely degraded with minimal conservation value. The amendment enabled the boundaries of the "Parks and Recreation" Reserve to be modified, as well as increased, to ensure that the most ecologically significant areas were retained, providing a conservation gain for the area.

The proposed amendment was referred to the Environmental Protection Authority (EPA) for advice on whether environmental assessment would be required. The EPA advised that the amendment would not require a formal assessment under Part IV of the *Environmental Protection Act 1986*. An integral component to EPA acceptance of the proposal, was Cedar Woods commitment to rezone a large portion of the site to "Parks and Recreation" Reserve and cede it to the state free of charge, and with interim management.

The "Parks and Recreation" Reserve will be vested as part of the conservation estate with the Conservation Commission of WA to be managed by DPaW. The gift of the land to the state government will allow DPaW to manage the area in perpetuity, protecting the area from development and minimising the impact to the area from surrounding land uses. As part of this process the area subject to the Conservation Covenant is also proposed to be increased to match the "Parks and Recreation" zoning, which will also form the amended boundary for Bush Forever Site No. 213.

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4.0 KEY ENVIRONMENTAL VALUES

4.1 Vegetation and Flora

4.1.1 Vegetation Complex

The site is situated at the toe of the Darling Scarp and presents a transitional landscape between the easternmost edge of the Bassendean Dune System, the Ridge Hill Shelf and the lower sector of the face of the Darling Scarp. The Ridge Hill Shelf System over the southern portion of the site is the only remaining area of this system in the Perth Metropolitan Region (DotE 2010).

The associated vegetation complex present over the site is the Forrestfield Complex (Heddle et al. 1980). Vegetation in the Forrestfield Complex ranges from open forest of *C. calophylla – E. wandoo – E. marginata* to open forest of *E. marginata – C. calophylla – A. fraseriana – Banksia* species (Government of Western Australia 2000). Fringing woodland of *E. rudis* occurs in the gullies that dissect this landform.

This complex has been extensively cleared for agriculture, mining and urban development and it is estimated that in 2000, there were only 1,020 ha (9%) of the original extent of Forrestfield Complex bushland remaining. The Western Australian Government's Bush Forever only identifies 573 ha or 5% of the original extent of Forrestfield Complex for protection. Consequently, the Forrestfield Complex is categorised as "poorly reserved" (Government of Western Australia 2000).

4.1.2 Vegetation Communities

Two Threatened Ecological Communities (TEC) have been identified on the Bushmead site:

- Floristic Community Type (FCT) 20c – Shrublands and woodlands of the eastern Swan Coastal Plain
- FCT 20a – *Banksia attenuata* woodlands over species-rich dense shrublands.

FCT 20c mainly occurs on transitional soils of the Ridge Hill Shelf on the Swan Coastal Plain (SCP) adjacent to the Darling Scarp, but also extends marginally onto the alluvial clays deposited on the eastern fringe of the SCP (RPS 2006). It is listed under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) as "Endangered" and as "Critically Endangered" by DPaW. It is known to occur in only two areas being the Talbot Road bushland in Stratton and the Bushmead Rifle Range.

This vegetation community has been identified within the central portion of the site, with the southernmost portion located within the proposed southern development area.

FCT 20a is classified as "Endangered" under DPaW's list of threatened and ecological communities.

The Conservation Masterplan (Appendix 1) illustrates the location of the TECs within the Bushmead site.

4.1.3 Rare Flora

Information obtained from the DPaW database searches (any site survey info) indicate that three different species of Priority flora have previously been recorded on the site. These include:

- *Isopogon drummondii* (P3)
- *Halgania corymbosa* (P3)
- *Calothamnus accedens* (P4).

Isopogon drummondii (P3) was recorded at two localities in the northern portion of the Bushmead site in 1990. *Halgania corymbosa* (P3) and *Calothamnus accedens* (P4) were recorded in 1977 and 2006 respectively in the southern portion of the site.

The special natural values of the Conservation Reserve, as defined in the Conservation Covenant include:

- areas of Forrestfield vegetation complex, of which there was less than 9% remaining within the Perth Metropolitan Region on the Swan Coastal Plain in 1998

- occurrences of the following Threatened Ecological Communities which are listed on the Department's List of Threatened Ecological Communities: "SCP20a – *Banksia attenuata* woodland over species rich dense shrublands" and "SCP20c – Shrublands and woodlands of the eastern side of the Swan Coastal Plain" and the latter also listed as a matter of national environmental significance under the EPBC Act

- a population of, or habitat for, the following species which are listed as Threatened Fauna under Schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice 2013 and listed as Matter of National Environmental Significance (MNES) under the EPBC Act: *Calyptorhynchus baudinii* (Baudin's black cockatoo), *Calypthorhynchus latirostris* (Carnaby's Black-Cockatoo) and *Dasyurus geoffroii* (chuditch)

- a population of *Isopogon drummondii* which is listed as Priority 3 on the Department's Priority Flora List (September 2013)
- a population of southern brown bandicoot or quenda (*Isoodon obesulus fusciventer*) which is listed as Priority 5 on the Department's Priority Fauna List (September 2013)
- the Kadina Brook, a tributary of the Helena River, recognised as a wetland of significant conservation value due to there being few creek lines in the Ridge Hill Shelf system not affected by quarrying or urbanisation and a section of which is classified as having vegetation in Very Good–Excellent condition
- that the bushland is recognised within the state government's Bush Forever policy as a regionally significant fragmented bushland/wetland linkage due to it being part of several strategic corridors within the Perth Metropolitan Region where the Swan Coastal Plain and the Darling Plateau meet through naturally vegetated areas
- mosaic of creek line and upland ecosystems which includes plant species of conservation significance, endangered ecological communities (TECs), threatened fauna and species either endemic to the Swan Coastal Plain or poorly represented in conservation reserves
- remnant stands of marri woodland, highly valued for protecting ecosystem functions, and enhancing landscape and social values.

4.2 Fauna Habitat

Key fauna assessments that have been undertaken at the Bushmead site include:

- a level 1 fauna survey undertaken by RPS in August and September 2011 which also included a significant tree survey for black cockatoos
- a level 1 fauna survey undertaken by Western Wildlife in 2006 (ERM 2006)
- a fauna assessment undertaken by Ecologia in 1991
- a fauna assessment in 1989 by Dames and Moore.

The fauna assessments identified the Conservation Area (and more broadly the Bushmead site) was used (or potentially used) by many fauna species of conservation significance (as listed under the WC Act or the EPBC Act), including:

1. Carnaby's Black-Cockatoo – *Calyptorhynchus latirostris.*
2. Forest red-tailed black cockatoo – *Calyptorhynchus banksii naso.*

3. Baudin's black cockatoo – *Calyptorhynchus baudinii.*
4. Rainbow bee-eater – *Merops ornatus.*
5. Peregrine falcon – *Falco peregrines.*
6. Quenda / southern brown bandicoot – *Isodoon obesulus* subsp. *fusciventer.*
7. Darling Range heath ctenotus – *Ctenotus delli.*

Habitat values within the Bushmead site and the Conservation Area have been impacted through various agricultural and human use activities, however there are some areas remaining in "Very Good" to "Degraded" condition that provide important fauna habitat.

The 2011 level 1 fauna survey undertaken indicates that the areas on site most likely to support fauna are those with the least degraded native vegetation. However, degraded vegetation on site may still support species of conservation significance as individual marri and jarrah trees provide potential habitat for the Carnaby's Black-Cockatoo, Baudin's black cockatoo and forest red tailed black cockatoo. In addition, areas around Kadina Brook and areas with a dense understorey are likely to be important for quenda.

4.3 Ecological Linkage

Kadina Brook represents an ecological linkage through the site, connecting remnant vegetation to the north (e.g. Helena River) and south (e.g. Gooseberry Hill National Park). Consequently, a 50 m buffer will be maintained either side of Kadina Brook to retain this important linkage. In addition, the 38.3 ha revegetation works will improve connectivity between upland habitats and creek line habitats.

4.4 Soils and Geology

Regional geology mapping indicates the following soil units occurring on the site (Gozzard 1986):

- SAND (S8) – very light grey at the surface and yellow at depth fine to medium grained Bassendean Sand
- SAND (S10) – S8 sand overlying clay from the Guildford Formation
- SAND (S12) – yellow fine to medium grained sand
- SANDSTONE (SS) – light grey, very hard, compact fine grained silty sandstone
- LATERITE (LA1) – cemented laterite up to 4 m thickness overlying mottled and/or pallid clays and saprolite

- GRAVEL (G2) – strong, brown, course lateritised granite pebbles in clay–silt mixture
- GRAVELLY SILT (Mgs2) – strong, brown with common pebbles of fine to course grained granite with variable sand content
- GRAVELLY SILT (Mgs2) – strong, brown with common pebbles of fine to course grained granite with variable sand content
- PEBBLY SILT (Mgs1) – strong brown silt with fine to occasionally course grained, laterite quartz, heavily weathered granite pebble, with some fine to medium grained quartz sand
- GRANITE (GR) – fine to course grained ranging in composition from granodiorite to granite.

4.5 Hydrology

4.5.1 Groundwater

The Superficial Aquifer underlying the site is known as the Cloverdale Groundwater System, which has a maximum saturated thickness of 30 m. Approximately 150 m^3/day of groundwater leaks downward from the Superficial Aquifer into the Leederville Aquifer, which in turn also leaks upward to recharge the Superficial Aquifer at approximately 100 m^3/day (Davidson 1995).

4.5.2 Groundwater Levels

During an investigation carried out by ERM in 2006, nine bores were installed across the site and during installation, depth to water ranged from 33.6 m AHD in the south to 18.7 m AHD in the north of the site. Groundwater in the northern portion was found to be the shallowest and considering the geology in this area (ERM 2007).

4.5.3 Surface Water

Surface run-off is negligible for the flat, well-drained portions of the site but is associated with the silt, clay and gravel lateritic soils of the site (ERM 2007). Surface water from these areas flows into Kadina Brook (ERM 2007). Kadina Brook runs south to north through the site and into the Helena River off site, which is a tributary of the Swan River. Kadina Brook is the only natural surface water feature present within the Conservation Area.

As part of the Kadina Brook foreshore survey undertaken by RPS (2011), a foreshore condition assessment was undertaken which identified the condition of Kadina Brook as ranging from "Good to Completely Degraded". The approximate density of the weed *Watsonia meriana* was also recorded during the survey and ranged between 10% to 90% coverage. A Stream Restoration Plan will be prepared to the satisfaction of DPaW.

4.6 Cultural Values

The Bushmead Rifle Range is a significant place both for its links to Australia's military history, and as an important remnant bushland within Perth's metropolitan region. A section of Bushmead Rifle Range is a designated Bushland Forever site. Apart from providing a government owned rifle range for use by defence personnel and the police, Bushmead has had a long social association with the public. Rifle clubs once held their regular Sunday shoots and competitions there, while the bushland was leased for grazing stock. Portions of the land were also used as convenient locations for storage, extraction, and disposal of legal and illegal waste materials and rubbish.

4.7 Key Threats

The key threats of the Conservation Area are described below.

1. Invasive and problem plants and animals.
2. Inappropriate fire regimes.
3. Unlawful use by unauthorised vehicles, illegal removal of vegetation, firewood collection and rubbish dumping.

5.0 MANAGEMENT CONTEXT

5.1 State Environmental Legislation

Planning for conservation reserves occurs at a number of levels. Figure A illustrates the planning levels typically undertaken for conservation reserves. As illustrated, management plans are guided by key legislation and policy, and in turn provide guidance for subsidiary management reports such as fire management plan, rehabilitation and revegetation and weed management plan.

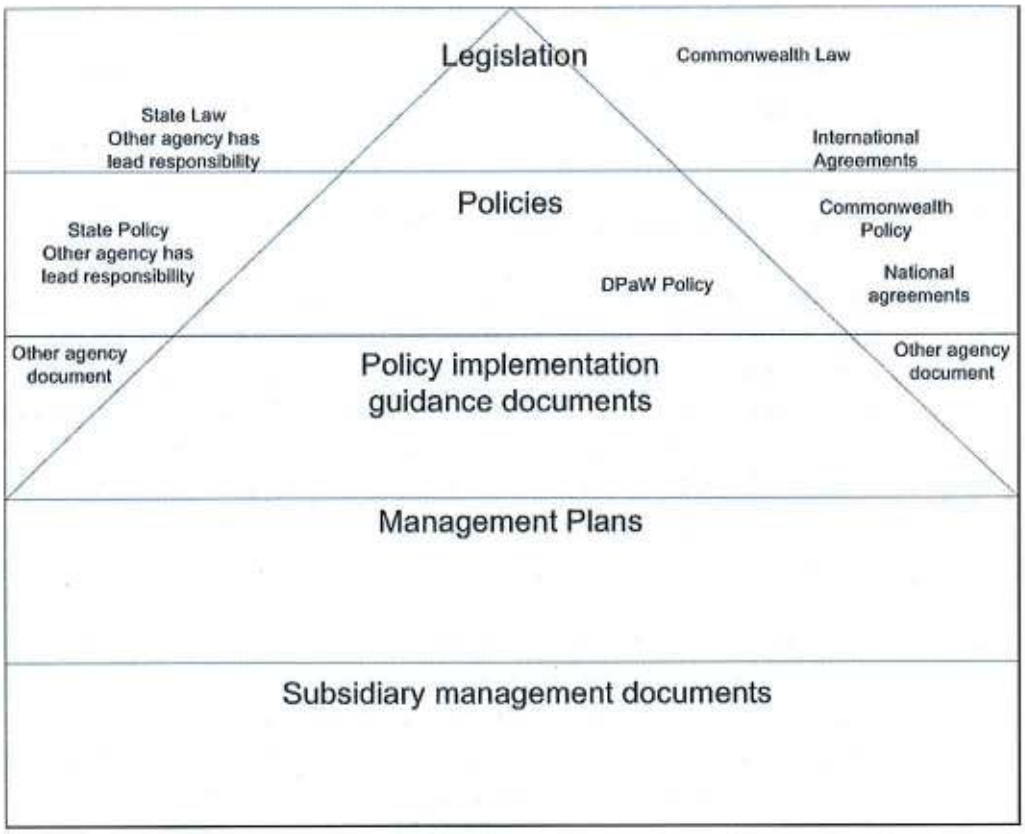

Figure A: Management Plan Hierarchy

DPaW is the responsible agency for the administration of the following state legislation:

1. The *Conservation and Land Management Act 1984* (CALM Act), which provides for the management of land and water vested in the Conservation Commission.

2. The *Wildlife Conservation Act 1950* (WC Act) which provides for the specific protection of native fauna and flora within Western Australia.

DPaW has several key policies relevant to this plan. These policies include:

- Policy Statement No. 3 Management of *Phytophthora* disease
- Policy Statement No. 10 Rehabilitation of disturbed land
- Policy Statement No. 14 Weed Management
- Policy Statement No. 15 Community involvement
- Policy Statement No. 19 Fire management.
- Policy Statement No. 35 Conserving threatened species and ecological communities.

5.2 Commonwealth Environmental Legislation

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), relates to the protection of nationally listed threatened species and ecological communities, heritage and key threatening processes. Actions that have, or likely to have, a significant impact on a Matter of National Environmental Significance (MNES), such as wetlands of international significance, threatened species and ecological communities and migratory species protected under international agreements, require approval from the Commonwealth Minister in addition to any approval required under state legislation.

The Bushmead Project was referred to the Commonwealth Department of the Environment pursuant to the provisions of the EPBC Act, which determined that it constituted a "controlled action" and, as such, requires assessment and a decision about whether approval should be granted under the EPBC Act. The Bushmead Project is considered likely to have a significant impact on MNES for the following reasons:

- the clearing of approximately 50 ha of foraging and breeding habitat for endangered Carnaby's Black-Cockatoo, the vulnerable forest red-tailed black cockatoo and the vulnerable Baudin's black cockatoo
- it is immediately adjacent to, and has the potential to indirectly impact on, a remnant patch of the endangered threatened ecological community *Shrublands and Woodlands of the eastern Swan Coastal Plain.*

This CMP forms part of an integrated response to both state and Commonwealth environmental management obligations arising from the Bushmead Project. It will be implemented consistent with the relevant state and Commonwealth legislation, policies and approvals which apply to the land.

5.3 Performance Assessment and Monitoring

The key performance indicators in the CMP define the outcome(s) of the management actions and provides the guidance to achieve these.

5.4 Key Performance Indicators

A set of key performance indicators (KPIs) has been established, together with performance measures, objectives and reporting requirements.

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6.0 MANAGEMENT ACTIONS

6.1 Urban Area Interface with Conservation Reserve

A public land interface, in the form of roads, public open space or pedestrian access ways will be maintained between the urban cells and the Conservation Reserve. This will reduce the potential for incidents of refuse dumping, weed invasion from private gardens and potential conflicts between land owner and natural bushland objectives (i.e. overhanging trees and branches).

6.2 Service Infrastructure

A 15 m wide easement is required through the Conservation Reserve, between the two urban cells, for essential services including but not limited to the provision of water, electricity, sewerage, telephone, gas and internet cables. The easement alignment is shown on the Diagram of Survey, described as area "A5", and on the Conservation Masterplan, described as "Services easement". It coincides with the alignment of the primary walk trail between the two urban areas.

The alignment of the Services easement has been selected based on its minimal disturbance to native vegetation. It coincides with predominantly cleared areas. Environment impact at the crossing of Kadina Brook will be minimised through appropriate construction methodologies and if the works require interference with the bed and or bank of Kadina Brook, approval from the Department of Water will be sought prior to commencing works.

The "Services easement" will allow ongoing access and maintenance. The final alignment may vary slightly from the alignment shown on the Diagram of Survey and CMP but will reflect the final alignment of the constructed services. Notwithstanding this modification in the final alignment, the easement will not exceed 15 m in width. A head of power to create the easement and allow minor variation to the final alignment is provided in the Conservation Covenant.

6.3 Road Access

The entries of the Neighbourhood Connector road to the southern urban cell traverse the Conservation Area, both off Sadler Drive and Ridge Hill Road. There is need for flexibility in the final alignment of these sections of road as they are not based on detailed design. Agreement has been reached with DPaW to allow some amendment to the final alignments, with consequential amendments to the Covenant Area and Diagram of Survey boundaries, provided:

- The conservation values of the Conservation Reserve boundary are maintained.

- The total area of the road equalling the total area shown on the Metropolitan Region Scheme and reflected in the Diagram of Survey (Appendix 1) is maintained.

A head of power to modify the final road alignments, with subsequent amendments to the Covenant Boundary and Diagram of Survey, is provided in the Conservation Covenant.

The entry of the Neighbourhood Connector road traversing Kadina Brook to the southern urban cell will require approval from the Department of Water to interfere with the bank and/or bed of Kadina Brook prior to commencing works.

The proposed vehicular access network to the urban cells has been designed to provide a minimum of two public access routes for each of the two urban cells through the provision of neighbourhood connectors. In addition, the internal road network has been strategically located to align predominantly along the boundary of both cells in order to provide a level of emergency access and defendable space between proposed lots and the conservation reserve, as well as assist in accommodating the 20 m wide Building Protection Zone for the adjacent lots, where possible.

The northern urban cell is proposed to link with Midland Road at two points to the west. However, in the event that this access is compromised, a 6 m wide Emergency Access Way (EAW) will link with a road from the adjoining subdivision, which ultimately navigates to Helena Valley Road. The EAW will be constructed out of gravel or crushed limestone. Gates (to be kept unlocked at all times) and signage will be erected at either end of the EAW in accordance with the relevant standards.

Access and egress to the Conservation Area for fire suppression machinery and DPaW maintenance will be provided through the Tier 1 Trail / Pathway construction standards detailed below.

6.4 Trails / Pathways

A network of trails and pathways will be provided within the Conservation Reserve to fulfil the following functions:

- Provide important linkages in and around the site for recreational use by walkers.
- Function as added fire breaks providing control lines for fire suppression and strategic access, as outlined in the Fire Management Plan.

A two tier path network is proposed being:

- Tier 1 – hard surface (bitumen) paths – 4 m wide plus 1 m shoulders and a 4 m vertical clearance, which apply to fire management access.

- Tier 2 – soft surface (crushed/compressed limestone/gravel) – 1–2 m wide, which apply to shorter pedestrian linkages.

Pathways that are accessible via the proposed road network will be fitted with heavy-duty gates and barriers to be constructed to a standard acceptable to DPaW.

Wayfaring points at key junctions will provide amenity value, guidance and help to control access. They will contain a colour coded post or similar with information about route distance and estimated time to complete.

Major Trail Heads will be located at key access points into the Conservation Area. They will contain spaces for parking. There will be no more than three to six shaded parking spaces at each major trail head location, as it is envisaged that most path users will be local residents already approaching on foot. Major trail heads will be defined with low fencing and bollards, restricting vehicles from accessing the Conservation Area beyond.

If the construction of the two tier path network requires interference with the bed and or bank of Kadina Brook at the designated crossing points, approval from the Department of Water will be sought prior to commencing works.

6.5 Drainage

Stormwater detention areas for both urban cells will be provided with overflow connections to Kadina Brook in accordance with the approved Local Water Management Strategy. The approved Urban Water Management Plan outlines measures to manage the impacts of stormwater overflow into the Conservation Area. Pedestrian crossings to Kadina Brook will be used to manage 100 year ARI by reducing peak flows downstream.

6.6 Threatened Ecological Communities Management

No development is proposed within the defined TECs areas. Management of the TEC will include fencing and construction management measures.

At DPaW's request, a Tier 1 pathway will be established along an existing cleared path alignment in the central conservation area, within the TEC. The primary purpose is to assist in providing access for fire management purposes. Cedar Woods has notified the Commonwealth Department of the Environment of this requirement, as part of the referral process under the EPBC Act.

In all other cases existing tracks within the TEC will be closed to reduce public access and potential degradation of native vegetation. Pedestrians will be guided along paths and persuaded not to cross revegetation and sensitive zones by appropriate fencing and interpretative information.

6.7 Rehabilitation and Revegetation

To offset the impact of clearing for the approved urban cells, Cedar Woods has identified 38.3 ha of cleared or degraded areas within the Conservation Area to be revegetated, pursuant to its conditional approval under the EPBC Act.

A separate Rehabilitation and Revegetation Plan will be prepared to the satisfaction of DPaW outlining the detail of the revegetation. The Rehabilitation and Revegetation Plan will respond to the requirements of both the Commonwealth Department of the Environment and Department of Parks and Wildlife, in terms of:

- site preparation
- revegetation species, which will be conducive to providing black cockatoo habitat
- planting methodology
- implementation, monitoring and maintenance
- risk management, including weed management
- ongoing performance monitoring, review and possible remedial works.

Cedar Woods has already commissioned the collection of seed and propagation material from the urban cells. The current Seed Bank Collection report lists a total of 118 batches and 52 species, of which 47 batches and 17 species occur on the DPaW's Black Cockatoo Foraging and Usage lists.

Other areas of the proposed Conservation Area are also in need of rehabilitation works, including, but not limited to weed management and fauna habitat general management. An integrated approach will be taken to the rehabilitation and revegetation of the Conservation Area. Kadina Brook has been identified as a management area, and a Stream Restoration Plan will be prepared for this area and implemented to improve the habitat and streamline value, and bank stability, of this waterway.

6.8 Weed Management

A Weed Management Plan will be prepared to the satisfaction of DPaW and implemented by a suitably qualified native vegetation restoration specialist consultant to prevent gradual deterioration of habitat. Weed management will be a critical component of the Rehabilitation and Revegetation Plan.

6.9 Fauna General Management

Protecting and enhancing any potential habitat within the Conservation Area through:

- revegetation (Section 3.0)

- suitable logs or hollows from vegetation cleared within the development areas will be retained and placed within the Conservation Area
- no action will be undertaken that may cause the introduction of new diseases to black cockatoos.

Nature play, sculptural elements and landscaping within the urban areas will also serve as habitat creation.

6.10 Feral Animal Control

A community education program will be undertaken, providing residents with brochures and information packs when buying into the development to address the following:

- the owners and the City of Swan's obligation under the *Cat Act 2012*, e.g. limits on cat ownership numbers and being locked indoors at night
- the owners and the City of Swan's obligations under the *Dog Act 1976*
- the impacts of cats on the natural environment
- general information on the local wildlife in the area, including what to do when encountering local wildlife, not to feed wild animals, the use of urban poisons and its effects on wildlife etc.
- fencing the building envelope to control pets
- control methods for domestic cats, including keeping cats inside overnight
- sterilising pets
- keeping dogs on a leash when walking
- restricting walking to designated paths.

6.11 Fire Management

A network of firebreaks will be installed as shown on the Conservation Masterplan (Appendix 1). These are required for management and maintenance access, strategic perimeter access, control lines for fire suppression and for the management of boundaries for hazard reduction, particularly at the interface between Conservation Area and urban development. A Fire Management Plan will be prepared at subdivision and will require endorsement by the City of Swan on advice from DPaW and the Department of Fire and Emergency Services.

Fire breaks around the urban cells will have 4 m vertical clearance. The firebreaks will meander within a 10 m wide firebreak zone to allow retention of significant trees and other vegetation. The extent of vegetation retained inside the firebreak line consist of retained overstorey trees and shrubs only, with the understorey to be slashed and fuel loads maintained annually at less than two tonnes per hectare.

Four metre wide strategic fire breaks will be provided around the perimeter of the Conservation Area, where they abut road reserves and the rail reserve and 6 m wide where the firebreak abuts private property.

Firebreaks will be installed and maintained by the developer until handover to DPaW. Alignments will coincide with existing paths, where possible.

A combination of the public road network, Building Protection Zones and Hazard Separation Zones proposed within each development cell will act as an interface treatment between the Conservation Area and urban residential development.

6.12 Fencing

A two-tier fencing plan is proposed, being:

- Tier 1 – main fencing standard applicable to boundary fencing and bushland protection is to be constructed of plain wire (4–5 high tensile strands).
- Tier 2 – lower order fencing applicable at strategic locations such as trail heads and boundaries between public open space and conservation areas is to be constructed of low post and rail treated pine log fencing.

6.13 Public Facilities within the Conservation Reserve

The north-west tip of the Bushmead site contains the remnants of the former Bushmead Rifle Range. It includes various bunds and infrastructure associated with this use. The area comprises of mainly low value vegetation such as woolly bush with species valuable to habitat creation such as Banksia species dotted throughout.

Existing cleared tracks criss-cross the relatively flat topography which occasionally break out into degraded spaces which are currently sparse of vegetation. The Conservation Masterplan envisions this area will contain a main walking / jogging track aligned with the former rifle range, punctuated by interpretive signage, and shaded rest points with seating. Areas of degraded vegetation will be fenced off and allowed to regenerate through a program of rehabilitation and revegetation. Subtle fencing and signage will encourage trail users to follow paths and provide information about the importance of the rehabilitation process.

The seasonal tributary, Kadina Brook, meanders through the site from south to north. Although degraded, this section of Kadina Brook is one of the few remaining flow-lines in the area that has not been channelised. Existing tracks weave between trees following the natural undulations of the brook and occasionally form crossing points. The Conservation Masterplan proposes a number of meandering trails aligned on existing tracks and natural undulations in the landform. The brook will provide an extensive feature of conservation interest with pleasant, shaded seating areas and bridge crossings.

The very south-eastern end of the Bushmead site contains some impressively steep slopes, numerous swathes of mature trees and rocky outcrops. When combined, the natural features of this area produce a picture perfect landscape with stunning views of the distant Perth CBD. The Conservation Masterplan seeks to capture and highlight these key features of this area. Rocky outcrops will become a fusion of natural and man-made elements to produce viewing platforms and seating. Interpretive signage will also go beyond the boundaries of the site and describe surrounding features and landmarks.

Public infrastructure in the Conservation Reserve including shaded rest point(s), seating and viewing platforms will be designed in consultation with DPaW's Recreation and Landscape Unit.

6.14 Interpretative Signage

A Signage Strategy will be prepared to the satisfaction of DPAW's Interpretation Unit through the development of a signage strategy. The boundary signage will be consistent with that used in other DPaW managed nature reserves. Interpretive signage/ information board panels will be provided, to DPaW standards, informing the public of the conservation values of the bushland areas and historical significance of the Bushmead site.

Signage will also feature within the Conservation Area to provide access control, footpath network maps and specific walk trail guidance (incorporating "you are here" signs) and information regarding rehabilitation initiatives and wildlife awareness.

6.15 Construction Management

Prior to subdivision, Cedar Woods will prepare and implement a Construction Management Plan to the satisfaction of DPaW which details construction management outcomes and responsibilities. Key components include:

- during construction, vegetation identified to be retained within the development area will be fenced to prevent accidental access by construction vehicles and personnel

- prior to construction works, the perimeter of the Conservation Area will be fenced. The fencing provided will be permeable to fauna so fauna can escape clearing activities. Specific fauna monitoring and relocation strategies will also be undertaken prior to construction works
- dust control
- if construction works require interference with the bed and or bank of Kadina Brook, approval from the Department of Water will be sought prior to commencing construction
- clearing works will be conducted at a slow pace, in co-ordination with a fauna specialist to allow fauna relocation prior to and during construction works
- should any accidental damage to vegetation occur during construction activities, these areas will be included in the rehabilitation and revegetation works
- induction for contractors will be undertaken emphasising the restrictive areas (or boundaries for the construction works), and fauna management
- a wildlife handler/fauna spotter will be on call during clearing works to handle any injured, abandoned or otherwise visibly distressed fauna.

6.16 Dieback Management

The Construction Management Plan will include dieback management protocols. All site personnel shall receive Dieback awareness during their inductions that will include:

- the potential consequences of spreading Dieback into "Protectable" areas
- their obligations to follow the Dieback management procedures as a member of the project team
- informing personnel entering the site of the areas that are infested with Dieback and areas that are not
- the Dieback hygiene management actions to follow, where Clean on Entry locations are, and what Dieback signage and field demarcation looks like
- how to respond if Dieback protocols have not been followed
- maintaining records of attendance to confirm personnel have received site inductions.

Components of the Dieback Management Plan will include:

- All contractors and subcontractors (including landscapers) vehicles should be certified dieback free when entering or leaving the site. This will reduce potential spread of *Phytophthora* around the site and from the site to new areas.
- All vehicles and machinery should be free of mud/soil/vegetation when arriving and leaving the site to reduce potential introduction of disease and weeds.
- Construction vehicles should be limited to the area proposed for development and not enter the Conservation Area.
- A single contractor clean-down/site entry point should be established and site personnel informed of this requirement prior to commencement.
- Minimise walking through the bushland by use of defined tracks and closing obsolete access points.
- Operations such as firebreak slashing should practice dieback hygiene management.
- Apply dieback hygiene during any revegetation and preferably source plants with Nursery Industry Accreditation.
- Some plants used in revegetation works should be dieback resistant.
- Any mulch used on site should be certified dieback free.

6.17 Site Clean Up

Cedar Woods will undertake a clean-up of the site to remove any rubbish, contaminated material and the removal of historic infrastructure (e.g. pipes / culverts, building debris) which may cause a visitor risk, to a standard to the satisfaction of DPaW, prior to the transfer of ownership / management.

6.18 Acid Sulfate Soils

The Department of Environment Regulation Acid Sulfate Soil (ASS) risk mapping, shows the majority of the site as having "moderate to low risk" of encountering ASS within depths greater than three metres. There is however, a small portion of the southern developable area which is mapped as having a "high to moderate" risk.

ASS will be investigated and managed in accordance with the applicable Department of Environmental Regulation Acid Sulphate Soil Guideline Series and requirements of dewatering licences as they arise.

6.19 Auditing

Cedar Woods will maintain accurate records substantiating all activities associated with the implementation of the CMP and make them available to the Department on request. Cedar Woods is aware that those actions which are in response approval under the EPBC Act may be subject to audit under, used to verify compliance with the conditions of approval and be the subject of ongoing reporting.

Table 1: Key Performance Indicators

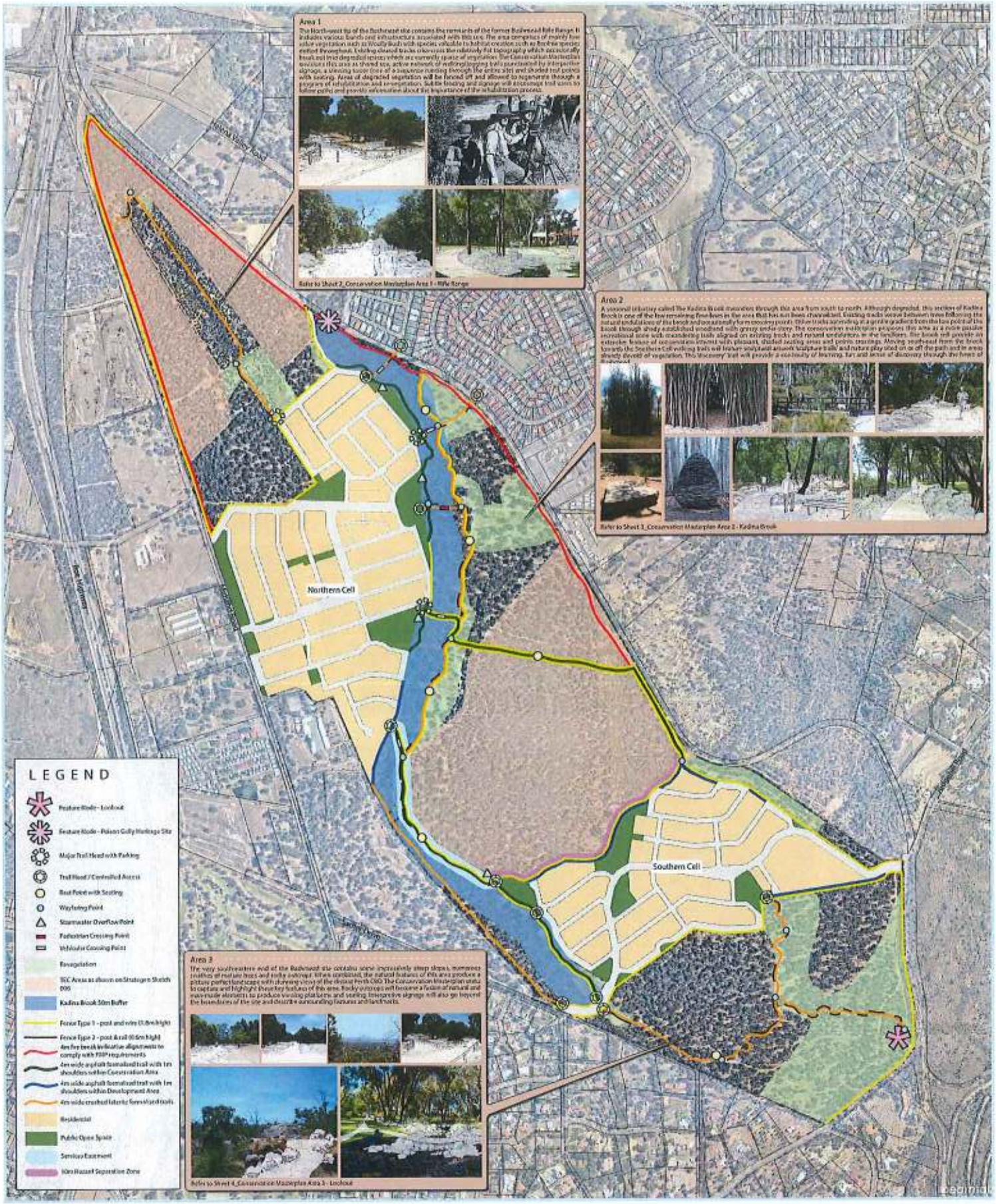
Performance Measure	Target	Reporting
1. Urban Area Interface	Provide public land interface between urban development cells and the Conservation Reserve, in the form of roads, public open space or pedestrian access ways.	Subdivision referral and approval process.
2. Service Infrastructure	Provide 15 m wide easement between the two urban cells, within that area of the Conservation Reserve, described as "Area 5" on the Diagram of Survey, and generally as shown on the Conservation Masterplan.	Alignment as shown on the Conservation Masterplan / Diagram of Survey or modified pursuant to the criteria outlined in the Conservation Covenant
3. Road Access	Should road alignments require modification, ensure the: ▪ conservation values of the Conservation Reserve boundary are maintained ▪ total area of the road equalling the total area shown on the Metropolitan Region Scheme and reflected in the Diagram of Survey (Plan 4) is maintained.	Alignments as per Metropolitan Region Scheme zoning / Diagram of Survey or modified pursuant to the criteria outlined in the Conservation Covenant
4. Trails / Pathways	Establish a two-tier network of trails and paths to fulfil the following functions: ▪ Tier 1 – hard surface (bitumen) paths 4 m wide plus 1.0 m shoulders and a 4 m vertical clearance which apply to fire management access ▪ Tier 2 – soft surface (crushed/compressed limestone/gravel) 1–2 m wide, which apply to shorter pedestrian links.	Conservation Masterplan
5. Drainage	Interface between urban cells and Conservation Reserve addressed through Local Water Management Strategy.	As per Urban Water Management Plan
6. TEC Management	Ensure no decline in extent or overall condition class (Bush Forever scales) of the TEC occurrences – FCT 20a and 20c.	EPBC Act Approval Conservation Masterplan Weed Management Plan Rehabilitation and Revegetation Plan
7. Rehabilitation and Revegetation	Preparation and implementation of a Revegetation Plan, as per EPBC Act Approval. Preparation and implementation of a Stream Restoration Plan for Kadina Brook, and general habitat rehabilitation within the proposed Conservation Area	EPBC Act Approval Conservation Masterplan Rehabilitation and Revegetation Plan Stream Restoration Plan
8. Weed Management	Preparation and implementation of a Weed Management Plan.	Weed Management Plan
9. Fauna Management	As per Construction Management Plan.	Construction Management Plan

Performance Measure	Target	Reporting
10. Feral Animal Control	The community education brochure will contain the following information: ▪ the owners and the City of Swan's obligation under the *Cat Act 2012*, e.g. limits on cat ownership numbers and being lock indoors at night ▪ the owners and the City of Swan's obligations under the *Dog Act 1976* ▪ the impacts of cats on the natural environment ▪ general information on the local wildlife in the area, including what to do when encountering local wildlife, not to feed wild animals, the use of urban poisons and its effects on wildlife, etc. ▪ fencing the building envelope to control pets ▪ control methods for domestic cats, including keeping cats inside over night ▪ sterilising pets ▪ keeping dogs on a leash when walking ▪ restricting walking to designated paths.	Information Packs subject to DPaW endorsement
11. Fire Management	Preparation and Implementation of a Fire Management Plan – a subdivision requirement.	Fire Management Plan Conservation Masterplan
12. Fencing	Establish two-tier fencing system, being ▪ Tier 1 – main fencing standard applicable to boundary fencing and bushland protection – constructed of plain wire (4–5 high tensile strands) ▪ Tier 2 – lower order fencing at strategic locations such as trail heads and boundaries between public open space and conservation areas – constructed of low post and rail treated pine logging.	Conservation Masterplan
13. Public Facilities	As per Conservation Masterplan	Conservation Masterplan
14. Interpretative Signage	Preparation and Implementation of a Signage Strategy to include: ▪ boundary signage ▪ interpretative signage/information panels – informing the public of the conservation values of the bushland areas and historical significance of the site.	Signage strategy
15. Construction Management	Preparation and Implementation of Construction Management Plan.	Construction Management Plan
16. Dieback Management	As per Construction Management Plan. No decline in extent or overall vegetation condition class (Bush Forever scales) as a result of *Phytophthora* species.	Construction Management Plan
17. Site Clean-up	Clean conservation reserve of any rubbish, contaminated material and removal of historical infrastructure.	DPaW sign-off prior to land transfer.
18. Acid Sulfate Soils	Manage risk of ASS in accordance with DER ASS Guideline Series, if required.	ASS response strategy, if required

RPS

APPENDIX I

Bushmead Conservation Masterplan



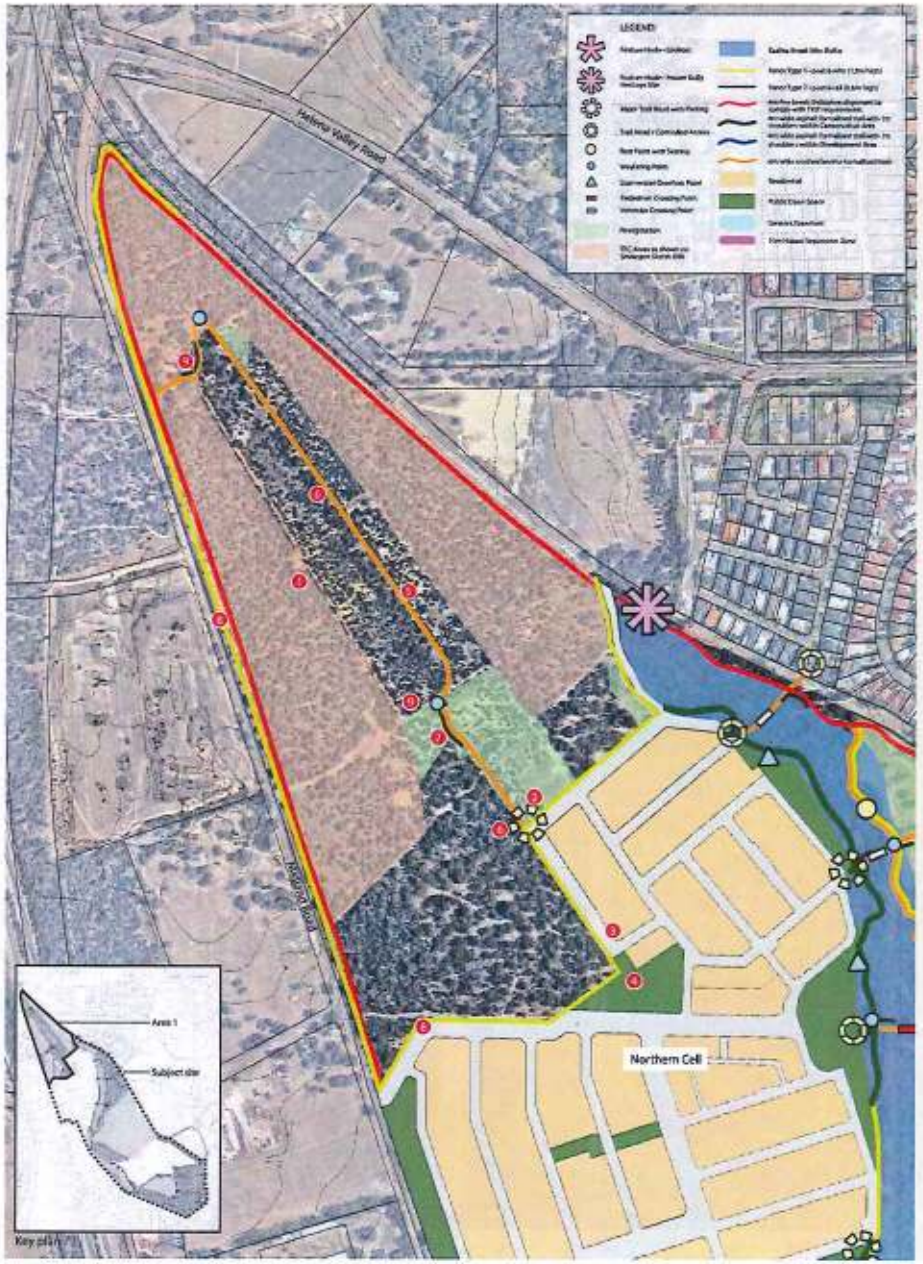
All path alignments, features and nodes have had preliminary ground truthing. Final positions to be confirmed on site during detail design and construction stage.

Aerial imagery provided under license courtesy of Nearmap Ltd

Bushmead Conservation Masterplan - Overview Rev E

Sheet 1 of 4 June 2016

EPCAD



LEGEND

1 SEATING / REST POINT

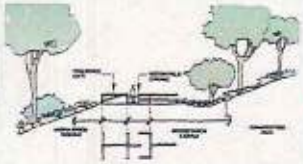
Seating and additional shade will be located at key junctions and 'halfway' points on formalised paths. They will be located in pleasant areas where minimal clearance is required. Local materials and recycled site objects will be used or referenced in the design to create furniture which adds to the sense of place. Local schools and artists could be approached to contribute to these elements providing a more unique suite of furniture. 'Sculptured' furniture could also act as an extension of the 'discovery' trail in conservation area 3, providing a link with similar elements and themes.

2 MAJOR TRAIL HEAD WITH PARKING

Major trail heads will be located at key access points into the conservation area. They will contain interpretive signage and space for parking. There will be no more than 3-6 shaded parking bays at each major trail head location as it is envisioned that most path users will be local residents generally already approaching on foot. Surfacing will be an 'informal' stabilised crushed laterite or similar, in keeping with the natural feel of the area. Major trail heads will be defined with low fencing and bollards restricting vehicles from accessing the conservation areas beyond.

3 TRAIL HEAD / CONTROLLED ACCESS

Trails heads leading into conservation areas at the interface of roads, pathways and development cells will be clearly defined with low fencing and interpretive signage. Low Fencing will provide guidance onto the trail and control access preventing pedestrian and vehicular access through sensitive conservation areas. Vehicle access along pathways will be restricted using bollards, chicanes and gates.



4 POS / CONSERVATION AREA INTERFACE

Paths from within development POS will connect into the network of trails in the conservation area providing strong linkages and seamless integration with the natural setting. Vegetation clearance, which may be required at these interfaces to meet fuel reduction requirements, could provide the opportunity to introduce small break out spaces containing interpretation signage, seating and integrated drainage.

5 FORMALISED TRAIL / FIRE BREAK

Existing trails which provide important linkages in and around the site will be formalised for recreational use by walkers and cyclists. They will also function as fire breaks providing control lines for fire suppression and strategic access as outlined in the Fire Management Plan. Wayfaring points at key junctions will provide amenity value, guidance and help to control access. They will contain a colour coded post or similar with information about route distance and estimated time to complete. Trail surfaces will be constructed from asphalt and stabilised crushed laterite in keeping with the character of the site. Key connections will be a more hard wearing durable surface such as asphalt.

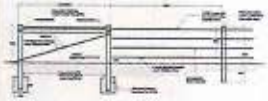
6 INTERPRETIVE SIGNAGE

Interpretive signage will provide information about flora and fauna located on site and the various conservation techniques being implemented to protect and enhance the area. Signage will be situated at key trail heads, wayfaring points and feature nodes.

7 HERITAGE SIGNAGE (RIFLE RANGE)

Heritage signage will provide information about the history of the former rifle range and highlight key topographical features past and present which formed part of its infrastructure.

8 FENCE TYPE 1 (POST & WIRE PERIMETER 1.8m HIGH)



This fencing will define the perimeter of the conservation area where it meets with Helena Valley Road and Midland Road. It will control access and protect sensitive habitat.

9 FENCE TYPE 2 (POST & RAIL 0.6m HIGH)

A lower post and rail fence will define key access points and intersections within the path network, guiding users along paths and to control access away from rehabilitation areas.

0m 100 200 300m

0min 1 2min

Note:
This plan to be read in conjunction with the following:
Local Structure Plan Lot 911 Midland Road, Hazelmere - CMP BUS FD1630 H (RDG)
Bushmead Environmental Assessment Report - January 2013 (RPS)
Fire Management Plan - September 2014 (Strategen)

All path alignments, features and nodes have had preliminary ground truthing. Final positions to be confirmed on site during detail design and construction stage.

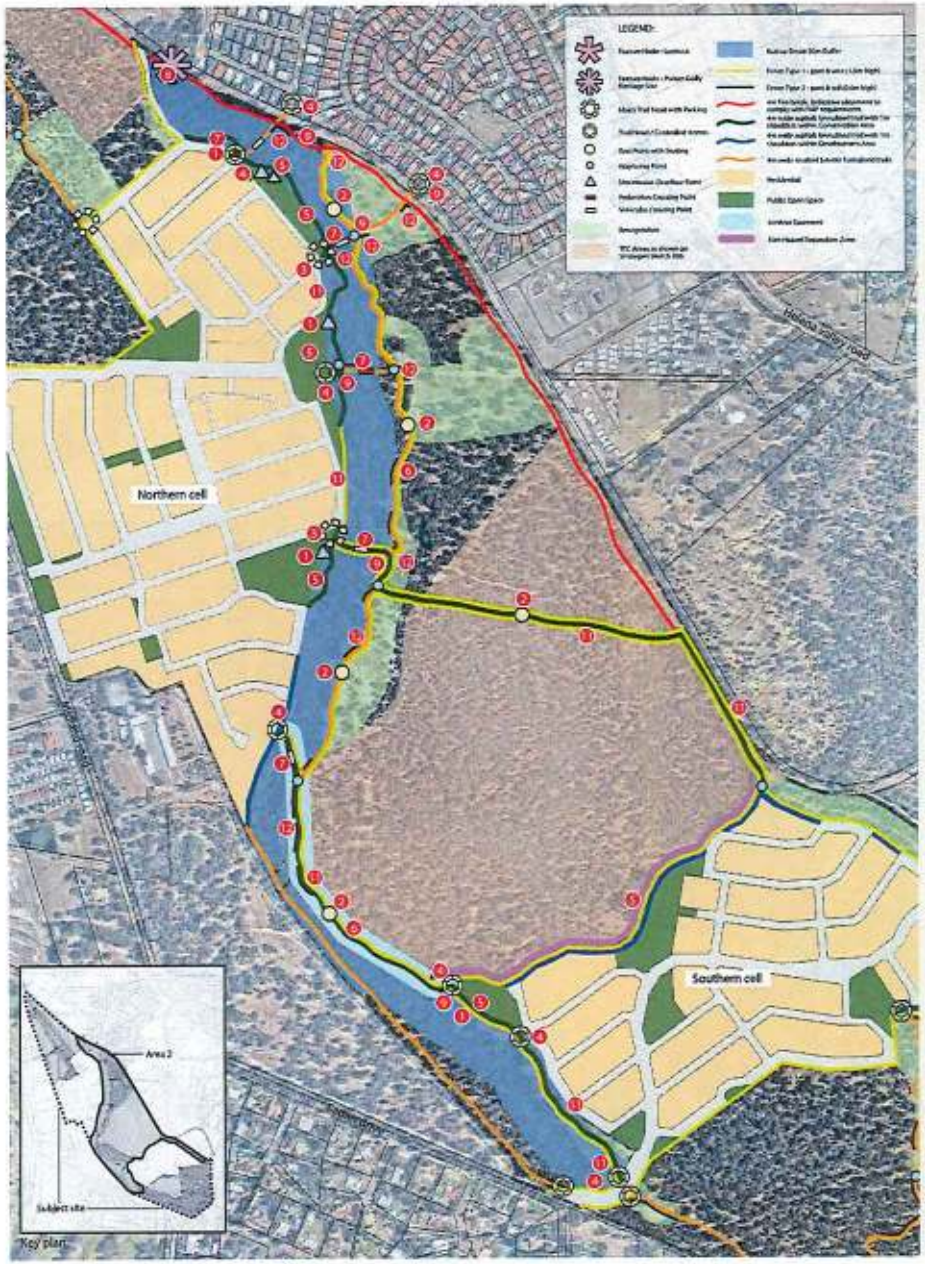
Aerial imagery provided under license courtesy of Nearmap Ltd.

Bushmead

Conservation Masterplan Area 1 - Rifle Rev E

Sheet 2 of 4 June 2016

EPCAD



LEGEND

1 STORM WATER

At key points drainage will be integrated within the landscape design to allow stormwater to flow to Kadina Brook. Flow paths will be defined by the natural slope of the land and the swales will reflect natural creek lines. Overland flow will be encouraged along natural flow paths with open drainage channels and vegetated swales to treat water. The overland flow paths will visually enhance the streetscapes, POS and bushland interface, but will also slow the movement of water, reducing the transport of sediment and leaf matter, improving access for maintenance and controlling the flow velocity. Reducing the flow velocity will assist to manage the potential risk of erosion to Kadina Brook.

2 SEATING / REST POINT

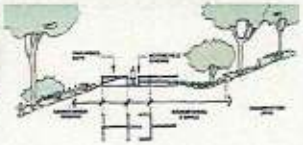
Seating and additional shade will be located at key junctions and 'halfway' points on formalised paths. They will be located in pleasant areas where minimal clearance is required. Local materials and recycled site objects will be used or referenced in the design to create furniture which adds to the sense of place. Local schools and artists could be approached to contribute to these elements providing a more unique suite of furniture.

3 MAJOR TRAIL HEAD WITH PARKING

Major trail heads will be located at key access points into the conservation area. They will contain interpretive signage and space for parking. There will be no more than 3-6 shaded parking bays at each major trail head location as it is envisioned that most path users will be local residents generally already approaching on foot. Surfacing will be an informal stabilised crushed laterite or similar, in keeping with the natural feel of the area. Major trail heads will be defined with low fencing and bollards restricting vehicles from accessing the conservation areas beyond.

4 TRAIL HEAD / CONTROLLED ACCESS

Trails heads leading into conservation areas at the interface of roads, pathways and development cells will be clearly defined with low fencing and interpretive signage. Low Fencing will provide guidance onto the trail and control access preventing pedestrian and vehicular access through sensitive conservation areas. Vehicle access along pathways will be restricted using bollards, chicanes and gates.



5 POS / CONSERVATION AREA INTERFACE

Paths from within development POS will connect into the network of trails in the conservation area providing strong linkages and seamless integration with the natural setting. Vegetation clearance, which may be required at these interfaces to meet fuel reduction requirements, could provide the opportunity to introduce small break out spaces containing interpretation signage and seating.

6 FORMALISED TRAIL / FIRE BREAK

Existing trails which provide important linkages in and around the site will be formalised for recreational use by walkers and cyclists. They will also function as fire breaks providing control lines for fire suppression and strategic access as outlined in the Fire Management Plan. Wayfaring points at key junctions will provide amenity value, guidance and help to control access. They will contain a colour coded post or similar with information about route distance and estimated time to complete. Trail surfaces will be constructed from asphalt and stabilised crushed laterite in keeping with the character of the site.

7 KADINA BROOK CROSSING

Trails approaching and crossing the low point of the Kadina Brook will feature board walks, bridges and deck platforms. These will be constructed with materials sympathetic to the surroundings and feature interpretive signage containing information about the Kadina Brook and valuable habitat it creates.

8 HERITAGE SIGNAGE (SITE OF POISON GULLY TRAIN CRASH)

Heritage signage will be situated near to the site of the Poison Gully accident, a train crash that occurred in 1904. It will contain information and historic imagery about the accident.

9 INTERPRETIVE SIGNAGE

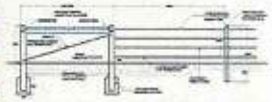
Interpretive signage will provide information about flora and fauna located on site and the various conservation techniques being implemented to protect and enhance the area. Signage will be situated at key trail heads, wayfaring points and feature nodes. Signage next to the Kadina Brook will contain information about the brook and the habitat it creates. Signage will be stainless steel or similar.

10 DISCOVERY TRAIL / NATURE PLAY

A series of linked formalised trails will become a sculpture trail connecting the northern and southern development cells. At defined points along the trail sculptures and artwork will be able to be discovered. These could include contributions by local artists and schools and also double as interactive furniture and nature play. The brief for these items will be very much 'of the landscape' with a focus on nature, conservation and sustainability.

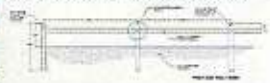
11 FENCE TYPE 1 (POST & WIRE PERIMETER 1.8m HIGH)

This fencing will define the perimeter of the conservation area where it meets with Helena Valley Road and Midland Road. It will control access and protect sensitive habitat.



12 FENCE TYPE 2 (POST & RAIL 0.6m HIGH)

A lower post and rail fence will define key access points and intersections within the path network, guiding users along paths and to control access away from rehabilitation areas.



0m 100 200 300m

Note:
This plan to be read in conjunction with the following:
Local Structure Plan Lot 911 Midland Road, Hazelmere – CWP BUS RO1036 M (RDG)
Bushmead Environmental Assessment Report - January 2012 (RPS)
Fire Management Plan - September 2014 (Strategen)

All path alignments, features and nodes have had preliminary ground truthing. Final positions to be confirmed on site during detail design and construction stage.

Aerial Imagery provided under licence courtesy of Nearmap Ltd.

Bushmead Conservation Masterplan Area 2 - Rev E Sheet 3 of 4 June 2016 EPCAD

Ref: 80812_Sheet 1_Conservation Masterplan Area 2 – Kadina Brook Rev E.ai

0min 1 2min
0m 100 200 300m

LEGEND

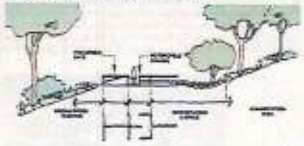
1 LOOKOUT

This is the highest point of the site and features a rocky outcrop and stunning views. The rocky outcrop will become a platform accessible by steps and protected by a shade structure. Balustrade and step details will appear to emerge from the rock and present a fusion of manmade and natural material. Interpretive signage and a panoramic viewfinder will provide an overview of the Bushmead site and picnic facilities and nearby car parking will attract visitors and passers-by from the nearby Paige Hill Road.

2 MAJOR TRAIL HEAD WITH PARKING

Major trail heads will be located at key access points into the conservation area. They will contain interpretive signage and space for parking. There will be no more than 3-6 shaded parking bays at each major trail head location as it is envisioned that most path users will be local residents generally already approaching on foot. Surfacing will be an informal stabilised crushed laterite or similar, in keeping with the natural feel of the area. Major trail heads will be defined with low fencing and bollards restricting vehicles from accessing the conservation areas beyond.

3 TRAIL HEAD / CONTROLLED ACCESS



Trails heads leading into conservation areas at the interface of roads, pathways and development cells will be clearly defined with low fencing and interpretive signage. Low Fencing will provide guidance onto the trail and control access preventing pedestrian and vehicular access through sensitive conservation areas. Vehicle accessibility pathways will be restricted using bollards, chicanes and gates.

4 POS / CONSERVATION AREA INTERFACE

Paths from within development POS will connect into the network of trails in the conservation area providing strong linkages and seamless integration with the natural setting. Vegetation clearance, which may be required at these interfaces to meet fuel reduction requirements, could provide the opportunity to introduce small break-out spaces containing interpretation signage, seating and integrated drainage.

5 FORMALISED TRAIL / FIRE BREAK

Existing trails which provide important linkages in and around the site will be formalised for recreational use by walkers and cyclists. They will also function as fire breaks providing control lines for fire suppression and strategic access as outlined in the Fire Management Plan. Wayfinding points at key junctions will provide amenity value, guidance and help to control access. They will contain a colour coded post or similar with information about route distance and estimated time to complete. Trail surfaces will be constructed from asphalt and stabilised crushed laterite in keeping with the character of the site.

6 INTERPRETATION (VIEW FINDER)

A viewfinder will be positioned on the lookout which contains local geographic information and overlays key landmarks such as the distant Perth CBD helping to orientate and view Bushmead in the wider context.

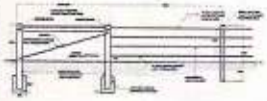
7 INTERPRETIVE SIGNAGE

Interpretive signage will provide information about flora and fauna located on site and the various conservation techniques being implemented to protect and enhance the area. Signage will be situated at key trail heads, wayfaring points and feature nodes.

8 SEATING / REST POINT

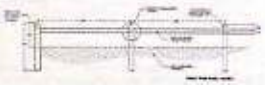
Seating additional shade will be located at key junctions and 'Pathway' points on formalised paths. They will be located in pleasant areas where minimal clearance is required. Local materials and recycled site objects will be used or referenced in the design to create furniture which adds to the sense of place. Local schools and artists could be approached to contribute to these elements providing a more unique suite of furniture. 'Sculptured' furniture could also act as an extension of the 'discovery' trail in conservation area 2, providing a link with similar elements and themes.

9 FENCE TYPE 1 (POST & WIRE PERIMETER 1.8m HIGH)



This fencing will define the perimeter of the conservation area where it meets with Helena Valley Road and Midland Road. It will control access and protect sensitive habitat.

10 FENCE TYPE 2 (POST & RAIL 0.6m HIGH)



A lower post and rail fence will define key access points and intersections within the path network, guiding users along paths and to control access away from rehabilitation areas.

Note:
This plan to be read in conjunction with the following:
Local Structure Plan Lot 911 Midland Road, Hazelmere - CWP BUS RD1030 M (PDG)
Bushmead Environmental Assessment Report - January 2012 (EPD)
Fire Management Plan - September 2014 (Strategen)

All path alignments, features and nodes have had preliminary ground truthing. Final positions to be confirmed on site during detail design and construction stage.

Aerial Imagery provided under license courtesy of Nearmap Ltd.

Bushmead Conservation Masterplan Area 3 - Rev E

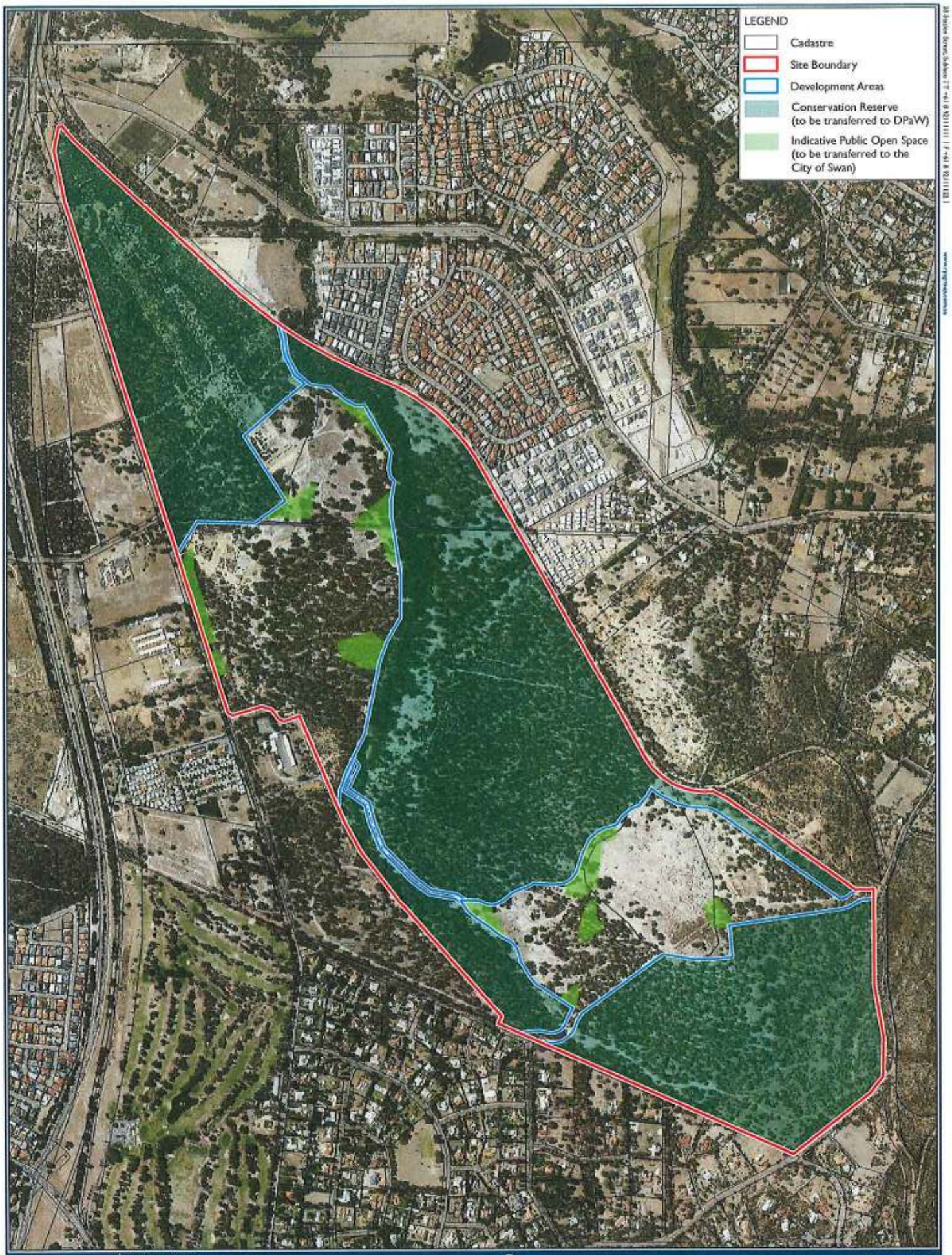
Sheet 4 of 4 June 2016

EPCAD

RPS

APPENDIX 2

Bushmead Conservation Area and Public Open Space Areas



RPS

Appendix 2
Conservation Reserve
and Public Open Space

RPS

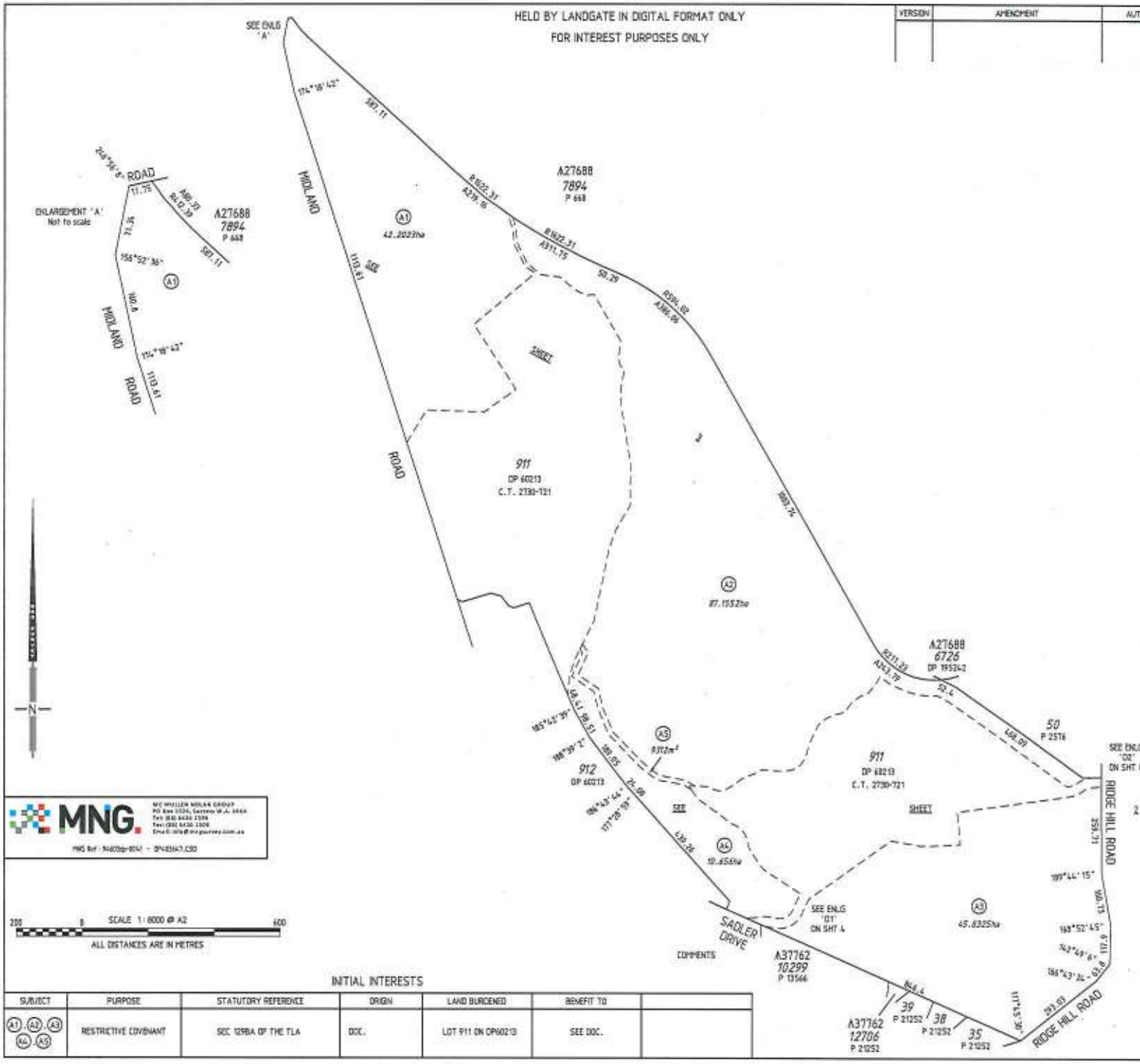
APPENDIX 3

Land Tenure Details

HELD BY LANDGATE IN DIGITAL FORMAT ONLY

FOR INTEREST PURPOSES ONLY

VERSION	AMENDMENT	AUTHORISED BY	DATE



MNG

MC MULLEN NOLAN GROUP
PO Box 3124, Canning Vale W.A. 6964
Tel: (08) 6436 1396
Fax: (08) 6436 1309
Email: info@mcgurvey.com.au

MNG Ref: 94600pr804 - DP403647.CSD

INITIAL INTERESTS

SUBJECT	PURPOSE	STATUTORY REFERENCE	ORIGIN	LAND BURDENED	BENEFIT TO	
(A1), (A2), (A3), (A4), (A5)	RESTRICTIVE COVENANT	SEC 129BA OF THE TLA	DOC.	LOT 911 ON DP60213	SEE DOC.	

TYPE FREEHOLD S.S.A. NO

PURPOSE INTEREST

PLAN OF
RESTRICTIVE COVENANT
AND/OR OTHER INTERESTS OVER
LOT 911 ON DP 60213

FORMER TENURE N/A

LOCAL AUTHORITY CITY OF SWAN

LOCALITY HAZELMERE

D.O.L. FILE

FIELD RECORD 127566

SURVEYOR'S CERTIFICATE - REG 54

I, Daniel T. GROGAN

hereby certify that this plan is accurate and is a correct representation of the -

(a) *survey, and/or

(b) *calculations from measurements recorded in the field records,

[* delete if inapplicable]

undertaken for the purposes of this plan and that it complies with the relevant written law(s) in relation to which it is lodged.

FINAL

LICENSED SURVEYOR DATE

LODGED

DATE FEE PAID ASSESS No.

I.S.C.

EXAMINED

DATE

WESTERN AUSTRALIAN PLANNING COMMISSION

FILE

Delegated under S. 16 P&D Act 2005 DATE

IN ORDER FOR DEALINGS

SUBJECT TO

FOR INSPECTOR OF PLANS AND SURVEYS DATE

APPROVED

INSPECTOR OF PLANS AND SURVEYS DATE
S. 18 Licensed Surveyors Act 1909

GOVERNMENT OF WESTERN AUSTRALIA

Landgate

DEPOSITED PLAN

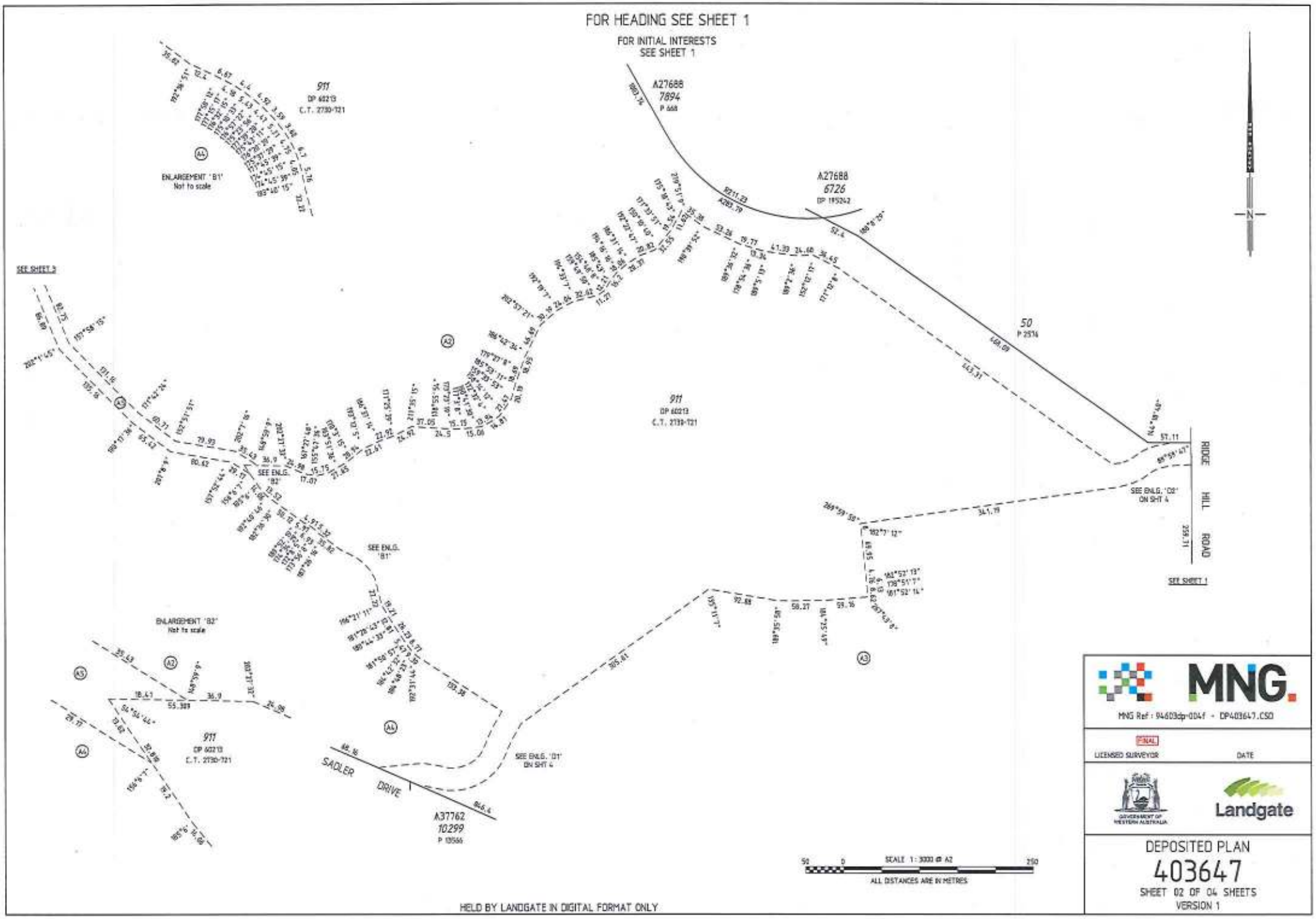
403647

SHEET 01 OF 04 SHEETS

VERSION 1

FOR HEADING SEE SHEET 1

FOR INITIAL INTERESTS
SEE SHEET 1



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MNG

MNG Ref : 94603dp-004f - DP403647.CSO

FINAL

LICENSED SURVEYOR DATE

GOVERNMENT OF WESTERN AUSTRALIA

Landgate

DEPOSITED PLAN

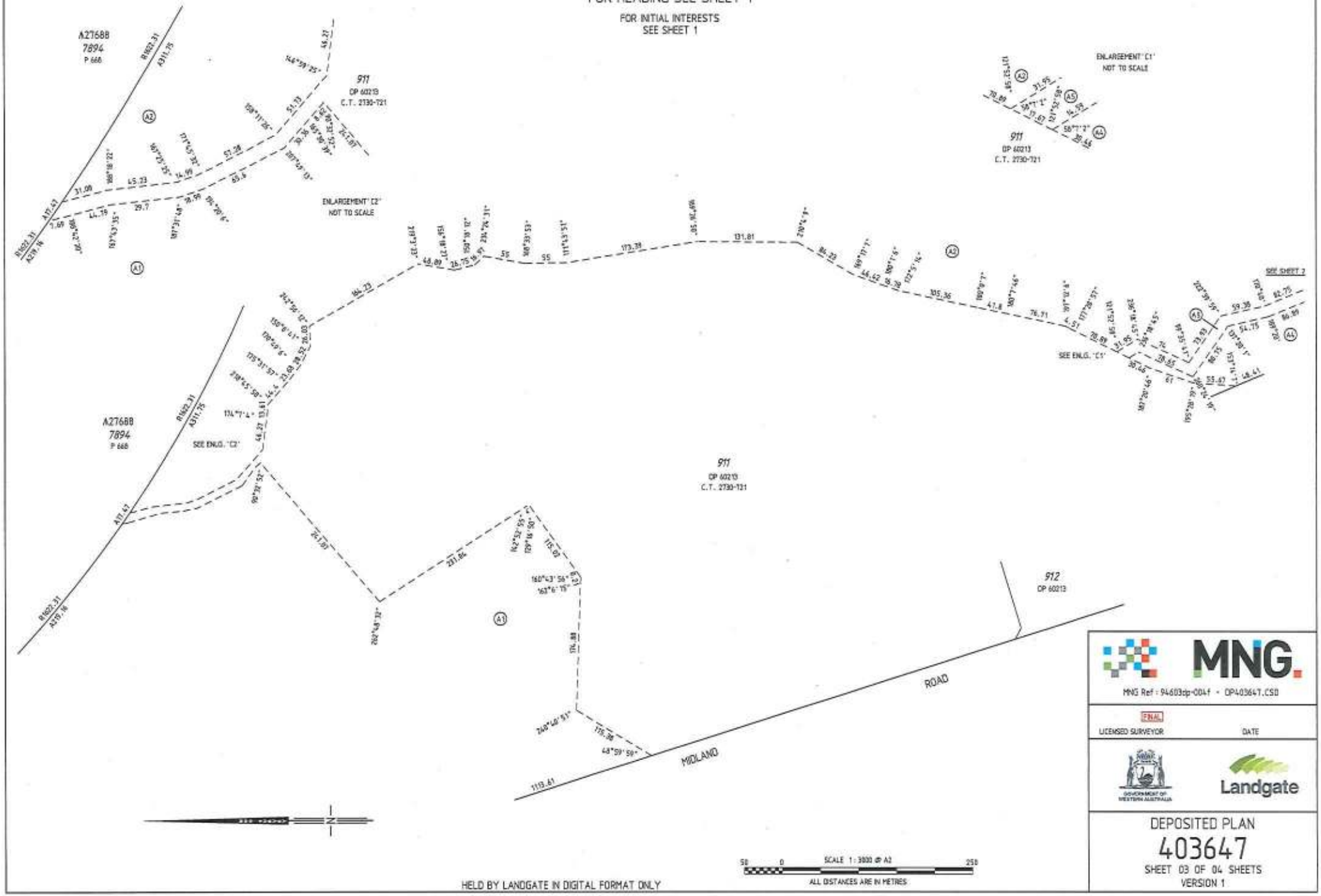
403647

SHEET 02 OF 04 SHEETS

VERSION 1

FOR HEADING SEE SHEET 1

FOR INITIAL INTERESTS
SEE SHEET 1



SCALE 1 : 3000 @ A2

50 0 250

ALL DISTANCES ARE IN METRES

HELD BY LANDGATE IN DIGITAL FORMAT ONLY

MNG

MNG Ref : 94603dp-004f - DP403647.CSD

FINAL

LICENSED SURVEYOR DATE

Landgate

DEPOSITED PLAN

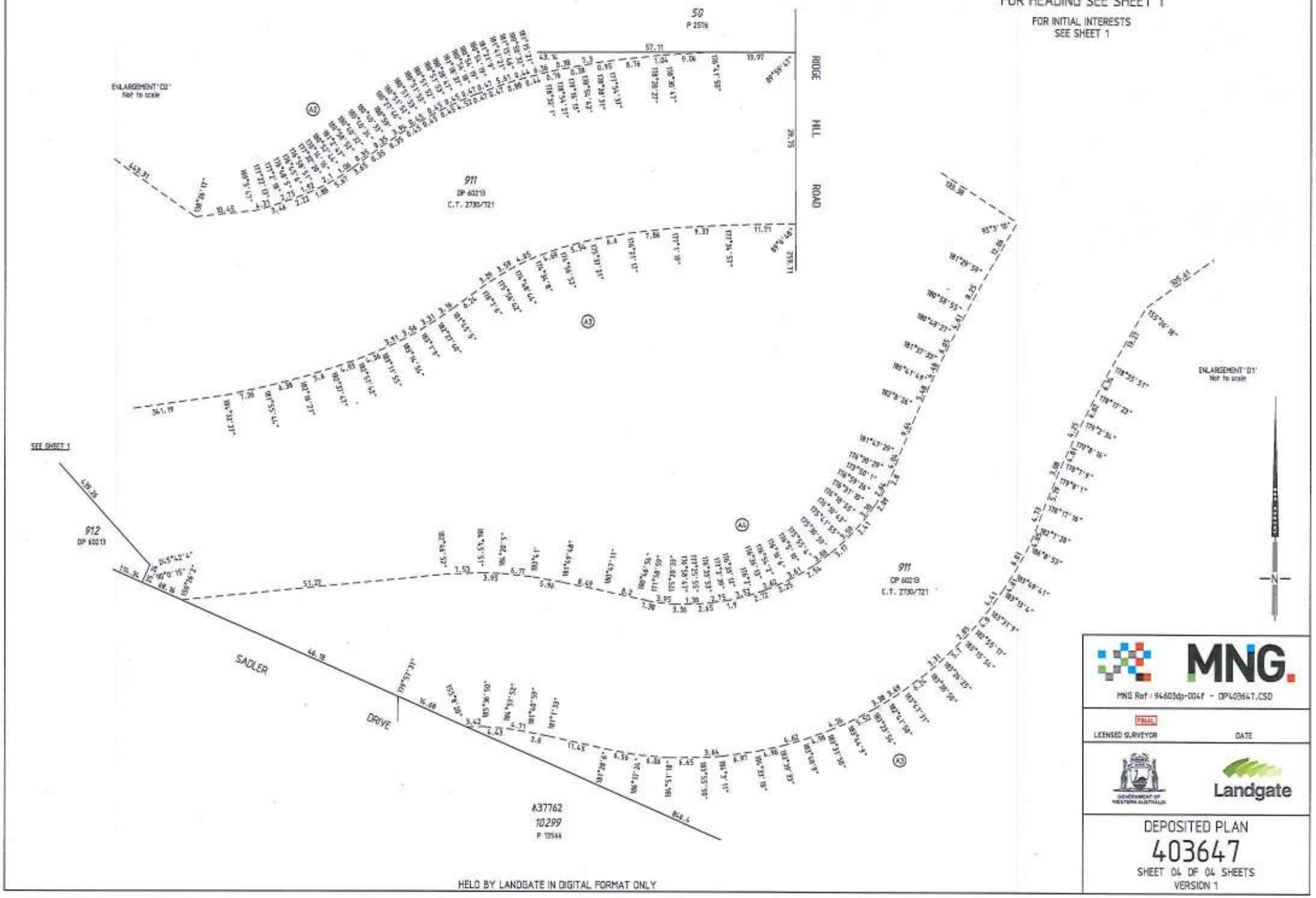
403647

SHEET 03 OF 04 SHEETS

VERSION 1

FOR HEADING SEE SHEET 1

FOR INITIAL INTERESTS
SEE SHEET 1



HELD BY LANDGATE IN DIGITAL FORMAT ONLY

MNG Ref : 94603dp-004f - DP403647.CSD

FINAL

LICENSED SURVEYOR DATE

Landgate

DEPOSITED PLAN
403647
SHEET 04 OF 04 SHEETS
VERSION 1

Appendix 5
Conservation (Restrictive) Covenant

FORM B2

APPROVAL NO. B1863

WESTERN AUSTRALIA
TRANSFER OF LAND ACT 1893 AS AMENDED

BLANK INSTRUMENT FORM

RESTRICTIVE COVENANT

(NOTE 1)

DESCRIPTION	**DEED OF COVENANT FOR THE CONSERVATION OF LAND**. Restrictive Covenant, pursuant to section 129BA of the Transfer of Land Act 1893, benefiting a public authority.
Date	**THIS RESTRICTIVE COVENANT** is made the 27th day of July, (20 16).
Owner, the registered proprietor of the burdened land	**BETWEEN** Dunland Property Pty Ltd (ACN 127 744 656) of 66 Kings Park Road, West Perth ("the **Owner**") **AND**
Benefiting public authority, name and description	Conservation and Land Management Executive Body ("the **Executive Body**") of care of the Department of Parks and Wildlife ("the **Department**"), Locked Bag 104, Bentley Delivery Centre, Western Australia 6983
Land	Those parts of Lot 911 on Deposited Plan 60213 shown respectiverly as A1, A2, A3, A4 and A5 on Deposited Plan 403647 being part of the Land comprised in Certificate of Title Volume 2730 folio 721 ("the **Land**").
RECITALS	**WHEREAS**
Covenant runs with the land	A. This Restrictive Covenant binds the Owner, and persons deriving title from it, in perpetuity.
Limitations, Interests, Encumbrances and Notifications	B. 1. T18266/1955 Easement burden to Minister of Water Supply Sewerage and Drainage for water supply purposes- see Transfer 18266/1955 and Deposited Plan 60213. 2. L415547 Mortgage to ANZ Fiduciary Services Pty Ltd
Intention of the Owner and the Executive Body	C. It is the intention of the Owner and the Executive Body that certain activities on the Land be restricted in order to protect its natural values, and in particular the special natural values listed in Recital D.
Special natural values	D. The special natural values of the Land are: • approximately 213 hectares of Forrestfield vegetation complex, of which there was less than 9% remaining within the Perth Metropolitan Region on the Swan Coastal Plain in 1998; • occurrences of the following threated ecological communities which are listed on the Department's List of Threatened Ecological Communities endorsed by

LANDGATE COPY OF ORIGINAL NOT TO SCALE Wed Sep 21 16:35:24 2016 JOB 52014078

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	the Minister for Environment (May 2014): 'SCP20a – *Banksia attenuata* woodland over species rich dense shrublands' and 'SCP20c – Shrublands and woodlands of the eastern side of the Swan Coastal Plain' and the latter also being listed as a matter of national environmental significance under the *Environment Protection and Biodiversity Conservation Act 1999*; • a population of the following species listed on the Department's Priority Flora List (November 2015: *Acacia oncinophylla* subsp. *oncinophylla*, *Asteridea gracilis*, *Halgania corymbosa*, *Isopogon drummondii*, *Lasiopetalum glutinosum* subsp. *glutinosum* and *Pithocarpa corymbulosa*, listed as Priority 3; and *Boronia tenuis* and *Calothamnus accedens*, listed as Priority 4; • a population of the following species listed as endangered under Schedule 2 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2015*: *Calyptorhynchus baudinii* (Baudin's black-cockatoo) and *Calyptorhynchus latirostris* (Carnaby's cockatoo); • a population of *Dasyurus geoffroii* (Chuditch) listed as vulnerable under Schedule 3 of the *Wildlife Conservaiton (Specially Protected Fauna) Notice 2015*; • a population of the following species which are listed as migratory birds protected under international agreement under Schedule 5 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2015*: *Merops ornatus* (rainbow bee-eater) and *Chlidonias leucopterus* (white-winged black tern); • a population of *Isoodon obesulus fusciventer* (Southern Brown Bandicoot or Quenda) which is listed as Priority 5 on the Department's Priority Fauna List (November 2015); • the Kadina Brook, a tributary of the Helena River, recognised as a wetland of significant conservation value due to there being few creeklines in the Ridge Hill Shelf system not affected by quarrying or urbanisation and a section of which is classified as having vegetation in very good – excellent condition; and • that the bushland is recognised within the State Government's Bush Forever policy as a regionally significant fragmented bushland/wetland linkage due to it being part of several strategic corridors within the Perth Metropolitan Region where the Swan Coastal Plan and the Darling Plateau meet through naturally vegetated areas.
LEGAL RELATIONSHIPS	**NOW THIS AGREEMENT WITNESSES:**
Owner's covenants	1. The Owner with the intention of binding so far as is possible all registered proprietors or other persons having an estate or interest in the Land to ensure compliance with the restrictions set out herein, HEREBY COVENANTS with the Executive Body that the Owner shall not, except with the prior written consent of the Executive Body or in accordance with Management Guidelines mutually agreed by the Owner and the Executive Body under clause 2 ("**Management Guidelines**"), do or permit to be done any act or thing upon the Land which in the reasonable opinion of the Executive Body is prejudicial to the natural values of the Land, and in particular the Owner shall not: a) subdivide or permit subdivision of the Land; b) place or permit to be placed any structure or dwelling on the Land, save for recreation and interpretation structures, in accordance with the Management

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	Guidelines; c) destroy or remove or permit the destruction or removal of any local indigenous flora or any indigenous fauna or their related habitats on or from the Land, save for: i) plant propagation and identification material, in accordance with the Management Guidelines; ii) as necessary to undertake works including the establishment and maintenance of firebreaks, fencing, tracks, signage, seating, shade structure and viewing platform, in such a manner as to minimise damage to indigenous flora and indigenous fauna, and in accordance with the Management Guidelines; iii) the purpose of undertaking the rehabilitation of natural areas and storm water management in accordance with the Management Guidelines; iv) the purpose of establishing and carrying out maintenance of essential services within the designated services easement shown as "A5" on Deposited Plan 403647 ("Services Easement"); or v) management of western grey kangaroo (*Macropus fuliginosus*) populations, in accordance with the Management Guidelines; d) introduce, or cause or permit the introduction of, any flora onto the Land that is not indigenous to the Land or its immediate surrounding area; e) destroy or do or permit (unless required by law) any act that would result in the deterioration in the natural state or in the flow, supply, quantity or quality of any body of water on the Land, save for managed stormwater overflow into Kadina Brook, and management of Kadina Brook, in accordance with the Management Guidelines; f) introduce, or cause or permit the introduction of, any fauna onto the Land that is not indigenous to the Land, save for domestic dogs which are not to be kept on the Land, but may enter the Land in accordance with the Management Guidelines, and in accordance with the relevant local government's regulations; g) conduct, permit or consent to any investigation or exploration for, or the mining, extraction, removal or production of gas, petroleum, minerals, soil, stones, sand, rock, gravel, clay or other substances on the Land; h) construct, erect, establish or permit or consent to (unless required by law) the construction, erection or establishment of any transmission lines or other services or works on the Land save for the provision of essential services (including but not limited to electricity, telecommunications and water) within tracks as identified in the Management Guidelines, or the Services Easement, in such a manner as to minimise damage to indigenous flora and indigenous fauna; i) carry out or permit on the Land the operation of any trade, industry or business; j) use or permit on the Land the use of vehicles including but not limited to trail bikes or four wheel drive vehicles or farm machinery, save for: i) to the extent required for the proper management and protection of the Land; or ii) on tracks, as identified in the Management Guidelines; k) carry out or permit on the Land the storage of rubbish or garden refuse or

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	materials; l) save where expressly permitted herein, carry out or permit on the Land any activities inconsistent or incompatible with the conservation of the indigenous flora and indigenous fauna on the Land; m) erect or permit to be erected any fence on the Land, save for: i) a perimeter fence around the Land; and ii) any permanent or temporary fencing required for the purpose of rehabilitation of the Land or access control, in accordance with the Management Guidelines; n) introduce or permit the introduction upon the Land of any rocks, soil, gravel, sand or other basic raw materials, except from external sources with minimised risk of introducing weeds and known plant pathogens including *Phytophthora* Dieback disease, and first approved in writing by the Executive Body, nor use or permit the use of earth moving machinery on the Land unless it has been first cleaned offsite and/or where appropriate precautions have been taken to reduce the risk of introduction or further spread of weeds and plant pathogens; and o) use or permit the use on the Land of guns, hunting weapons, animal traps or poisons, save for the purposes specified in the Management Guidelines.
Executive Body's Covenants	2. THE EXECUTIVE BODY HEREBY WAIVES the restrictions referred to in Clause 1 to the extent necessary for the implementation of mutually agreed Management Guidelines which will address issues including, but not limited to, provisions for reasonable fire protection including carrying out controlled rotational fuel reduction measures subject to express agreement between the Executive Body and the Owner in writing prior to the Land being deliberately burnt. 3. The Executive Body waives any future claim to financial benefits arising from carbon sequestration or other ecosystem service rights that may become associated with the Land.
Mutual Covenants	4. IT IS HEREBY MUTUALLY AGREED by the Owner and the Executive Body that the Owners covenants and restrictions expressed herein shall run with and bind the Land and shall enure for the benefit of the Executive Body. 5. This Restrictive Covenant does not preclude the Owner from entering into another covenant or agreement over the Land, such as for carbon rights, provided that the operation of that further covenant or agreement does not negatively impact on the natural values of the Land, or the ability of the Owner to comply with the Management Guidelines and this Restrictive Covenant.
Variation of Covenants	6. If the Owner seeks a variation of this covenant, then provided that the natural values identified by the Executive Body are not significantly compromised, and an appropriate variation can be made to address such alteration, the Executive Body may at its discretion agree to the variation provided that written approval for the variation has been obtained from the Western Australian Planning Commission ("the Commission") where the Land has been covenanted as a condition of the subdivision approval issued by the Commission.
Interpretation	7. a) Reference to a party or parties includes the personal representatives,

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	successors and lawful assigns of the party or parties. b) Where a reference to a party includes more than one person the rights and obligations of those persons shall be joint and several. c) Headings have been inserted for guidance only and shall be deemed not to form part of the text.
Further obligations	8. Nothing herein shall prevent or exempt the Owner from complying with all Federal, State and Local Government laws.

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Execution	**Executed by the parties as a Deed**

Executed by
DUNLAND PROPERTY PTY LTD)
ACN 127 744 656 in accordance)
with section 127(1) of the)
Corporations Act 2001 (Cth):)

SIGNATURE OF DIRECTOR .....

Paul Sadleir
MANAGING DIRECTOR

PRINT NAME OF DIRECTOR .....

SIGNATURE OF *~~DIRECTOR~~
/*COMPANY SECRETARY .....

PRINT NAME OF *~~DIRECTOR~~
/*COMPANY SECRETARY ..... Paul Freedman
COMPANY SECRETARY

**delete that which does not apply*

The COMMON SEAL of the)
CONSERVATION AND LAND)
MANAGEMENT EXECUTIVE BODY)
)

CONSERVATION AND LAND MANAGEMENT EXECUTIVE BODY
COMMON SEAL

was hereunto affixed as authorised by the Executive Body in the presence of:

JAMES SHARP .....
CHIEF EXECUTIVE OFFICER
DEPARTMENT OF PARKS AND WILDLIFE

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Signed by:

EXECUTED by
ANZ FIDUICARY SERVICES PTY LTD)
ABN 91100709493)

SIGNED for and on behalf of **ANZ Fiduciary Services** Pty Limited by
ANASTASIA KALOGIANNIS
who certifies that she/he is a
ASSOCIATE DIRECTOR
Agency Services, of Australia and New Zealand Banking Group Limited pursuant to Power of Attorney Registered N154341 PA
dated 01.10.15 in the presence of:

Witness: Attorney

MICHAEL DAWKINS
BANKER 242 PITT STREET SYDNEY 2000

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2. If insufficient space hereon Additional Sheet Form B1 should be used.
3. Additional Sheets shall be numbered consecutively and bound to this document by staples along the left margin prior to execution by the parties.
4. No alteration should be made by erasure. The words rejected should be scored through and those substituted typed or written above them, the alteration being initialled by the persons signing this document and their witnesses.

NOTES

1. Insert document type.
2. A separate attestation is required for every person signing this document. Each signature should be separately witnessed by an Adult Person. The address and occupation of the witness must be stated.

EXAMINED

N395495 RC
29 Jul 2016 10:21:33 Perth

LODGED BY	Department of Parks and Wildlife
ADDRESS	Locked Bag 104 Bentley Delivery Centre BENTLEY WA 6983
PHONE No.	(08) 9219 9518
FAX No.	(08) 9334 0199
REFERENCE No.	
ISSUING BOX No.	

PREPARED BY	Department of Parks and Wildlife
ADDRESS	Locked Bag 104 Bentley Delivery Centre BENTLEY WA 6983
PHONE No.	(08) 9219 9518
FAX No.	(08) 9334 0199

INSTRUCT IF ANY DOCUMENTS ARE TO ISSUE TO OTHER THAN LODGING PARTY

2
2

TITLES, LEASES, DECLARATIONS, ETC, LODGED HEREWITH

1. ..... Received Items Nos.
2. .....
3. 0
4. .....
5. ..... Receiving Clerk
6. .....

Registered pursuant to the provisions of the TRANSFER OF LAND ACT 1893 as amended on the day and time shown above and particulars entered in the Register.

Landgate

THE GOVERNMENT OF WESTERN AUSTRALIA

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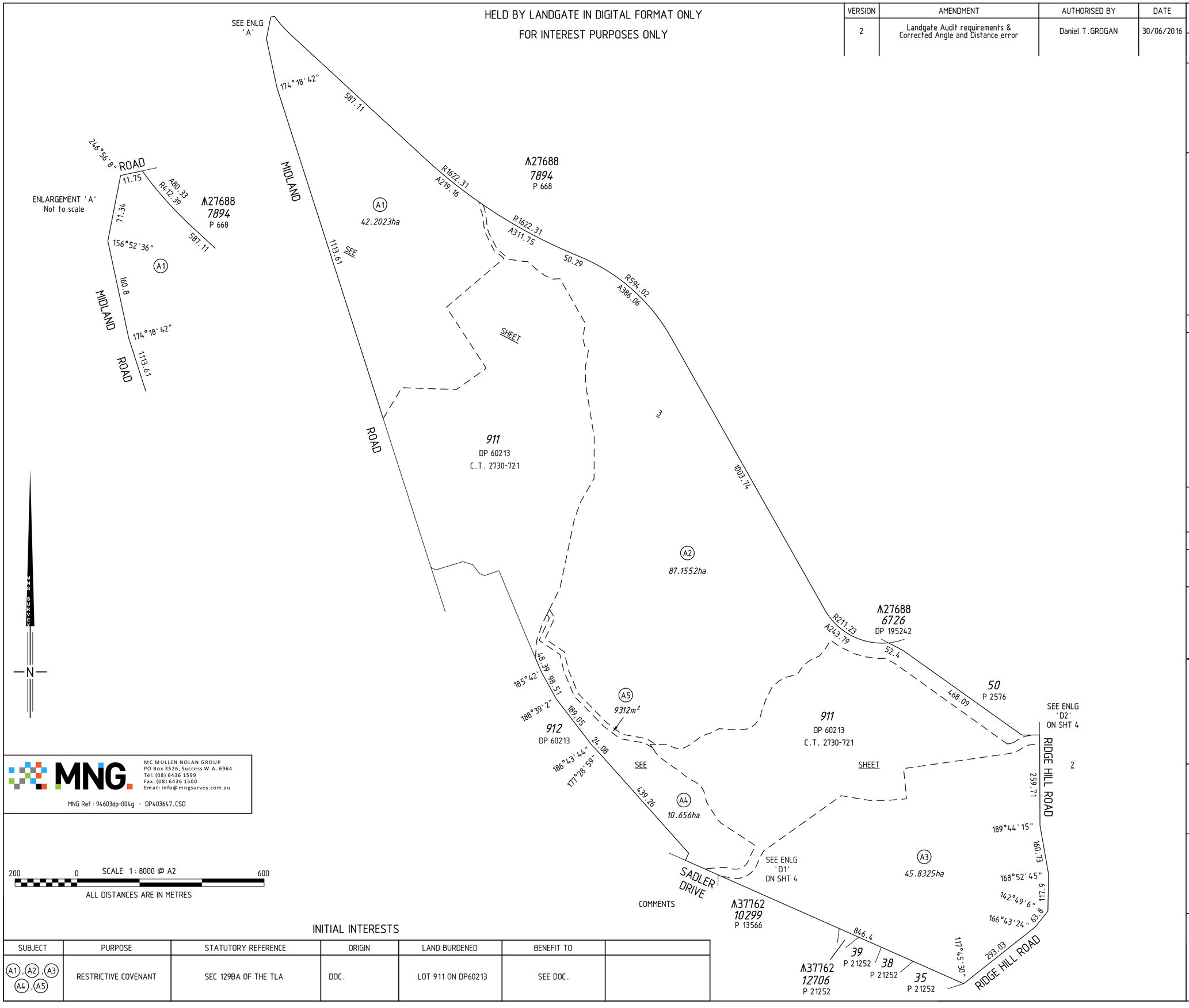
VERSION	AMENDMENT	AUTHORISED BY	DATE
2	Landgate Audit requirements & Correcfed Angle and Distance error	Daniel T.GROGAN	30/06/2016



MC MULLEN NOLAN GROUP
PO Box 3526, Success W.A. 6964
Tel: (08) 6436 1599
Fax: (08) 6436 1500
Email: info@mngsurvey.com.au

MNG Ref : 94603dp-004g - DP403647.CSD

SCALE 1 : 8000 @ A2

200 0 600

ALL DISTANCES ARE IN METRES

INITIAL INTERESTS

SUBJECT	PURPOSE	STATUTORY REFERENCE	ORIGIN	LAND BURDENED	BENEFIT TO	
(A1),(A2),(A3) (A4),(A5)	RESTRICTIVE COVENANT	SEC 129BA OF THE TLA	DOC.	LOT 911 ON DP60213	SEE DOC.	

TYPE FREEHOLD S.S.A. NO

PURPOSE INTEREST

PLAN OF

RESTRICTIVE COVENANT
AND/OR OTHER INTERESTS OVER
LOT 911 ON DP 60213

FORMER TENURE N/A

LOCAL AUTHORITY CITY OF SWAN

LOCALITY HAZELMERE

D.O.L. FILE

FIELD RECORD 127566

SURVEYOR'S CERTIFICATE - REG 54

I, Daniel T.GROGAN
hereby certify that this plan is accurate and is a correct representation of the -
(a) *survey, and/or
(b) *calculations from measurements recorded in the field records,
[* delete if inapplicable]
undertaken for the purposes of this plan and that it complies with the relevant written law(s) in relation to which it is lodged.

FINAL

LICENSED SURVEYOR DATE

LODGED

DATE FEE PAID ASSESS No.

I.S.C.

EXAMINED

DATE

WESTERN AUSTRALIAN PLANNING COMMISSION

FILE

Delegated under S.16 P&D Act 2005 DATE

IN ORDER FOR DEALINGS

SUBJECT TO

FOR INSPECTOR OF PLANS AND SURVEYS DATE

APPROVED

INSPECTOR OF PLANS AND SURVEYS DATE
(S. 18 Licensed Surveyors Act 1909)

GOVERNMENT OF WESTERN AUSTRALIA

Landgate

DEPOSITED PLAN

403647

SHEET 01 OF 04 SHEETS

VERSION 2

FOR HEADING SEE SHEET 1

FOR INITIAL INTERESTS
SEE SHEET 1

911
DP 60213
C.T. 2730-721

A27688
7894
P 668

A27688
6726
DP 195242

50
P 2576

RIDGE HILL ROAD

SADLER DRIVE

A37762
10299
P 13566

SEE SHEET 3

SEE SHEET 1

SEE ENLG. 'B1'

SEE ENLG. 'B2'

SEE ENLG. 'D1' ON SHT 4

SEE ENLG. 'D2' ON SHT 4

ENLARGEMENT 'B1'
Not to scale

ENLARGEMENT 'B2'
Not to scale

SCALE 1 : 3000 @ A2

50 0 250

ALL DISTANCES ARE IN METRES

MNG Ref : 94603dp-004g - DP403647.CSD

FINAL

LICENSED SURVEYOR DATE

GOVERNMENT OF WESTERN AUSTRALIA

Landgate

DEPOSITED PLAN
403647
SHEET 02 OF 04 SHEETS
VERSION 1

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FOR HEADING SEE SHEET 1

FOR INITIAL INTERESTS
SEE SHEET 1

A27688
7894
P 668

911
DP 60213
C.T. 2730-721

ENLARGEMENT 'C1'
NOT TO SCALE

ENLARGEMENT 'C2'
NOT TO SCALE

SEE ENLG. 'C1'

SEE ENLG. 'C2'

SEE SHEET 2

911
DP 60213
C.T. 2730-721

912
DP 60213

ROAD

MIDLAND

SCALE 1 : 3000 @ A2

50 0 250

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GOVERNMENT OF WESTERN AUSTRALIA

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DEPOSITED PLAN
403647
SHEET 03 OF 04 SHEETS
VERSION 1

FOR HEADING SEE SHEET 1

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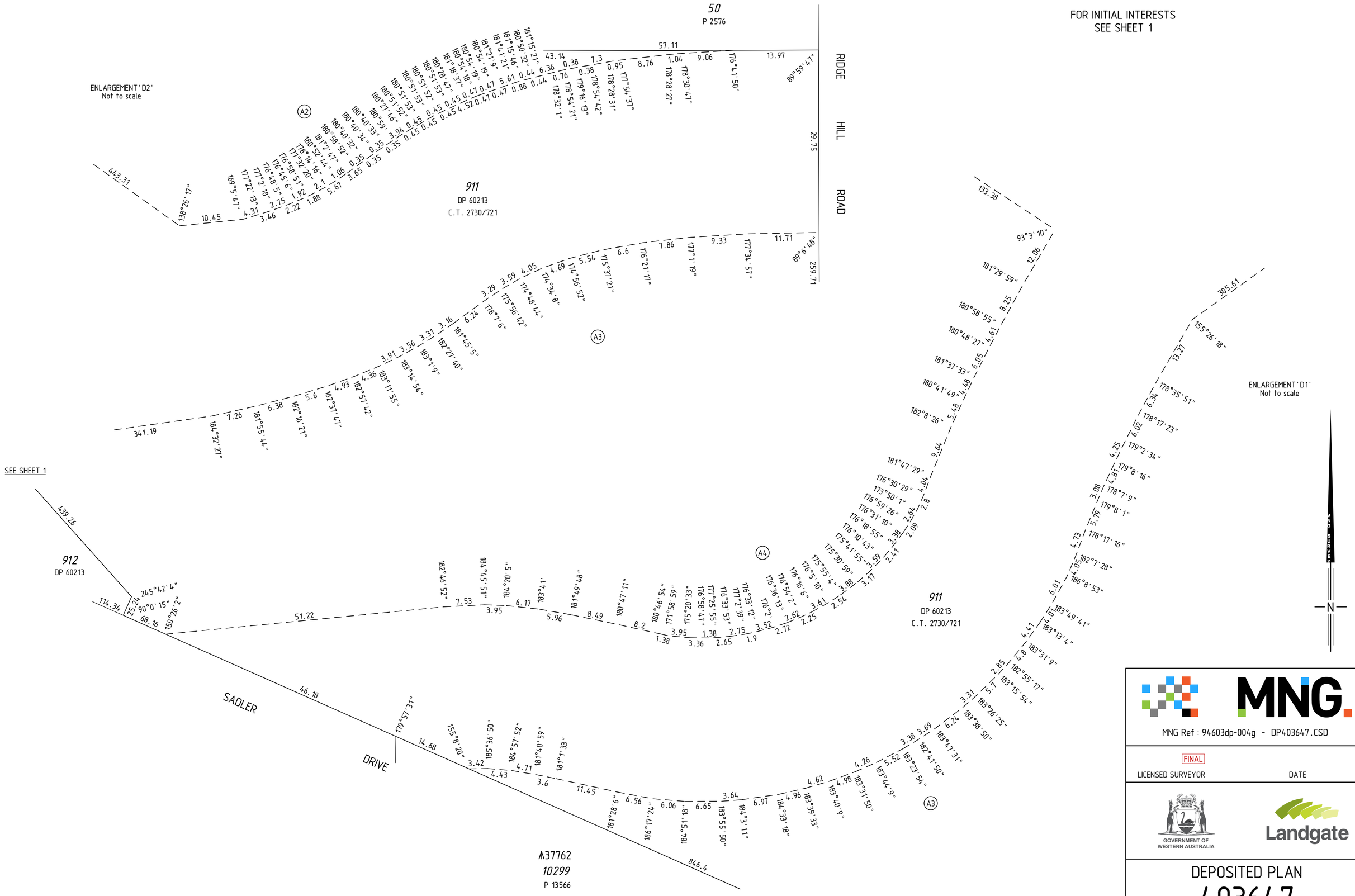
SEE SHEET 1



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SHEET 04 OF 04 SHEETS
VERSION 1

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Appendix 6
Construction Management Plan

Level 1, 50 Subiaco Square Road Subiaco WA 6008 PO Box 243 Subiaco WA 6904
Phone (08) 9380 3100 Fax (08) 9380 4606
177 Spencer Street Bunbury WA 6230 PO Box 287 Bunbury WA 6231
Phone (08) 9792 4797 Fax (08) 9792 4708

To: Nick Wheeler

Date: 17 January 2017

Company: Cedar Woods

Project No: CED14293.01

Fax/email: Nick.Wheeler@cedarwoods.com.au

Inquiries: Anna Welker/Darren Walsh

Bushmead Development
Construction Management Plan

1. Introduction

This Construction Management Plan (CoMP) identifies management measures, monitoring actions, contingencies and reporting to be undertaken by the Contractor on behalf of Dunland Property Pty Ltd (Dunland) as part of the Bushmead Development (the Project). The Bushmead Development comprises development of a portion of Lot 911 Midland Road, Hazelmere.

This CoMP has been prepared to satisfy the requirement to prepare and 'implement a Construction Management Plan to the satisfaction of DPaW', as stated in the Conservation Management Plan (CMP), in accordance with condition 9 of the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) Project approval (EPBC 2015/7414). The CoMP should be read in conjunction with the CMP prepared for this Project.

The scope of the CoMP is to manage clearing and construction activities to be undertaken to develop the Project. In particular this plan is required to address:

- the protection of flora and vegetation during construction
- the protection of fauna during construction
- dust control
- dieback and hygiene management.

The CoMP does not consider any operational aspects beyond the construction timeframe of the Project.

Related management plans

A number of other management plans related to the Bushmead Development are also required to be prepared, including the:

- Conservation Management Plan
- Weed Management Plan
- Rehabilitation and Revegetation Plan
- Stream Restoration Plan
- Fire Management Plan
- Urban Water Management Plan.

To avoid duplication none of the actions proposed to be included in the above management plans will be reference within this plan.

Roles and responsibilities

Responsibility for implementation of this CoMP rests with Cedar Woods Properties Limited (Cedar Woods), on behalf of Dunland. The Cedar Woods Project Manager (to be determined by Cedar Woods) will be responsible for overall implementation of this plan, to ensure clearing and construction activities are in accordance with the CoMP. All employees and contractors shall meet the requirements of this CoMP and associated procedures. Responsibility for management measures specified in this CoMP will be delegated to relevant contractors as appropriate.

Key Project personnel associated with Construction management, include the Cedar Woods Project Manager, Construction Project Manager, Landscape Manager, Revegetation Manager, Environmental Consultant and construction contractors (as applicable), shall ensure that all management measures are undertaken to satisfactory standards and that all personnel are aware of their responsibilities. All contractors will be required to operate in accordance with this CoMP. The responsibilities of key personnel are set out in Table 1.

Table 1: Roles and responsibilities associated with the Construction Management Plan

Role	Responsibilities

Cedar Woods Project Manager	• act as primary liaison between Cedar Woods, Dunland and the Construction Project Manager
	• ensure all contracts implement environmental management provisions
	• review reports as prepared by the Construction Project Manager
	• provide support to the Construction Project Manager as required
	• review the effectiveness of the CoMP in achieving environmental objectives, including a review of any corrective actions
	• report to regulatory authorities as required under approval conditions
	• ensure the preparation of the following management plans:
	  • Weed Management Plan
	  • Rehabilitation and Revegetation Plan
	  • Stream Restoration Plan
	  • Fire Management Plan
	  • Urban Water Management Plan
	  • Rubbish and Refuse Removal Plan.

Construction Project Manager	• overall accountability to ensure construction activities do not adversely impact upon the environmental values of the Project area through correct CoMP implementation • ensure all construction personnel attend inductions and required training programs and are aware of their requirements of the CoMP and related procedures • ensure environmental incidents are reported to the Cedar Woods Project Manager in accordance with the CoMP • review and ensure closing out of any corrective actions • provide support to construction personnel and other contractors on-site as required during the construction phase.
Landscape Manager	• overall accountability to ensure landscape activities do not adversely impact upon the environmental values of the Project area through correct CoMP implementation • ensure all landscape personnel attend inductions and required training programs and are aware of their requirements of the CoMP and related procedures • ensure environmental incidents are reported to the Cedar Woods Project Manager in accordance with the CoMP • review and ensure closing out of any corrective actions • provide support to landscape personnel and other contractors on-site as required during the construction phase.

Role	Responsibilities
Revegetation Manager	• overall accountability to ensure revegetation activities do not adversely impact upon the environmental values of the Project area through correct CoMP implementation ensure all revegetation personnel attend inductions and required training programs and are aware of their requirements of the CoMP and related procedures • ensure environmental incidents are reported to the Cedar Woods Project Manager in accordance with the CoMP • review and ensure closing out of any corrective actions • provide support to revegetation personnel and other contractors on-site as required during the construction phase.
Environmental Consultant	• overall accountability to a Dieback assessment is undertaken within the conservation area and that the Construction Project Manager, Landscape Manager, Revegetation Manager and Project Manager are aware of the results and affect on conservation area management • undertake black cockatoo breeding inspections as required • provide specialised advice to personnel
Construction personnel/ contractors	• implementation of the CoMP as instructed by the Construction Project Manager • compliance with all applicable legal requirements and those specified in the CoMP • report all environmental incidents to the Construction Project Manager • attend environmental inductions or any other training as required by this CoMP.

2. Construction Environmental Management Plan

Objectives

Objectives of the CoMP are to ensure that:

- activities associated with development of the Project do not adversely affect adjacent environmental values, particularly associated with the Conservation Area
- any potential environmental impacts of the development are managed in accordance with legislative requirements and best practice environmental management.

Specific environmental objectives and performance indicators are outlined in Table 2.

Table 2: Environmental objectives and performance indicators

Issue	Objective	Performance indicator
Vegetation and flora		
Vegetation disturbance	To ensure that clearing is confined to approved areas	No clearing outside approved boundaries
Vegetation health and condition	To ensure that vegetation health and condition in areas within the Project area are not affected by construction activities	No decline in vegetation health attributable to construction activities at locations outside of the approved clearance boundary
Threatened Ecological Community	Ensure no clearing of the EPBC Act listed endangered Shrublands and Woodlands of the Eastern Swan Coastal Plain Threatened Ecological Community as shown in Figure 1	No clearing of the EPBC Act listed endangered Shrublands and Woodlands of the Eastern Swan Coastal Plain Threatened Ecological Community as shown in Figure 1

Fauna		
Fauna habitat	To ensure that clearing is kept to a minimum and confined to approved areas	No clearing outside approved boundaries
Direct impacts on fauna	To prevent native fauna stress, injuries or deaths as a result of construction of the Project	No deliberate loss of native fauna due to interference from site personnel
	To prevent the clearing of active Carnaby's Black Cockatoo, Baudin's Black Cockatoo and/or Forest Red-tailed Black Cockatoo breeding trees as shown in Figure 1 during black cockatoo breeding season (1 July–31 December)	No clearing of known black cockatoo breeding trees during black cockatoo breeding season
Dust		
Human health	To ensure that dust emissions do not adversely impact upon the health and welfare of construction personnel or land users at adjacent sensitive receptors	No public or personnel dust complaints
Amenity	To ensure that dust emissions do not adversely impact upon the amenity of adjacent land users	No sustained visual dust observed beyond the immediate boundaries of construction sites No public or personnel dust complaints
Phytophthora (Dieback)		
Introduction of Phytophthora	To eliminate the potential introduction of Phytophthora into the area from external sources	No decline in extent or overall vegetation condition class (Bush Forever scales) as a result of Phytophthora species caused by the construction activities. No increase in dieback infestation as a result of construction activities.

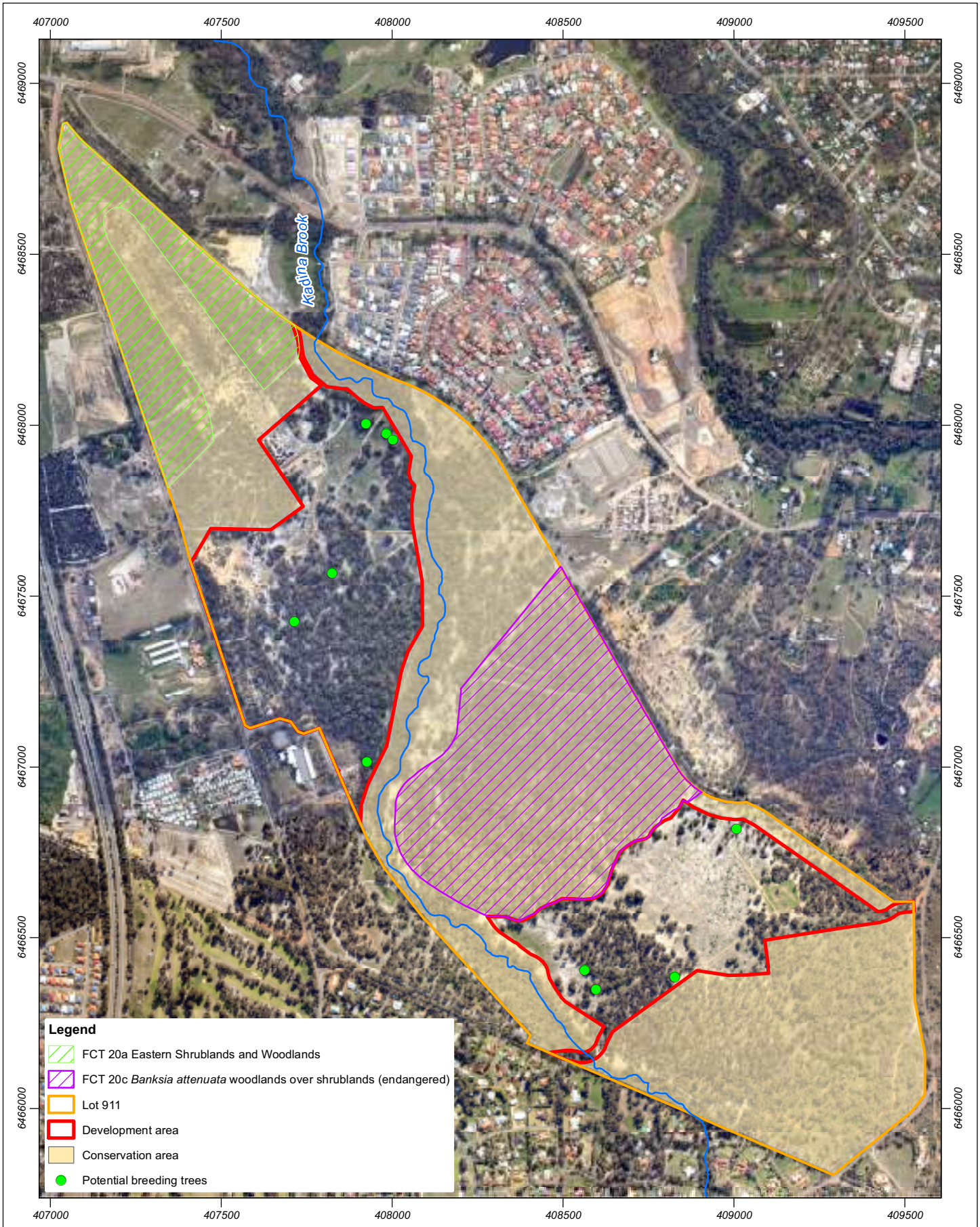

Figure 1: Significant environmental features

Scale 1:15,000 at A4

0 100 200 300 400 500 m

N

Coordinate System: GDA 1994 MGA Zone 50
Note that positional errors may occur in some areas
Date: 17/01/2017
Author: JCrute
Source: Client 2014.

strategen ENVIRONMENTAL
info@strategen.com.au
www.strategen.com.au

Path: Q:\Consult\2014\CED\CED14293\ArcMap_documents\M003\Rev A\CED14293_01_M003_RevC_F001.mxd

Key management measures

Table 3: Key management actions for construction phase of Bushmead Development

Item	Management action	Timing	Responsibility
Site induction			
1.	Implement site inductions for all construction contractors prior to their commencement of work on site. The induction will summarise the following: • management strategies as outlined in this CoMP • responsibilities of personnel under the CoMP • demarcation and areas of no entry • protected flora and fauna species likely to be onsite • procedures on reporting, sighting and managing native fauna, including injured native fauna • location of Threatened Ecological Communities and the 10 potential breeding trees with suitable hollows • specific environmental legislative and licence conditions applicable to the site • location of Dieback infested areas, when known • potential consequences of spreading Dieback into conservation areas • Dieback management procedures, including green card training for personnel likely to be undertaking construction activities within the conservation area • location of Clean on Entry/Exit locations area, and details of Dieback signage and field demarcations • dust impacts and management.	Prior to construction and ongoing.	Project Manager / Construction Project Manager
2.	Maintain records of attendance at site inductions to confirm personnel have received site inductions.	Prior to construction and ongoing.	Construction Project Manager
Vegetation and flora			
3.	Identify all areas of retained vegetation using GPS coordinates referenced to site clearing drawing.	Prior to clearing.	Construction Project Manager
4.	Clearly mark (e.g. pegging) the area to be cleared and ensure areas of vegetation or trees nominated to be excluded from the clearing works are visually identifiable to all personnel involved in the works.	Prior to clearing.	Construction Project Manager
5.	Demarcate large areas of vegetation that are to be protected to prevent intrusion and disturbance.	Prior to clearing adjacent to these areas.	Construction Project Manager
6.	Fence the perimeter of the conservation area with fencing that is permeable to fauna.	Prior to clearing within each cell.	Construction Project Manager
7.	Ensure no clearing is undertaken without written permission from the Cedar Woods Project Manager.	At all times.	Construction Project Manager
8.	Ensure no clearing of the EPBC Act listed endangered Shrublands and Woodlands of the Eastern Swan Coastal Plain Threatened Ecological Community as shown in Figure 1.	During construction.	Construction Project Manager
9.	Ensure no clearing of vegetation is undertaken outside of the construction area except in the event of an emergency or as directed by emergency services.	During construction.	Construction Project Manager
10.	Demarcate the bed and banks of Kadina Brook adjacent to clearing boundaries.	Prior to construction works adjacent to Kadina Brook.	Construction Project Manager
11.	Ensure no works are undertaken within the bed and or bank of Kadina Brook without prior approval from the Department of Water.	During construction.	Construction Project Manager

Fauna			
12.	Organise a fauna specialist to inspect the ten breeding trees (Figure 1) if adjacent to clearing boundaries, for evidence of active nesting activity during Carnaby's Black Cockatoo and Forest Red-tailed Black Cockatoo breeding season.	During black cockatoo breeding season (July – December) - within 14 days prior to clearing of each Stage.	Construction Project Manager
13.	Inspect the ten breeding trees (Figure 1) for evidence of active nesting activity during Carnaby's Black Cockatoo and Forest Red-tailed Black Cockatoo breeding season.	During black cockatoo breeding season (July – December) - within 7 days prior to clearing of each Stage.	Environmental Consultant
14.	Implement contingency actions as listed in Table 5 if active black cockatoo nesting activity is observed during the survey.	During black cockatoo breeding season (July – December) prior to clearing and/or during construction for each stage.	Construction Project Manager
15.	Conduct clearing in a sequential manner and in a way that encourages escaping wildlife away from the activity into adjacent natural areas and not across roads or into other areas of threat (e.g. trenches).	During construction.	Construction Project Manager
16.	Ensure a wildlife handler/fauna spotter is on call during clearing works to handle any injured, abandoned or otherwise visibly distressed fauna.	During clearing works.	Construction Project Manager
17.	If any injured, abandoned or otherwise visibly distressed fauna are observed when a wildlife handler/fauna spotter is not present contact the Parks and Wildlife wildcare hotline on 08 9474 9055.	During construction.	Construction Project Manager
18.	Check open excavations and trenches for fauna and remove any trapped animals by authorised fauna handlers.	During construction - immediately prior to backfill and twice daily when trenching present.	Construction Project Manager
19.	Trenches will remain open only for the time required for construction purposes and will be backfilled as soon as the trenches are no longer required.	During construction.	Construction Project Manager
20.	Feeding of fauna, hunting or keeping of firearms or pets on site is prohibited.	During construction.	Construction Project Manager
Dust			
21.	Keep the area of exposed surface to the minimum required for construction activities.	During construction.	Construction Project Manager
22.	Cease or reschedule dust generating activities in adverse weather conditions.	During construction - in adverse weather conditions.	Construction Project Manager
23.	Stabilise cleared areas and any dry, dust-prone areas or stockpiles to prevent dust lift off. Stabilisation methods may include wetting, application of hydromulch or other sealing material.	During construction.	Construction Project Manager
24.	Ensure vehicles do not operate on areas other than designated roads, access tracks and construction areas.	During construction.	Construction Project Manager
25.	Enforce a maximum speed limit in construction areas to reduce dust lift off.	During construction.	Construction Project Manager
Hygiene (Phytophthora [Dieback] and weeds)			
26.	Undertake a Dieback assessment of the conservation area to determine the Dieback status of the area.	Prior to any construction works within the conservation area.	Environmental Consultant
27.	Update the CoMP with the results of the Dieback assessment.	Prior to any construction works within the conservation area.	Environmental Consultant
28.	Provide maps of any Dieback infested areas to construction, revegetation and landscape contractors.	Prior to any construction works within the conservation area.	Environmental Consultant
29.	Provide dedicated wash/clean down points at the entry to the conservation area and when exiting infested areas.	Prior to any construction works within the conservation area and/or prior to works within infested areas.	Construction Project Manager

30.	Ensure all vehicles and machinery are free of mud/soil/vegetation when arriving and leaving the site to reduce potential introduction of disease and weeds.	During construction - when arriving and leaving the site.	Construction Project Manager / Landscape Manager/ Revegetation Manager
31.	Ensure all vehicles, machinery and shoes are free of mud/soil/vegetation when entering any Dieback uninfested areas within the conservation area to reduce potential introduction of disease and weeds.	During construction - when entering any Dieback unaffected areas within the conservation area.	Construction Project Manager / Landscape Manager/ Revegetation Manager
32.	Maintain a hygiene register, including records of daily inspections, to document the hygiene measures undertaken.	During construction.	Construction Project Manager / Landscape Manager/ Revegetation Manager
33.	Demarcate construction areas in order to restrict access to designated roads and access tracks.	During construction.	Construction Project Manager
34.	Minimise walking through the bushland by encouraging the use of defined tracks and closing obsolete access points including installing signage highlighting no go areas.	During construction.	Construction Project Manager
35.	Ensure any operations such as firebreak slashing adhere to Dieback hygiene management processes.	During construction.	Construction Project Manager
36.	Ensure any mulch used on site within the construction area is Dieback free.	During construction.	Construction Project Manager/ Landscape Manager/ Revegetation Manager
37.	Apply Dieback hygiene during revegetation and source plants with Nursery Industry Accreditation, with some plants being Dieback resistant in accordance with the Restoration and Revegetation Management Plan.	During revegetation.	Revegetation Manager

Monitoring and reporting

Table 4: Key monitoring actions for construction phase of Bushmead Development

Item	Monitoring action	Frequency/Timing	Location	Responsibility
Site induction				
1.	Records of site inductions kept for all construction personnel.	Prior to construction and ongoing	Site / Contractor office / Online	Construction Project Manager
Vegetation and flora				
2.	Delineation of retained vegetation and significant trees.	Prior to clearing of each stage	Project area	Construction project Manager
3.	Reconcile actual clearing (area and location) against approved clearing extent (to be supplied to the contractor by Cedar Woods) to ensure clearing is within approved areas.	Following clearing, once per area	Areas to be cleared	Construction Project Manager
4.	Integrity of fencing surrounding conservation areas.	Prior to construction and ongoing	Conservation area adjacent to areas to be cleared	Construction Project Manager
Fauna				
5.	Review inspection records to ensure trenches are regularly checked to ensure fauna are not trapped and fauna egress is maintained.	Weekly when trenching present	Construction area	Construction Project Manager
6.	Observation of fauna (native and feral fauna).	Opportunistically	Construction area	All personnel
7.	Reports of fauna encounters/ collisions and actions taken.	Opportunistically	Construction area	All personnel
Dust				
8.	Integrity of dust stabilisation measures.	Opportunistically	Construction area	Construction Project Manager
9.	Inspection of the construction boundary to identify any dust emissions outside the construction boundary.	Opportunistically – during times of high wind	Construction boundary	Construction Project Manager
Weeds and Dieback				
10.	Inspection of vehicles prior to entry on site.	Prior to entering site	Construction entry	Construction Project Manager / Landscape Manager / Revegetation Manager
11.	Inspection of vehicles prior to entry into Dieback uninfested areas in the conservation area.	Prior to entry into Dieback uninfested areas	Dieback uninfested areas	Construction Project Manager / Landscape Manager / Revegetation Manager
12.	Monitor vegetation condition class (Bush Forever scales) and Dieback mapping within the conservation area.	Baseline prior to any construction works within the conservation area Annually ongoing during construction (uninfested areas only)	Conservation area	Environmental Consultant

Contingency actions

Table 5: Contingency actions for construction phase of Bushmead Development

Item	Trigger	Contingency action	Responsibility
Vegetation and flora			
1.	Clearing outside of areas approved by Cedar Woods or clearing without authorisation from Cedar Woods	Any clearing outside of areas approved by Cedar Woods for vegetation clearance or clearing without authorisation will be considered a serious environmental incident and will be managed as follows: • notify DEE* in accordance with approval requirements and Parks and Wildlife where applicable • investigate cause including interviews with contractors to determine when the incident occurred, what was involved and why it occurred • implement corrective and preventative actions • redefine boundaries if due to inadequate boundary marking • if disturbance to vegetation requires mitigation, then the area disturbed shall be rehabilitated in accordance with the Rehabilitation and Weed Management Plan • communicate incident investigation outcomes to personnel • reconcile clearing against the requirements of the EPBC 2015/7414.	Cedar Woods Project Manager
2.	Clearing of more than 50 ha within the Project area, as approved for vegetation clearance in EPBC 2015/7414	Any clearing outside of areas approved for vegetation clearance indicated in EPBC 2015/7414 and approved by Parks and Wildlife will be considered a serious environmental incident and will be managed as follows: • notify DEE* in accordance with approval requirements and Parks and Wildlife where applicable • investigate cause including interviews with contractors to determine when the incident occurred, what was involved and why it occurred • implement corrective and preventative actions • redefine boundaries if due to inadequate boundary marking • if disturbance to vegetation requires mitigation, then the area disturbed shall be rehabilitated in accordance with the Rehabilitation and Weed Management Plan • communicate incident investigation outcomes to personnel.	Cedar Woods Project Manager
3.	Clearing of EPBC Act listed endangered Shrublands and Woodlands of the Eastern Swan Coastal Plain Threatened Ecological Community	Any clearing of the TEC will be considered a serious environmental incident and will be managed as follows: • notify DEE* in accordance with approval requirements and Parks and Wildlife where applicable • investigate cause including interviews with contractors to determine when the incident occurred, what was involved and why it occurred • implement corrective and preventative actions • redefine boundaries if due to inadequate boundary marking • if disturbance to vegetation requires mitigation, then the area disturbed shall be rehabilitated in accordance with the Rehabilitation and Weed Management Plan • communicate incident investigation outcomes to personnel.	Cedar Woods Project Manager
Fauna			
4.	Fauna death or injury resulting from trenching activities	• Increase monitoring to three times daily as a minimum, , during construction to monitor fauna presence • Report all fatalities or injuries to native fauna in an environmental incident report.	Construction Project Manager

5.	Active Carnaby's Black Cockatoo or Forest Red-tailed Black Cockatoo nesting is observed in stages proposed to be cleared	• clearly identify and mark the tree(s) with flagging tape • report nesting tree(s) to Construction Project Manager and Cedar Woods Project Manager • install temporary bunting and signage to provide a 10 m buffer around the nesting tree(s) • do not clearing any vegetation within the 10 m buffer • retain the nesting tree(s) during the nesting season (July-December) • re-inspect the tree(s) at the end of nesting season to confirm all birds have vacated the nest • report the status of nesting tree(s) to the Construction Project Manager and Cedar Woods Project Manager and confirm suitability for clearing • inform Parks and Wildlife of all nesting activity.	Environmental Consultant/ Construction Project Manager
6.	Clearing of one of the 10 potential breeding trees as shown in Figure 1	• organise the installation of three artificial nesting hollows for Black Cockatoos within the Conservation Area for every potential nesting tree cleared • ensure the design placement and method of installation is in accordance with relevant artificial hollow guidance material as defined in EPBC 2015/7414.	Environmental Consultant/ Construction Project Manager
Dust			
7.	Failure of dust stabilisation measures	• investigate extent of failure • determine appropriate measures to stabilise dust (additional hydromulch, water etc) • apply additional management measures.	Construction Project Manager
8.	Dust emissions outside of the construction boundary	• determine extent of dust emissions • determine appropriate dust mitigation measures (additional hydromulch, water etc) • apply additional management measures.	Construction Project Manager
9.	Complaint regarding dust received	• determine extent of dust emissions • determine appropriate dust mitigation measures (additional hydromulch, water etc) • apply additional management measures • consult with complainant regarding above measures.	Construction Project Manager
Weeds and Dieback			
10.	Vehicles not clean on entry	• investigate cause • ensure importance of maintaining hygiene is communicated to all personnel • clean-down affected machinery / vehicles at designated clean/wash down stations • inspect site for weeds / Dieback • implement weed management measures if required.	Construction Project Manager / Cedar Woods
11.	Decline in extent or overall vegetation condition class (Bush Forever scales) or an increase in the dieback front as shown by dieback mapping.	• investigate cause • if a result of Phytophthora spread by construction activities: * ensure importance of maintaining hygiene is communicated to all personnel * re-emphases green card training standards * discuss with DPaW appropriate management measures.	Construction Project Manager / Cedar Woods

DEE – Commonwealth Department of the Environment and Energy.

Appendix 7
Vegetation Condition

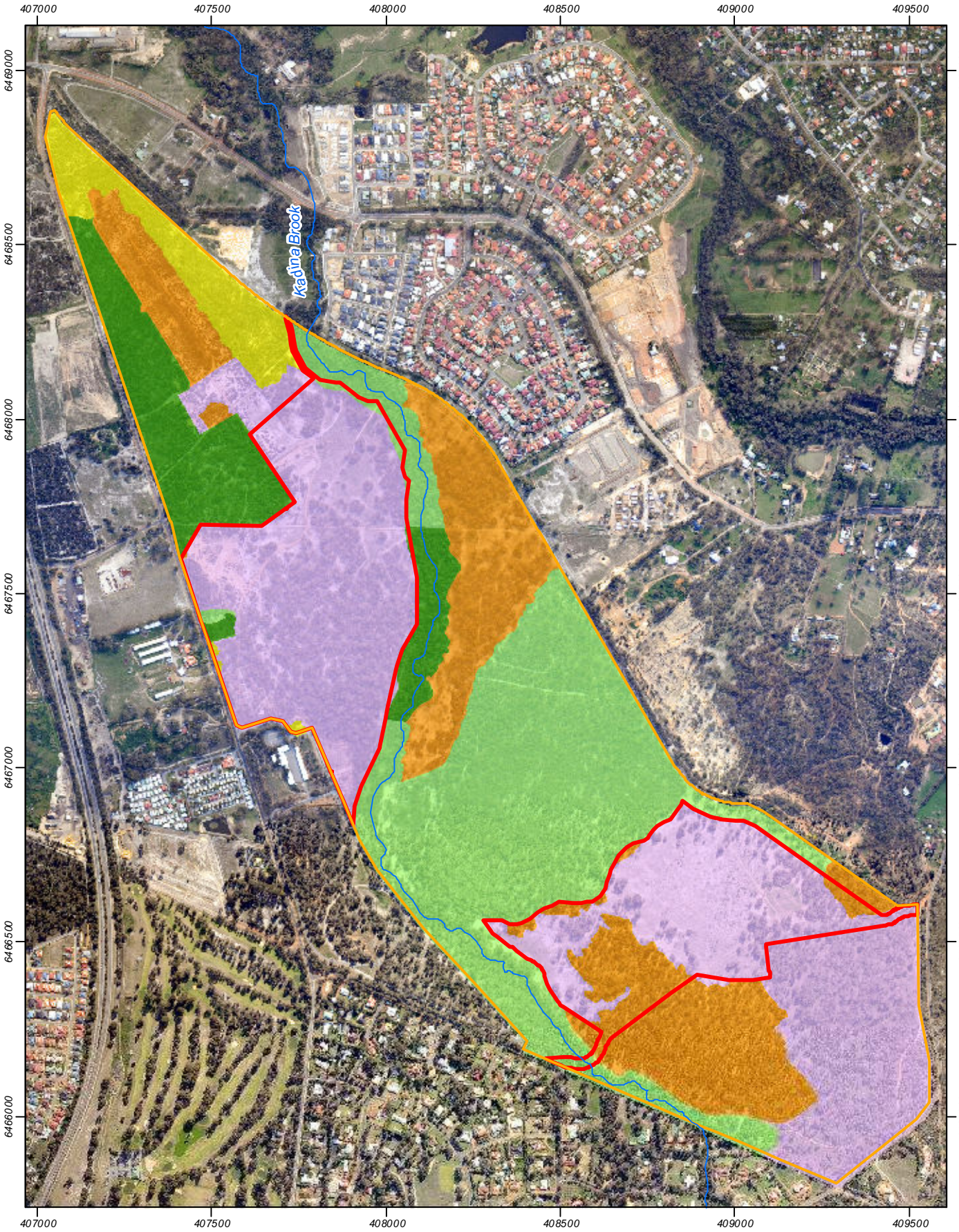

Figure 7: Vegetation condition

Scale 1:15,000 at A4

0 100 200 300 400 500 m

N

Coordinate System: GDA 1994 MGA Zone 50
Note that positional errors may occur in some areas
Date: 24/12/2014
Author: JCrute
Source: Aerial image & Development area: Client 2014.

Legend

- Lot 911
- Development area

Vegetation condition

- 3 - 4 (Very Good to Good)
- 4 (Good)
- 4 - 5 (Good to Degraded)
- 5 (Degraded)
- 6 (Completely Degraded)

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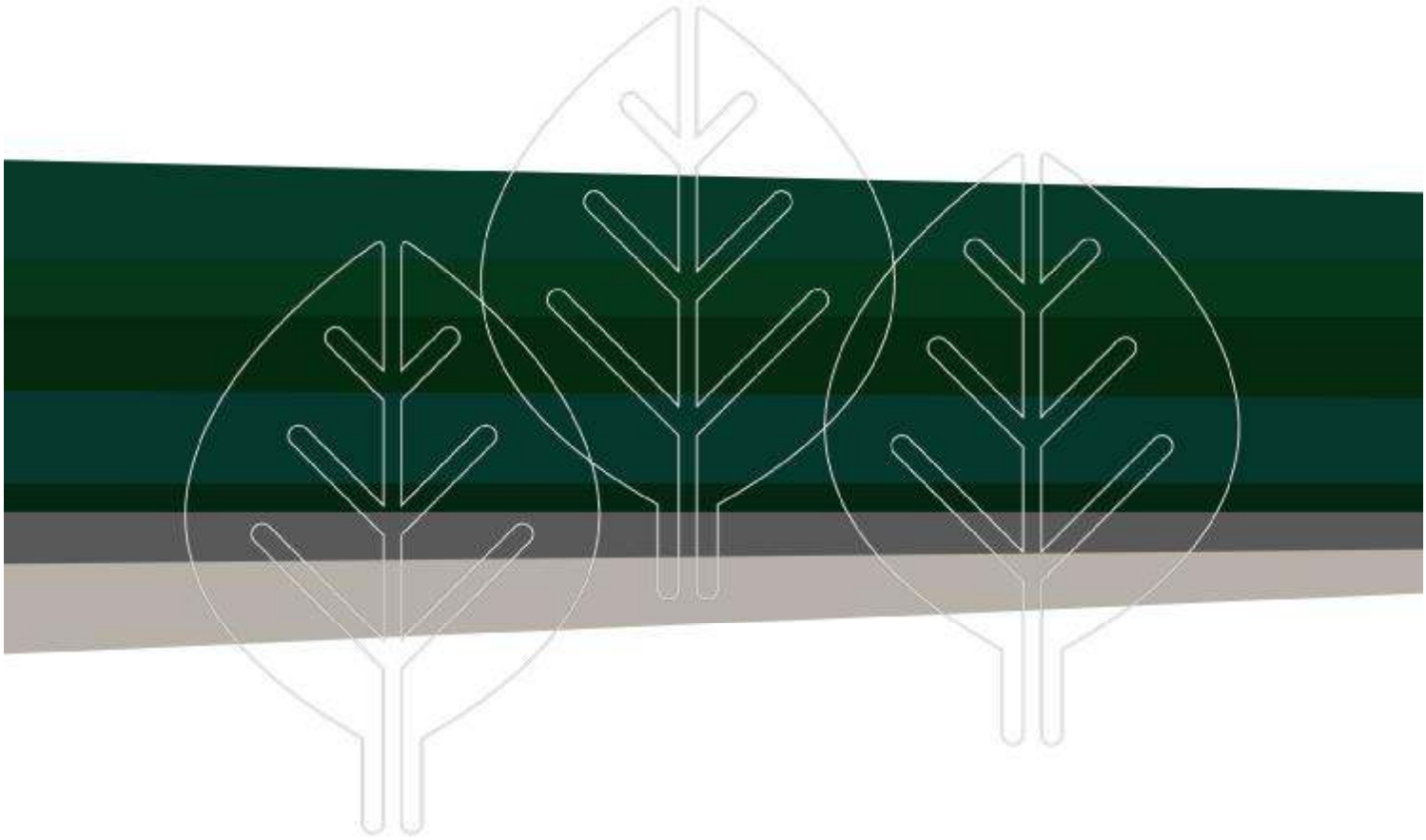
www.strategen.com.au

Path: Q:\Consult\2014\CED\CED14293\ArcMap_documents\R001\Rev0\CED14293_01_R001_Rev0_F007.mxd

Appendix 8
Revegetation, Stream Restoration and Weed Management Plan

revegetating
rehabilitating
restoring

tranen
revegetation systems



Bushmead Estate
Revegetation, Stream Restoration and Weed Management Plan

Cedar Woods

P648B-01 Rev03

September 2017

Disclaimer

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0	24/12/2015	Initial document	RSW	DMG
1	8/03/2017	Revised Plan	RSW	DMG/PJG
2	3/08/2017	Revised Plan	RSW	DMG
3	6/09/2017	Revised Plan	RSW	DMG

Table of Contents

1 INTRODUCTION AND BACKGROUND

1.1 Background

The Bushmead Conservation Management Plan (CMP) (RPS, 2016) includes a requirement for preparing a range of subsidiary plans. Among these is a Revegetation and Weed Management Plan to manage revegetation of degraded areas and weed management across the site, and a Stream Restoration Plan for the Kadina Brook. These plans have been combined into this Revegetation, Stream Restoration and Weed Management Plan, which has been prepared on behalf of Cedar Woods Properties Ltd (Cedar Woods) in liaison with the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA). It identifies the location, management actions, monitoring and completion targets for revegetation and weed management areas in the Bushmead Development, located in a portion of Lot 911, Midland Road, Hazelmere (Appendix 1).

1.2 Approvals and Conditions

Background information relating to the purchase of the site, environmental approvals and land tenure is described in the CMP (RPS 2016). A summary of this information is provided below to provide context within this document.

In July 2010, the Bushmead site was purchased by Cedar Woods from the Department of Defence. Following a technical review of all historical environmental reports and additional site specific flora and vegetation and fauna investigations, a MRS Amendment 1242/41 was submitted by Cedar Woods in 2013 which proposed rezoning of the Bushmead site from 'Public Purpose (Commonwealth Government)' to 'Parks and Recreation'.

The proposed amendment was referred to the EPA for advice on whether environmental assessment would be required. The EPA advised that the amendment would not require a formal assessment under Part IV of the Environmental Protection Act 1986. An integral component to EPA acceptance of the proposal was Cedar Woods' commitment to rezone a large portion of the site to Parks and Recreation reserve and cede it to the State free of charge, and with interim management.

The Parks and Recreation reserve will be vested as part of the conservation estate with the Conservation Commission of WA to be managed by DBCA. Cedar Woods will implement the CMP actions and subsequently cede the Conservation Reserve to the Conservation Commission as a conservation estate, to be managed by DBCA, as part of the subdivision approval process.

1.3 Documentation

This report is based on the following information provided by the Client:

- Western Australian Planning Commission (2016) Approval Subject to Condition(s) Freehold (Green Title) Subdivision for Application No. 152785, dated 26 July 2016;

- Western Australian Planning Commission (2016) Approval Subject to Condition(s) Freehold (Green Title) Subdivision: Reconsideration of Condition(s) for Application No. 152785, dated 10 November 2016;
- Western Australian Planning Commission (2017) Lot 911 Midland Road, Hazelmere (WAPC Ref: 152785) letter to Roberts Day, dated 7 April 2017;
- Department of the Environment (2016) Approval – Bushmead Residential Development, Hazelmere, WA (EPBC 2015/7414);
- EPCAD (2016) Bushmead Conservation Masterplan – Overview (Rev E, June 2016);
- JDA (2015) Lot 911 Midland Rd, Hazelmere – Local Water Management Strategy. Report Prepared by JDA Consultant Hydrologists for Cedar Woods, August 2015;
- JDA (2016) Lot 911 Midland Rd, Hazelmere – Stages 1 to 3 Urban Water Management Plan, WAPC No. 152785. Report Prepared by JDA Consultant Hydrologists for Cedar Woods, August 2016;
- RPS (2016) Bushmead Conservation Management Plan. Report No. L1010807:2 (Rev 2, July 2016). Prepared for Cedar Woods Properties Ltd;
- Glevan Consulting (2016) Bushmead Conservation Areas: *Phytophthora* Dieback Occurrence Assessment (Version 2.0). Prepared for Cedar Woods Properties Ltd;
- Strategen (2017) Bushmead Development Construction Management Plan. Prepared for Cedar Woods, January 2017.

1.4 Objectives

The objectives of this plan are to:

- Describe the current conditions of the Bushmead site, including weed loads and locations of revegetation sites;
- Identify completion targets for remnant vegetation and revegetation areas and the timeframe in which the targets should be met;
- Describe appropriate weed control techniques within remnant vegetation and in revegetation sites; and
- Describe the strategies to be used for revegetation, including species lists and a schedule of activities.

2 SITE DESCRIPTION

2.1 Site Location and Size

Bushmead is located at the foot of the Darling Escarpment in Helena Valley. It is bound by Midland Road to the west, Ridge Hill Road to the south-east and Gooseberry Hill National Park to the north-east. North of the site is an established residential area (Appendix 1).

The site is 272 ha in size, with 187 ha to become the Conservation Reserve, and the two development areas to be 36 and 49 ha in size.

2.2 Land Tenure

The Conservation Reserve is identified as those parts of Lot 911 on Deposited Plan 60213 being comprised in Certificate of Title Volume 2730 Folio 721 that are labelled A1, A2, A3 and A4 on Deposited Plan 403647 (this description taken directly from the CMP; RPS, 2016, page 3).

Once Cedar Woods has implemented the actions in the CMP in a staged process, the Conservation Reserve will be ceded to the Conservation Commission as a conservation estate, to be managed by DBCA.

2.3 Climate

Climate for the area is described as Mediterranean, with warm, dry summers and cool wet winters. Summer occurs from December to February with mean maximum temperatures ranging from 29.0°C to 32.0°C. Winter occurs from June to August with mean maximum temperatures ranging from 17.9°C to 19.0°C, and mean minimum temperature ranging from 8.0°C to 9.0°C (data obtained from Bureau of Meteorology (BoM) website for weather station number 009021 – Perth Airport). Average annual rainfall is 769.5 mm.

2.4 Land Form and Soils

Geological and soils information has been summarised in the CMP (RPS, 2016). The key landform and soils characteristics that are important to revegetation works are described below.

The majority of the site occurs on the relatively flat Bassendean Dune system which comprises sandy soils. Kadina Brook runs through the centre of the site in a south to north orientation (flow is in this direction), and comprises sandy soils in the north and gravel soils in clay-silt mixture in the south. The far south-eastern part of the site is the point at which the Darling Scarp begins to rise from the Swan Coastal Plain. Here, the soils turn to laterite and gravelly silt, and the landscape becomes steeper, with a westerly aspect.

2.5 Dieback Status

The dieback status of the site is described by Glevan Consulting (2016). The central and southern portions of the site were uninterpretable due to a lack of indicator species for the disease, while a significant portion of the northern conservation area was assessed as infested with dieback. There was also an uninfested area in the northern conservation area. The Construction Management Plan developed for the project includes a dieback management protocol which must be followed when undertaking revegetation activities (Strategen 2017).

2.6 Vegetation

The majority of the site is located at the eastern-most edge of the Bassendean Dune System, with the eastern corner of the site located on the Ridge Hill Shelf and the lower sector of the face of the Darling Escarpment. The Ridge Hill Shelf System over the southern portion of the site is the only remaining area of this system in the Perth Metropolitan Region (RPS, 2016).

Vegetation and flora was described in the CMP by RPS (2016), and the following description is summarised from the CMP:

The vegetation complex present on site is the Forrestfield Complex (Heddle et al. 1980), which ranges from open forest of *Corymbia calophylla – Eucalyptus wandoo – Eucalyptus marginata* to open forest of *E. marginata – C. calophylla – Allocasuarina fraseriana – Banksia* species. Fringing woodland of *Eucalyptus rudis* occurs in the gullies that dissect this landform.

This complex has been extensively cleared and it is estimated that in 2000, there were only 1,020 ha (9%) of the original extent of Forrestfield Complex bushland remaining. The Western Australian Government's Bush Forever only identifies 573 ha or 5% of the original extent of Forrestfield Complex for protection. Consequently, the Forrestfield Complex is categorised as "poorly reserved" (Government of Western Australia 2000).

Large portions of the site include good quality *Banksia* woodland. Any area of good quality *Banksia* woodland is considered Endangered under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Two Threatened Ecological Communities (TECs), as identified under Western Australian legislation, have been identified on the Bushmead site:

- Swan Coastal Plain Floristic Community Type (SCP FCT) 20a – *Banksia attenuata* woodlands over species rich dense shrublands; and
- SCP FCT 20c – Shrublands and woodlands of the eastern Swan Coastal Plain.

SCP FCT 20a occurs on the northern portion of the site in the part referred to as Conservation Area A in this plan (Appendix 2). This FCT is classified as Endangered under Western Australian legislation (DBCA 2016). The mean species richness determined by Gibson et al. (1994) is 67.4 species per 100 m^2 for FCT 20a.

SCP FCT 20c mainly occurs on transitional soils of the Ridge Hill Shelf on the Swan Coastal Plain adjacent to the Darling Scarp. It is listed as Critically Endangered under Western Australian legislation (DBCA 2016). FCT 20c has been identified within the

central portion of the site, in part of the site referred to as Conservation Area B in this plan (Appendix 2). The mean species richness determined by Gibson et al. (1994) is 64.0 species per 100 m^2 for FCT 20c.

For the upland areas occurring on the slopes of the Ridge Hill Shelf, FCTs have been inferred from the descriptions in Markey (1997) for the Northern Darling Scarp (NDS), and are relevant to revegetation works in what is called Conservation Area C in this report. These FCTs have been inferred from the landform descriptions in Markey (1997) more so than the species occurrence, as the understorey of this area is very degraded. The NDS FCTs that are most likely to have occurred in Conservation Area C of the Bushmead site are:

- NDS FCT 1a – Upper slope *Eucalyptus wandoo* woodlands (mean species richness of 66.9 species per 100 m^2);
- NDS FCT 4 – Woodlands on steep colluvial slopes of Scarp face and upper valleys (mean species richness of 75.7 species per 100 m^2);
- NDS FCT 5 – Central granite shrublands (mean species richness of 64.9 species per 100 m^2); and
- NDS FCT 7 – Woodlands on poorly drained colluvial deposits (mean species richness of 61.3 species per 100 m^2).

NDS FCT 1a has conservation significance in that it is reserved only in one secure area, at Walyunga National Park (Markey 1997) (a secure area being a National Park or Nature Reserve). Markey (1997) also specifically describes the conservation importance of this FCT at Bushmead, which formed part of her study, observing that it is the only example of this FCT on the Ridge Hill Shelf, and also the only example which occurs at lower altitudes (about 90 m above sea level (asl)) than the typical occurrence (about 208 m asl).

For the Kadina Brook, classification of the vegetation is more difficult with respect to FCTs, due to few classifications being conducted in the region for this landform (ephemeral creeks through the Ridge Hill Shelf). Hence, no classification has been assigned for the purpose of this plan, other than to determine a mean species richness for the purposes of defining completion targets. Hence, on the advice from DBCA, the Kadina Brook is most similar to SCP FCT 11 – Wet forests and woodlands, which has a mean species richness of 27.2. It is also likely to be similar to vegetation communities in drainage lines identified by Keighery and Trudgen (1992) for the eastern side of the Swan Coastal Plain, including the *Eucalyptus rudis* and *Melaleuca rhaphiophylla* Woodland and Open Forest for the northern (downstream) part of the brook, and Marri and *Eucalyptus rudis* Woodland for the southern (upstream) part. However, no species richness estimates are available for these community types.

2.7 Fauna

Fauna values of the Bushmead site are provided in the CMP (RPS 2016). The Bushmead site is potentially used by the following species of conservation significance:

- Carnaby's Black-Cockatoo *(Calyptorhynchus latirostris);*
- Forest Red-Tailed Black-Cockatoo *(Calyptorhynchus banksii naso);*
- Baudin's Cockatoo *(Calyptorhynchus baudinii);*
- Rainbow Bee Eater *(Merops ornatus);*
- Peregrine Falcon *(Falco peregrines);*
- Quenda / Southern Brown Bandicoot *(Isodoon obesulus* subsp*. fusciventer);*

- Carpet Python *(Morelia spilota* subsp*. imbricata);* and
- Darling Range Heath *Ctenotus (Ctenotus delli)*

2.8 Conservation Value

The Bushmead site has significant conservation values. These are listed in the CMP (RPS 2016), and values which are relevant to revegetation, stream restoration and weed management are summarised here:

- Three species of Priority flora have previously been recorded on the site:
  - *Isopogon drummondii* (P3);
  - *Halgania corymbosa* (P3); and
  - *Calothamnus accedens* (P4).
- The site contains areas of Forrestfield vegetation complex, of which there was less than 9% remaining within the Perth Metropolitan Region on the Swan Coastal Plain in 1998;
- Occurrences of two State-listed TECs: 'FCT 20a – *Banksia attenuata* woodland over species rich dense shrublands' and 'FCT 20c – Shrublands and woodlands of the eastern side of the Swan Coastal Plain'. These communities, as well as other areas of good condition *Banksia* woodland on the site, are also considered as Endangered communities under the EPBC Act;
- The Kadina Brook, a tributary of the Helena River, recognised as a wetland of significant conservation value due to there being few creeklines in the Ridge Hill Shelf system not affected by quarrying or urbanisation and a section of which is classified as having vegetation in very good – excellent condition; and
- The bushland is recognised within the State Government's Bush Forever policy (site 213) as a regionally significant fragmented bushland/wetland linkage due to it being part of several strategic corridors within the Perth Metropolitan Region where the Swan Coastal Plain and the Darling Plateau meet.

2.9 Existing and Previous Land Uses

The Bushmead site has previously been used for military and agricultural purposes as well as an abattoir liquid waste disposal site. In 2009 a Conservation Covenant was established between the Commonwealth Department of Defence and the then State Department of Environment and Conservation to protect conservation values of the site. In 2010, the site was purchased by Cedar Woods and has had no active land use since this time.

2.10 Weeds

The majority of the site is weedy, including those areas with significant remnant vegetation, where weeds intersperse with native plants. Woody weeds are a significant problem across the site, particularly in the northern part of the site where mature *Leptospermum laevigatum* (Coast Teatree) has become dominant and is invading remnant bushland.

A list of weed species observed on site is provided in Appendix 4. This is not exhaustive, but covers the majority of weeds that have significant cover or are problematic weeds for revegetation efforts. It includes some species native to Western Australia that are not naturally found in the local area.

From a management perspective, the woody weeds and some priority weeds have been identified for specific management under this plan, with associated completion targets (see Section 3.4). These woody weeds and priority weeds are shown in Table 1 below. Distribution and cover scores for the priority and woody weeds are shown in Appendix 5.

List 1 priority weeds are those weeds that are considered possible to kill throughout the site and reduce to 0% cover. These weeds respond well to herbicide, and seedbanks can usually be managed to prevent reinvasion over the timeframe considered in this plan. List 2 priority weeds are weeds which are highly invasive and already widespread on the site, and for which control is difficult because of the likelihood of a large soil seed bank and / or the species is difficult to eradicate using herbicides over the timeframes identified in this plan. For List 2 priority weeds, a cover completion target has been set in consultation with DBCA.

Table 1 Woody Weeds and Priority Weeds

Species	Common Name	Completion Target
Woody Weeds (0% cover target on completion)		
Acacia decurrens	Early Black Wattle	0% cover
Acacia ?floribunda		0% cover
Acacia iteaphylla	Flinders Ranges Wattle	0% cover
Acacia longifolia	Sydney Golden Wattle	0% cover
Acacia podalyriifolia	Queensland Silver Wattle	0% cover
Agonis flexuosa	Peppermint	0% cover
Chamaecytisus palmensis	Tagasaste	0% cover
Chamelaucium uncinatum	Geraldton Wax	0% cover
Corymbia citriodora	Lemon-Scented Gum	0% cover
Erythrina × sykesii	Coral Tree	0% cover
Eucalyptus erythrocorys	Illyarrie / Red-capped Gum	0% cover
Ficus carica	Common Fig	0% cover
Leptospermum laevigatum	Coast Teatree	0% cover
Melaleuca nesophila	Mindiyed	0% cover
Melia azedarach	White Cedar / Cape Lilac	0% cover
Nerium oleander	Oleander	0% cover
Olea europaea	Olive	0% cover
Ricinus communis	Castor Oil Plant	0% cover
Schinus terebinthifolius	Japanese Pepper	0% cover
Priority Weeds – List 1 (0% cover target on completion)		
Agapanthus praecox	Agapanthus	0% cover
Citrullus lanatus	Pie Melon / Paddy Melon	0% cover
Cortaderia selloana	Pampas Grass	0% cover
Gomphocarpus fruticosus	Narrowleaf Cottonbush	0% cover
Ipomoea cairica	Coast Morning Glory	0% cover
Phytolacca octandra	Red Ink Plant	0% cover
Watsonia meriana var. *bulbillifera*	Bulbil Watsonia	0% cover
Watsonia meriana var. *meriana*	Watsonia	0% cover
Zantedeschia aethiopica	Arum Lily	0% cover
Priority Weeds – List 2 (≤ 10% cover target on completion, as indicated)		
Asparagus asparagoides	Bridal Creeper	≤ 5% cover
Cynodon dactylon	Couch Grass	≤ 5% cover
Echium plantagineum	Paterson's Curse	≤ 10% cover
Ehrharta calycina	Perennial Veldt Grass	≤ 5% cover
Eragrostis curvula	African Lovegrass	≤ 5% cover
Freesia alba × leichtlinii	Freesia	≤ 5% cover
Moraea flaccida	One-Leaf Cape Tulip	≤ 10% cover

Note: The distribution of all priority weeds (list 1 and list 2) have been mapped in Appendix 5, except *Citrullus lanatus* and *Asparagus asparagoides*. These two species may be widespread but at low densities (hard to detect in a bushland of such large scale), or in scattered populations. Generally, they were observed as individual plants at very low densities at the time of survey.

3 OBJECTIVES, GENERAL MANAGEMENT STRATEGY AND COMPLETION TARGETS

The Conservation Management Plan (CMP) for the Bushmead site identifies that 38.3 ha of cleared or degraded land within the Conservation Area is to be revegetated, pursuant to approvals under the EPBC Act (RPS 2016, p. 20). Following several site inspections by Tranen, a total of 41.3 ha was identified for revegetation, with the remaining land in the Conservation Area (148 ha) managed to reduce weed loads.

The revegetation, stream restoration and weed management strategy has several key components:

- Retention and management of existing vegetation, including TECs;
- Management of problematic weed species;
- Revegetation to increase plant density and species diversity in degraded areas; and
- Weed management and stream restoration for degraded sections of the Kadina Brook.

The strategy for the site has been developed based on the following geographical designations (refer to Appendix 2 for a map of the areas):

- **Conservation Area A**, which includes four revegetation sites, a TEC (FCT 20a) and remnant vegetation;
- **Conservation Area B**, which includes five revegetation sites, a TEC (FCT 20c) and remnant vegetation;
- **Conservation Area C**, which includes two broad revegetation areas and remnant vegetation; and
- **Conservation Area D**, which is the Kadina Brook and its buffer area.

Each of the management areas described in this section are delineated on the map in Appendix 3. A summary of the management requirements in each zone can found in Appendix 7.

The completion targets for all areas managed under this plan have been designed based on a six-year implementation plan, which includes at least one year of site preparation, planting and / or seeding, and a five-year management period. Following these works, the whole conservation estate will be handed over to DBCA for management, assuming the completion criteria have been met, as listed below.

The strategy for weed management and revegetation works will be adaptable over the management period, based on learnings from the on-going revegetation works across the site. Variations to the management strategies will be agreed with DBCA prior to implementation.

3.1 Revegetation, Stream Restoration and Weed Management Objectives

The general objectives for the project are to re-establish plant species that are endemic, or likely to be endemic, to the local area in identified revegetation sites, and reduce weed populations throughout bushland areas and the Kadina Brook, with particular focus on priority and woody weeds identified in Table 1.

Completion targets have been designed to achieve these objectives, and are presented in Section 3.4.

3.2 General Revegetation Strategy

The general strategy for revegetation at most sites across Bushmead is similar, and will consist of the following works:

- Site Preparation (Year 1):
  - Weed control up to four times in 12 months, depending on weeds present and severity of infestation (most likely timing: late autumn, mid-winter, mid-spring, early summer). Up to twelve months of weed control will be undertaken prior to any revegetation works occurring;
  - Scalping of the site to remove the top 5 – 10 cm of soil (to remove weed seeds and / or stolons of *Cynodon dactylon* (Couch Grass)). Scalping to occur in late summer or autumn;
  - Ripping to a depth of 0.5 m to break up the subsoil to assist with moisture penetration and root development. Ripping to occur in late autumn or early winter depending on rainfall;
  - Placement of hollow and / or solid logs on site for fauna habitat;
  - Installation of a 1.8 m tall fence to prevent kangaroos entering site, plus a rabbit-proof skirt buried to a depth of 30 cm;
- Initial Revegetation Works (Year 2):
  - Pre-planting weed control in winter;
  - Scarification of the soil surface to provide niches for seeds to lodge and germinate;
  - Direct seeding at a rate of 3 kg/ha;
  - Tubestock installation in winter at a density of 0.5 plants / m^2 for shrubs and groundcovers and trees at 300 stems / ha;
- Maintenance (Years 2 – 6):
  - Five years of maintenance which includes weed control up to four times per year, infill planting of tubestock as required to maintain plant densities, and fence maintenance as required.

Where particular sites have additional requirements, or some of the techniques above are not to be used, this will be outlined under headings for each Conservation Area in Section 4. Revegetation techniques for Kadina Brook (Conservation Area D) will vary slightly from the strategy listed above for most sites, and this is described in Section 4.4. A summary matrix showing quantities and works items has been prepared for all sites (Appendix 7).

3.3 Key Timeframes

3.3.1 Site Preparation

Site preparation works are to commence as soon as this plan is approved and all necessary permits for working within a TEC are obtained. Site preparation works are likely to commence in spring 2017.

3.3.2 Initial Revegetation Works

Initial revegetation works, involving the direct seeding and first planting of tubestock, will commence in the first winter following completion of site works. This is likely to commence in winter 2018 for most sites. Other sites, which may have significant weed issues or may be affected by construction of development infrastructure, will receive the initial revegetation treatment in winter 2019 after approximately two years of weed control. More detailed information on commencement of revegetation works by site is presented in Appendix 8.

3.3.3 Maintenance Period

Maintenance of revegetation sites will continue until early spring 2023 (assuming planting works can commence in winter 2018). For most revegetation sites, this allows for five years of maintenance following initial planting works. Some sites (as detailed in Appendix 8), will be maintained for four years after initial planting and seeding works, but will have had an extra year of site preparation beforehand, resulting in the same management timeframe.

3.4 Completion Targets

Table 2 shows the completion targets for the four Conservation Areas. All monitoring reports will compare progress towards these targets, and maintenance activities and contingency measures will be undertaken where the targets are not being met. An assessment of completion targets within each Conservation Area will be undertaken in September 2023, six years after management works commence. If the completion targets have been met after this period, DBCA will accept management responsibility for the Conservation Areas. If the targets have not been met, further works may be required by the developer. Refer to Section 3.5 for handover requirements in the event targets have not been met.

When assessing completion targets for plant densities and species richness, existing plants and seedlings observed from natural germination will be included in these assessments.

Table 2 Completion Targets for Conservation Areas

Completion targets are to be met by September 2023 (assuming site preparation commences in spring 2017)

No.	Completion Target	Area A	Area B	Area C (Sandy)	Area C (Laterite)	Area D
1	Shrub /groundcover density in revegetation sites	1 plant / m^2 (or foliar cover ≥ 50%)	1 plant / m^2 (or foliar cover ≥ 50%)	1 plant / m^2 (or foliar cover ≥ 50%)	1 plant / m^2 (or foliar cover ≥ 50%)	1 plant / 2 m^2 (or foliar cover ≥ 30%)[1]
2	Tree density:					
2(a)	Minimum overall tree density in revegetation sites	300 stems/ha	300 stems/ha	300 stems/ha	300 stems/ha	n/a[2]
2(b)	Minimum *Banksia attenuata* density	100 stems/ha	100 stems/ha	80 stems/ha	n/a	n/a[2]
2(c)	Minimum *Banksia menziesii* density	100 stems/ha	100 stems/ha	80 stems/ha	n/a	n/a[2]
2(d)	Minimum *Corymbia calophylla* density		30 stems/ha	50 stems/ha	100 stems/ha	n/a[2]
2(e)	Minimum *Eucalyptus marginata* density	20 stems/ha	20 stems/ha	50 stems/ha	50 stems/ha	n/a[2]
2(f)	Minimum *Eucalyptus wandoo* density	n/a	n/a	n/a	100 stems/ha	n/a[2]
2(g)	Presence of *Allocasuarina fraseriana*	Yes	Yes	Yes		n/a[2]
2(h)	Presence of *Banksia grandis*	Yes	Yes	Yes	Yes	n/a[2]
2(i)	Presence of *Banksia ilicifolia*	Yes	Yes			n/a[2]
2(j)	Presence of *Eucalyptus todtiana*	Yes	Yes			n/a[2]
3	Species richness:					
3(a)	Total species richness measured across a Conservation Area – difficult to set targets based on lack of data. Aim to maximise richness with a target of 60% of FCT value (not to be used as a criteria for site handover)	40.4 (based on SCP FCT 20a)	38.4 (based on SCP FCT 20c)	36.8 (based on NDS FCT 7)	40.1 (based on NDS FCT 1a)	16.3 (based on SCP FCT 11)
3(b)	Minimum species richness measured within FCT equivalent (10 x 10 m quadrat) to be 30% of FCT value	20.2 (based on SCP FCT 20a)	19.2 (based on SCP FCT 20c)	18.4 (based on NDS FCT 7)	20.1 (based on NDS FCT 1a)	8.2 (based on SCP FCT 11)
4	Foliar cover of woody weeds (see Table 1 for list of woody weeds)	0%	0%	0%	0%	0%
5	Maximum foliar cover of priority weeds from List 1 (see Table 1)	0%	0%	0%	0%	0%
6	Maximum foliar cover of priority weeds from List 2 (see Table 1)	5% or 10% (dependent on species - see Table 1)	5% or 10% (dependent on species - see Table 1)	5% or 10% (dependent on species - see Table 1)	5% or 10% (dependent on species - see Table 1)	5% or 10% (dependent on species - see Table 1)
7	Overall stream condition index[3]	n/a	n/a	n/a	n/a	'Moderate' parameter rating or better

[1] Foliar cover target is lower because seedlings may have lower growth rates under the canopy in Kadina Brook.
[2] Tree density in Kadina Brook (Conservation Area D) is already high; therefore revegetation will focus on understorey species.
[3] Overall stream condition index is described in detail in the River Restoration Manual (Water and Rivers Commission 1999).

3.5 Site Handover

Handover of the site to DBCA will occur if it is demonstrated through the monitoring that the completion targets have been met at the completion of the project (September 2023). Once handover to DBCA occurs, the developer has no further responsibility for managing the area.

For areas that do not meet the targets, a works plan will be agreed upon between the developer and DBCA which will set out the activities to be undertaken, detailed specifications on how the activities will be undertaken, and a timeframe for which maintenance will be the responsibility of the developer. Once all activities have been performed within the allotted timeframe, DBCA will accept responsibility for the site.

Completion targets may be revised through the life of this plan, as described in Section 7.3. If the revised completion targets are met within the timeframe specified, this will trigger site handover.

4 MANAGEMENT STRATEGIES FOR CONSERVATION AREAS

4.1 Conservation Area A – TEC and Revegetation Areas

Area A is predominantly covered by a TEC which is FCT 20a – *Banksia attenuata* woodlands over species rich dense shrublands. The remainder of Area A is remnant vegetation that ranges from completely degraded to good condition.

The **objective for revegetation and weed management in Area A** is to re-establish plant species that are endemic, or likely to be endemic, to the local area in identified revegetation sites, and reduce weed populations throughout bushland areas, with particular focus on priority and woody weeds identified in Table 1 on page 7).

The **completion targets for Area A** after six years of works and as listed in Table 2 are:

1. Shrub / groundcover density in revegetation sites to be 1 plant/m^2 or foliar cover to be ≥ 50%;
2. Tree density in revegetation sites to be at least 300 stems / ha, and individual tree species to occur at minimum densities as listed in Table 2 (page 12);
3. Minimum species richness across Area A to be 40.4 species (equivalent to 60% of the species richness for FCT 20a);
4. Minimum species richness measured within 100 m^2 quadrats (or equivalent) to be 20.2 species (equivalent to 30% of FCT value for FCT 20a);
5. Foliar cover of woody weeds to be 0%;
6. Maximum foliar cover of priority weeds from List 1 in Table 1 to be 0%; and
7. Maximum foliar cover of priority weeds from List 2 to be as detailed in Table 1 (page 7).

The general management approach for Conservation Area A is to:

- Control and reduce weed populations within the TEC and other remnant bushland areas that have vegetation in a good to very good condition; and
- Revegetate sites that are degraded and largely clear of native vegetation. Three areas have been identified for revegetation in the Conservation Masterplan (EPCAD, 2016), while a fourth area was identified by Tranen during the field inspection; and
- Hand over management of Area A to DBCA six years after commencing revegetation works, as per the handover description in Section 3.5.

The following is a description of the management sites in Area A. Revegetation for most sites will follow the strategy outlined in Section 3.2, though some sites have additional works items that may be implemented, such as incorporation of mulch into topsoil. These are described below for the relevant sites.

4.1.1 Threatened Ecological Community – FCT 20a

Figure 1 Threatened Ecological Community – FCT 20a

SCP FCT 20a contains a range of vegetation condition ratings, from Degraded to Very Good condition. There are large populations of woody weeds that occur within the TEC; of particular concern are the large populations of *Leptospermum laevigatum* (Coast Teatree) which are mature shrubs that have established in disturbed areas, and spread into the undisturbed parts of the bushland. A very large population occurs in the northern tip of the site (these can be seen in the background of the photo in Figure 1 above). In the southern part of the TEC, a mature, mixed shrubland of the woody weeds Coast Teatree, *Melaleuca nesophila* (Mindiyed), and *Chamelaucium uncinatum* (Geraldton Wax) occurs. Although the latter two are native to Western Australia, they are not locally occurring, so they also need to be controlled to improve the condition of the TEC. Herbaceous, cormous and grassy weeds also occur throughout parts of the TEC, some of which are perennial weeds that will be targeted to reduce their potential to spread throughout the TEC. These include weeds in the Priority List in Table 1 such as *Watsonia meriana* var. *meriana* (Watsonia), *Ehrharta calycina* (Perennial Veldt Grass) and *Eragrostis curvula* (African Lovegrass).

The objective for the TEC in Area A is to remove existing mature woody weeds, control any germinants from the woody weeds, and reduce the general weed load throughout the TEC in order to meet the completion targets for woody and priority weeds (Section 3.4).

Weed management within the TEC requires the following approach, with reference to control techniques outlined in Appendix 4:

- Woody weed control (spraying and / or cut and paint or drill and fill techniques);
- Targeted control of priority weeds as listed above and in Table 1 on page 7;
- Initially, frequency of control events will be up to four times per year in the key growth periods of autumn, winter, spring and summer. If weed populations begin to reduce, frequency of control may reduce to prevent off-target impacts on native flora of the TEC.

4.1.2 Revegetation Site A1

Figure 2 Revegetation Site A1

Site A1 is a cleared area of 0.22 ha with scattered clumps of *Adenanthos cygnorum* occurring within it, and *Banksia* woodland around the perimeter. The revegetation area has been increased slightly from that identified in the Conservation Masterplan (EPCAD, 2016) to include the sandy track and disturbed land to the north east. The cleared area is dominated by Couch Grass, with other weeds also observed including Perennial Veldt Grass, African Lovegrass, Watsonia and *Arctotheca calendula* (Cape Weed).

To achieve the revegetation objectives, weed control and site preparation are important to reduce competition with the native plants to be re-established. Couch Grass is the most serious weed on the site and will need an intensive management approach to reduce its impact on the re-establishing vegetation.

After two years of intensive weed management on the site, a combined approach of direct seeding and tubestock planting will be implemented to return the native plant community, as per the works outlined in Section 3.2. Initial seeding and planting works are scheduled to commence in winter 2019 for A1.

4.1.3 Revegetation Site A2

Site A2 occurs in the southern section of Area A and is 2.42 ha in size. The site has scattered clumps of *Adenanthos cygnorum* and *Banksia* woodland occurring within some parts of it, and large areas of woody weeds on the north-western side.

A2 has been divided into two zones to reflect a difference in techniques that will likely yield the best results in each section:

1. **A2a:** semi-degraded vegetation community 1.95 ha in size with an over/mid-storey of *Banksia attenuata, B. menziesii, Allocasuarina fraseriana, A. cygnorum* and *Jacksonia floribunda*. This vegetation community retains a reasonable structure in most parts, though the southern portion contains an area of 3,500 m^2 with no native vegetation. Revegetation works for A2a will follow the general strategy listed in Section 3.2.
2. **A2b:** completely degraded area 0.47 ha in size with mostly introduced woody weeds in the overstorey, consisting of Mindiyed and Coast Teatree with a bare understorey. Occasional natives occur on site, mostly *A. cygnorum* in very low densities. Revegetation works for A2b will follow the general strategy listed in Section 3.2, though some additional works are required:
    - Remove woody weeds from site. It is important to remove or kill seeds from the felled woody weeds; this can be achieved either by removing the woody weed material from site, or by heaping and burning on site. The latter will depend on obtaining approvals from DBCA and / or the Department of Fire and Emergency Services (DFES);
    - Installation of mulch on site, spread roughly to a depth of 50 mm. The use of mulch is proposed because the soils are unlikely to support vegetation in the long term without some form of improvement through incorporation of organic matter. Mulch could be from composted material cleared from development cells;
    - The site will be ripped to a depth of 0.5 m to break up the subsoil and incorporate mulch in topsoil.

Initial seeding and planting works are scheduled to commence in winter 2018 for A2.

Figure 3 Revegetation Site A2a

Figure 4 Revegetation Site A2b

4.1.4 Revegetation Site A3

Figure 5 Revegetation Site A3

Site A3 is a small, thin area in the south-eastern corner of Conservation Area A on the border of Kadina Brook. The site is 0.23 ha in area and contains a low density of native vegetation with an overstorey of *Corymbia calophylla*, *Allocasuarina fraseriana* and *Nuytsia floribunda,* and an understorey of *Xanthorrhoea preissii*, *Adenanthos cygnorum*, *Dasypogon bromeliifolius* and *Acacia pulchella.*

To achieve the revegetation objectives, weed control will be important to reduce competition with the native plants to be re-established. The most dominant weed species is Watsonia, and this occurs in a patchy distribution throughout the site. There are other perennial and annual weeds that were observed on site, the most serious of which were Perennial Veldt Grass, Cape Weed and Couch Grass, the latter occurring in a small patch at the southern end of the site. Revegetation works will occur as per the strategy outlined in Section 3.2, with initial seeding and planting works scheduled to commence in winter 2018.

4.1.5 Revegetation Site A4

Figure 6 Revegetation Site A4

Site A4 is a predominantly cleared area of 0.9 ha containing scattered native and non-native trees and shrubs. This area was not listed for revegetation in the Conservation Masterplan (EPCAD, 2016), but occurs within the TEC of Conservation Area 1 and therefore requires management to maintain TEC values. Most of the area is covered with Couch Grass, and contains areas with populations of *Freesia alba* × *leichtlinii* (Freesia) and *Lupinus cosentinii* (Blue Lupin). Trees include the non-natives *Erythrina* × *sykesii* (Coral Tree)*, Melia indica* (White Cedar or Cape Lilac) and *Corymbia citriodora* (Lemon-scented Gum), all of which are trees in excess of 6 m tall. There are also populations of Coast Teatree, Geraldton Wax and *Chamaecytisus palmensis* (Tagasaste) on the site, as well as many other perennial and annual grasses and herbs, and a few other woody weeds.

To achieve the revegetation objectives, weed control will be important to reduce competition with the native plants to be re-established. Couch Grass and Coast Teatree are the priority weeds on the site, and will need an intensive management approach to reduce their impact on the re-establishing vegetation. After two years of intensive weed management, a combined approach of direct seeding and tubestock planting will be implemented in winter 2019 to return the native plant community, as described in Section 3.2.

4.1.6 Area A – Balance of Site (Remnant Vegetation)

Figure 7 Area A – Remnant Vegetation (not TEC or Revegetation Site)

Parts of Area A that are not TEC or a revegetation site are also to be managed under this plan. **The management objective** for these areas is to prevent the spread of weeds within them, and reduce weed biomass, particularly for priority and woody weeds (see Table 1 on page 7). Most of the weed control works will be done in conjunction with weed management in the TEC.

An indicative schedule of works is provided below:

- Woody weed control. This is mainly Coast Teatree, which are very large plants;
- Spot spraying once a year with herbicide to target woody weed seedlings; and
- Targeted control of other weeds, predominantly Watsonia and perennial grasses in the bushland.

4.2 Conservation Area B – TEC and Revegetation Areas

Most of Conservation Area B is covered by a TEC which is FCT 20c – Shrublands and woodlands of the eastern Swan Coastal Plain (RPS, 2016). The remainder of Area B is remnant vegetation that ranges from completely degraded to good condition.

The **objective for revegetation and weed management in Area B** is to re-establish plant species that are endemic, or likely to be endemic, to the local area in identified revegetation sites, and reduce weed populations throughout bushland areas, with particular focus on priority and woody weeds identified in Table 1 on page 7.

The **completion targets for Area B** after six years of works and as listed in Table 2 are:

1. Shrub / groundcover density in revegetation sites to be 1 plant/m^2 or foliar cover to be ≥ 50%;
2. Tree density in revegetation sites to be at least 300 stems / ha, and individual tree species to occur at minimum densities as listed in Table 2 on page 12;
3. Minimum species richness across Area B to be 38.4 species (equivalent to 60% of the species richness for FCT 20c);
4. Minimum species richness measured within 100 m^2 quadrats (or equivalent) to be 19.2 species (equivalent to 30% of FCT value for FCT 20c);
5. Foliar cover of woody weeds to be 0%;
6. Maximum foliar cover of priority weeds from List 1 in Table 1 to be 0%; and
7. Maximum foliar cover of priority weeds from List 2 to be as detailed in Table 1 on page 7.

The general management approach for Conservation Area B is to:

- Control weed populations within the TEC and other areas that have vegetation in a good to very good condition through the use of herbicide spot spraying and woody weed control; and
- Revegetate parts that are degraded and largely clear of native vegetation. Five sites have been identified for revegetation;
- Hand over management of Area B to DBCA six years after commencing revegetation works, as per the handover description in Section 3.5.

The following is a description of the management sites in Area B. Revegetation for most sites will follow the strategy outlined in Section 3.2, though some sites have additional works items that may be implemented, such as incorporation of mulch into topsoil. These are described below for the relevant sites.

4.2.1 Threatened Ecological Community – FCT 20c

Figure 8 Threatened Ecological Community – FCT 20c

SCP FCT 20c is a 50 ha tract of continuous vegetation. It has very low densities of weeds, most of which are concentrated on the edges, and near or on trails. There is a large population of Coast Teatree on the western margin of the TEC, adjacent to revegetation site B3. Herbaceous and grassy weeds also occur throughout parts of the TEC, mostly in low densities.

The objective for the TEC is to remove the large population of Coast Teatree adjacent to revegetation site B3, control any germinants from the woody weeds, and reduce the general weed load throughout the TEC.

Weed management within the TEC area requires a combined approach of woody weed management and herbaceous / grassy weed management. Weeds will be managed in the following manner, with reference to control techniques in Appendix 4:

- Mature woody weeds to be killed;
- TEC area to be treated with a herbicide spot spraying regime that will aim to reduce weed biomass and cover of woody weed seedlings and priority weeds (see Table 1 on page 7);
- Spot spraying for weeds will occur up to four times per year in the key growth periods of autumn, winter, spring and summer and continue for a minimum of five years after initial works commence, or until completion targets have been met.

4.2.2 Revegetation Site B1

Figure 9 Revegetation Site B1

Site B1 is an ex-pasture area of 2.36 ha which has had the understorey cleared and replaced with pasture grasses and other weeds such as Cape Weed, Blue Lupin, Perennial Veldt Grass and *Ehrharta longiflora* (Annual Veldt Grass). There are also mature groves and scattered individuals of Tagasaste and *Gomphocarpus fruticosus* (Narrow-Leaf Cotton Bush). A native mature overstorey of *Corymbia calophylla* (Marri) and *Eucalyptus marginata* (Jarrah) also occurs on site.

After a year of intensive weed management, a combined approach of direct seeding and tubestock planting will be implemented in winter 2018 to return the native plant community, as described in Section 3.2.

4.2.3 Revegetation Site B2

Figure 10 Revegetation Site B2

Site B2 is similar in appearance to Site B1, and its management shall be of a similar nature. Site B2 is an ex-pasture area of 4.60 ha which has had the understorey cleared and replaced with pasture grasses and other weeds such as Cape Weed, *Echium plantagineum* (Patterson's Curse), Blue Lupin, Perennial Veldt Grass and Annual Veldt Grass. There are also mature groves and scattered individuals of Tagasaste and Narrow-Leaf Cotton Bush. A native mature overstorey of Marri and Jarrah also occurs on site.

As with Site B1, at least one year of weed control will be implemented prior to revegetation works, which consists of a combination of direct seeding and tubestock planting in winter 2018, as described in Section 3.2.

4.2.4 Revegetation Site B3

Figure 11 Revegetation Site B3

Site B3 is a long, thin area of 2.68 ha which has two vegetation community types which roughly divide the area in half. In the north, there is a vegetation community similar to Sites B1 and B2, with Marri and Jarrah trees over a pasture-like understorey. The southern half of the site is disturbed woodland with a very low density of shrubs and sedges, predominantly *A. cygnorum* and *Daviesia divaricata,* with scattered *Banksia menziesii* and *Allocasuarina fraseriana.* The site is a transition community from the TEC to Kadina Brook. Weeds in the southern half of the site include mature and immature Coast Teatree, and African Lovegrass.

Woody weeds (Coast Teatree) will require manual removal; herbaceous and grassy weeds can be controlled effectively with glyphosate and grass selective herbicide as needed, as can the pasture-like weeds across the north of the site. After at least a year of intensive weed management on the site, a combined approach of direct seeding and tubestock planting will be implemented in winter 2018 to return native plants to the community, as described in Section 3.2.

4.2.5 Revegetation Site B4

Figure 12 Revegetation Site B4

Site B4 occurs along the north-eastern boundary of the property, is 2.37 ha in area, and is directly north of the proposed southern development cell (see Appendix 3). The topography of the site is elevated compared with the rest of Conservation Area B. Site B4 grades from sandy soils in the western and central areas, to laterite soils in the more elevated eastern section. The majority of the site contains Jarrah and Marri trees over a degraded understorey including *Banksia sessilis, Xanthorrhoea preissii,* and *Hakea lissocarpha*. The site contains a range of weed species, including woody weeds of Tagasaste and *Phytolacca octandra* (Red Ink Plant). There are also small infestations of Paterson's Curse on the revegetation site, as well as Capeweed, Perennial Veldt Grass and Watsonia. Shady areas contain Freesia and Annual Veldt Grass.

To achieve the revegetation objectives, weed control followed by direct seeding and tubestock planting will be used in winter 2018, as described in Section 3.2. Mature woody weeds (mainly Tagasaste) will be killed and seedlings controlled, while pasture-like weeds will be controlled with a broad spectrum herbicide such as glyphosate. The Freesia should be sprayed with metsulfuron methyl, which may need to be a separate weed control event in July / August. Areas where a lot of Freesia occurs may be planted one year later to allow more complete control of the weeds.

4.2.6 Revegetation Site B5

Figure 13 Revegetation Site B5

Site B5 is 0.83 ha in size, and will be located on the southern edge of the southern development cell (Appendix 3). The site is a degraded woodland of Jarrah, Marri and *Eucalyptus rudis* (Flooded Gum). The western half of the site is located within the Kadina Brook buffer area, while the eastern half is degraded vegetation on sandy soils. There are woody weeds on site and in the adjacent Kadina Brook buffer area, with *Acacia longifolia* (Sydney Golden Wattle) and *A. iteaphylla* (Flinders Ranges Wattle) occurring in small patches. Other weeds that will require control include Paterson's Curse, Watsonia and Cape Weed. The Conservation Masterplan shows a 4 m wide asphalt trail being constructed through the middle of the revegetation site (EPCAD, 2016). Preferentially, revegetation works would be implemented after the path has been constructed.

The western side of the site will be revegetated using plant species that are suitable for the lower elevation and wetter Kadina Brook area with sandy-clay soils, and the eastern side will be revegetated using species suitable to the drier, more elevated sandy soils. Woody weeds (mainly non-native wattles) will require manual control, while pasture-like weeds will be sprayed with broad spectrum herbicide. Sections of the existing track that are to be revegetated will be ripped, and where practical, the site will be covered in mulch for aesthetics and weed suppression near the path. Tubestock will be planted following mulch installation.

The timing of revegetation works is dependent on the construction of the track that runs through the middle of the site, but is scheduled to occur in winter 2018. Weed control will commence ahead of construction if possible, while planting will occur once construction of the track is complete. It is preferable to fence the site to protect plants from kangaroos and rabbits, though it may be difficult to do this with a 4 m wide track through the middle. An alternative to fencing this area is to place tree guards around the plants to protect the very young seedlings from kangaroo and rabbit grazing, and this is the most likely option on this site.

Works that may be required at this site, in addition to those listed in Section 3.2, are:

- Mulch installation to a depth of 75 mm. This step will be confirmed with DBCA prior to implementation, as mulch can be a vector of *Phytophthora* dieback;
- Sections of existing track that are not used for the asphalt track will be ripped to a depth of up to 0.5 m to break up the subsoil, as will other clear areas away from tree roots. Ripping will occur in summer or autumn before the soil becomes too moist;
- Tubestock installation in winter at a density of 2 plants / m^2. The high density planting is designed to rapidly increase cover and dissuade members of the public from entering the area. Completion targets remain as listed in Section 3.4.
- Tubestock to be protected from grazers with corflute tree guards if a fence is not practical.

4.2.7 Area B – Balance of Site (Remnant Vegetation)

Parts of Area B that are not TEC or a revegetation site will be managed to control woody and priority weeds (see Table 1 on page 7). Most of the weed control works will be done in conjunction with weed management for the revegetation sites or TEC, using control techniques listed in Appendix 4.

4.3 Conservation Area C – Eastern Sandplain and Darling Scarp

Conservation Area C occurs in the south-eastern corner of the Bushmead site (Appendix 2). It consists of Jarrah and *Banksia* woodland in sandy soils on the western side of Area C, and Jarrah, Marri and *Eucalyptus wandoo* (Wandoo) woodland on the elevated eastern section of the area. The eastern section of the area has some steep slopes, rocky outcrops and gravelly soils. The understorey across all of Area C is predominantly weedy, dominated by annual grasses and Cape Weed, and with significant but patchy populations of Paterson's Curse, *Moraea flaccida* (One-Leaf Cape Tulip), Narrow-Leaf Cotton Bush, Freesia and Watsonia. There are also a lot of woody weeds on the scarp. The main woody weeds observed were *Olea europea* (Olive), Tagasaste and Flinders Ranges Wattle. Woody weeds were also observed in the sandy areas of Conservation Area C, including Sydney Golden Wattle, *Acacia decurrens* (Early Black Wattle) and many Flinders Ranges Wattles throughout the intact bushland.

There are two revegetation sites that have been identified in the Conservation Masterplan (EPCAD, 2016), which differ in size, community type, and management issues. One of these revegetation sites, C2, is large (18.7 ha), and consists of two soil types. Hence, it has been divided into separate management units:

- C2L: laterite and gravelly, clay soils associated with the Ridge Hill Shelf; and
- C2S: yellow sands which are likely to be colluvial deposits from the Ridge Hill Shelf, transitioning to the eastern Swan Coastal Plain.

The **objective for revegetation and weed management in Area C** is to re-establish plant species that are endemic, or likely to be endemic, to the local area in identified revegetation sites, and reduce weed populations throughout bushland areas, with particular focus on priority and woody weeds identified in Table 1 on page 7.

The **completion targets for Area C** after six years of works and as listed in Table 2 are:

1. Shrub / groundcover density in revegetation sites to be 1 plant/m^2 or foliar cover to be ≥ 50%;
2. Tree density in revegetation sites to be at least 300 stems / ha, and individual tree species to occur at minimum densities as listed in Table 2 (see page 12);
3. Minimum species richness across Area C sites on lateritic soils to be 40.1 species (equivalent to 60% of the species richness for NDS FCT 1a);
4. Minimum species richness across Area C sites on sandy soils to be 36.8 species (equivalent to 60% of the species richness for NDS FCT 7);
5. Minimum species richness measured within 100 m^2 quadrats (or equivalent) to be 20.1 species (equivalent to 30% of FCT value for NDS FCT 1a);
6. Minimum species richness measured within 100 m^2 quadrats (or equivalent) to be 18.4 species (equivalent to 30% of FCT value for NDS FCT 7);
7. Foliar cover of woody weeds to be 0%;
8. Maximum foliar cover of priority weeds from List 1 in Table 1 to be 0%; and
9. Maximum foliar cover of priority weeds from List 2 to be as detailed in Table 1 on page 7.

The general management approach for Conservation Area C is to:

- Revegetate open sites that are degraded and largely clear of native understorey, using species likely to be endemic to the area;

- Reduce weed cover for priority and woody weeds to the targets specified in this plan; and
- Hand over management of Area C to DBCA six years after commencing revegetation works, as per the handover description in Section 3.5.

The following is a description of the management sites in Area C. Revegetation for most sites will follow the strategy outlined in Section 3.2, though some sites have additional works items that may be implemented, such as spreading of mulch on top of the soil. These are described below for the relevant sites. It is anticipated that most sites in Area C will be seeded and planted in winter 2018, but seed availability may reduce the potential for this to occur, in which case some of these sites may be seeded and planted in winter 2019.

4.3.1 Revegetation Site C1

Figure 14 Revegetation Site C1

Site C1 occurs in the far western corner of Conservation Area C, and is adjacent to the main planned road into the southern development cell (Appendix 3). Revegetation Site B5 is immediately north of this road, so it is likely that revegetation works will be undertaken concurrently on these two sites. Site C1 is 0.46 ha in area, and will be bisected by a 4 m wide asphalt trail once development occurs. Most of the site currently lies beneath a compacted track which is covered in loose blue metal (see Figure 14 above). Several earth mounds also occur near Kadina Brook, on the edge of the revegetation site. There was a burnt-out car body on the site when inspected in October 2015, and the area appears to be heavily frequented by the public.

Marri and Jarrah woodland borders the site to the north, and Kadina Brook fringing vegetation borders it to the south, with *Eucalyptus rudis* the dominant tree.

Revegetation works will follow a similar schedule to that provided in Section 3.2, though some additional works are required:

- Significant earthworks are required for the majority of Site C1. All blue metal shall be removed from site or used elsewhere in the development areas. The other earth mounds shall be either spread around the revegetation site or removed, depending on the nature of the material once investigated;
- Deep ripping is essential to fracture the compacted ground to allow easier root and water penetration into the subsoil;
- Mulch is specified for this site, if it can be sourced as dieback free, and spread to a depth of 75 mm;
- Tubestock installation will be undertaken at a high density (2 plants / m^2) to rapidly increase stem densities and return plant diversity to the area. The high density planting is designed to rapidly increase cover and dissuade members of the public from entering the area;
- Direct seeding is not proposed for this site as it tends to be ineffective when spread onto a mulch layer; and
- If a fence is impractical to construct due to the trail constructed through the site, corflute tree guards will be used to protect seedlings.

As with revegetation Site B5, the timing of revegetation works is dependent on the construction of the track that runs through the middle of the site. Weed control will commence ahead of construction if possible, while planting will most likely occur once construction of the track is complete.

4.3.2 Revegetation Site C2L

Site C2L occurs in the far eastern edge of the site, and is mapped on the Conservation Masterplan as an irregularly shaped polygon that follows the zones of least canopy cover (EPCAD, 2016) (Appendix 3). Soils are laterite and gravelly clays associated with the Ridge Hill Shelf. Across the majority of the C2L area, only canopy trees remain; there is very little native understorey. Weeds in this zone make up almost the entire understorey, and is dominated by annual grasses, Cape Weed, One-Leaf Cape Tulip, Paterson's Curse, and Narrow-Leaf Cotton Bush. Many other weeds also occur in the area, including many woody weeds (Olive, Tagasaste and introduced wattles the most abundant).

The canopy in this zone is a mixture of Jarrah, Marri and Wandoo, while native understorey is mostly absent, except on some of the rockier parts in the far eastern side of the site.

Site C2L will be challenging to revegetate owing to the relatively high density of existing canopy cover, steep slopes, rocky outcrops, compacted soils, high weed cover and large population of kangaroos. Because of these difficulties, the whole area depicted as revegetation site C2L in Appendix 3 will not be planted or seeded. Rather, sub-sections with little or no canopy cover within the overall C2L site have been identified for intensive revegetation works, with

the balance to receive weed control only (section labelled C2L-WC) where priority and woody weeds will be targeted for control (see Table 1 for a list of weeds).

Figure 15 Revegetation Site C2L

A preliminary inspection of the area identified three potential sites (marked C2L1 to C2L3) within which revegetation works could occur, ranging in size from 0.58 to 4.85 ha. Where it is possible within these areas (i.e. not too steep, rocky, or heavily vegetated), ripping will be undertaken to fracture the soil to allow plant roots to grow. Ripping will occur along the contour to reduce erosion potential. Each site will be fenced to exclude herbivores and revegetated using tubestock planting and direct seeding, as per the works outlined in Section 3.2.

The timing of revegetation works is scheduled for winter 2018, but this may be dependent on the degree of weed cover and the availability of seed. Weed control will commence at least one year ahead of planting and seeding to reduce the weed seed bank.

4.3.3 Revegetation Site C2S

Site C2S occurs to the west of C2L (Appendix 3), and occurs on yellow sands of the eastern Swan Coastal Plain and lower Ridge Hill Shelf. The total area of the site is 5.07 ha, though it will be the gaps between canopy trees that will be revegetated, rather than the whole area. Canopy species dominate the vegetation, particularly Marri, with very little native understorey. Weeds in this zone make up almost the entire understorey, dominated by annual grasses and

Cape Weed. Many other weeds also occur in the area, including many woody weeds (Olive, Tagasaste and introduced wattles the most abundant).

Within C2S there are areas of already dense canopy cover. These areas will be controlled for weeds (shown as C2S-WC in Appendix 3) and not receive any revegetation treatments. The revegetation area which will receive seed and tubestock is approximately 2.84 ha, and is scheduled for revegetation in winter 2018. However, this is dependent on procurement of sufficient seed, and may be delayed until winter 2019.

Weed control will commence at least one year ahead of planting and seeding to reduce the weed soil seed bank. Revegetation works will occur as outlined in Section 3.2.

Figure 16 Revegetation Site C2S

4.3.4 Area C – Balance of Site (Remnant Vegetation)

Area C contains large amounts of native remnant vegetation. This plan allows for targeted weed control of priority and woody weeds within these areas only (see Table 1 for the weeds to be targeted). Appendix 4 shows the control techniques that will be used for weeds that are identified in the area.

Figure 17 Area C – Balance of Site (Remnant Vegetation)

4.4 Conservation Area D – Kadina Brook

Figure 18 Kadina Brook (showing up to 90% weed cover)

Kadina Brook runs in a roughly south – north orientation, splitting the site in half. Water flows on occasions during winter from south to north through the brook, flowing into the Helena River off-site. The vegetation in Kadina Brook is in a degraded condition throughout the southern half of its length, but condition is better in the northern half. Water quality and nearby groundwater quality are generally poor, particularly for the southern (upstream) portion, possibly owing to the use of the south-eastern portion of the site for disposal of livestock effluent under licence from 1970 to 1982 (JDA, 2015; 2016). There is an intact overstorey of *Eucalyptus rudis, Melaleuca rhaphiophylla*, *Corymbia calophylla* and occasional *Eucalyptus wandoo*, but the understorey is weedy and dominated by Watsonia and Narrow-Leaf Cotton Bush. Weed cover along the Kadina Brook, including the 50 m buffer, ranges from 10% to near 100%.

The Brook is a focal point for the development of the site, with walk trails along its entire length. Management of this area aims to reduce the weed cover throughout to assist natural regeneration of native plants, and to increase understorey density through the planting of tubestock in key areas. It is considered that in the timeframes available for management of this site, an improvement in stream condition can be achieved in key areas, and these have been identified for restoration work. Field inspection has identified that the upstream (southern) portion of the Brook is in a degraded condition compared with the downstream (northern) portion. Therefore, stream restoration will take place over broader areas in the southern portion, while restoration activities in the northern portion will be confined to smaller restoration sites for habitat improvement. Restoration of upstream components can also be critical to reduce degradation of downstream areas in the future.

The **objective for revegetation and weed management in Area D** is to re-establish plant species that are endemic, or likely to be endemic, to the local area in identified revegetation sites, and reduce weed populations throughout the brook, with particular focus on priority and woody weeds identified in Table 1 (see page 7).

The **completion targets for Area D** after five years of maintenance and as listed in Table 2 are:

1. Shrub / groundcover density in revegetation sites to be 1 plant / 2 m^2 or foliar cover to be ≥ 30%;
2. Minimum species richness in Area D to be 16.3 species (equivalent to 60% of the species richness for SCP FCT 11);
3. Minimum species richness measured within 100 m^2 quadrats (or equivalent) to be 8.2 species (equivalent to 30% of FCT value for SCP FCT 11);
4. Foliar cover of woody weeds to be 0%;
5. Maximum foliar cover of priority weeds from List 1 in Table 1 to be 0%;
6. Maximum foliar cover of priority weeds from List 2 to be as detailed in Table 1 (page 7); and
7. Overall stream condition index to be 'moderate' or better, based on methodology outlined in the River Restoration Manual (Water and Rivers Commission, 1999).

The general management approach for Conservation Area D is to:

- Control weed populations along the Brook and its buffer through the use of herbicide spot spraying and woody weed control; and
- Revegetate parts that are degraded and largely clear of native understorey. Fifteen sites have been identified for revegetation;
- Hand over management of Area D to DBCA six years after commencing revegetation works, as per the handover description in Section 3.5.

Fifteen revegetation sites have been identified along the length of the Kadina Brook where tubestock and direct seeding (in some areas) will be used to increase plant density. The revegetation sites identified at this planning stage range in size from 0.02 ha up to 7.25 ha, though the exact size and dimensions of these areas will also be determined by the final location and dimensions of the paths and trails to be installed adjacent to the revegetation sites (Appendix 3).

The general revegetation strategy outlined in Section 3.2 will apply to some of the sites, but as most sites are smaller than those for other Conservation Areas, and have some degree of canopy cover, the techniques will be slightly different. Also, given the number and complexity of the sites identified for revegetation, the exact methods used will vary for each, but may consist of the following schedule of works:

- Site Preparation (Year 1):
    - Control of woody weeds and management of recruitment as it occurs;
    - Weed control for grasses, geophytes and herbaceous weeds, including targeting Watsonia in early spring, on a yearly basis, as needed;
    - Ripping in areas where ground is compact (e.g. old tracks);
    - Fence to exclude kangaroos and people for some sites. The sites that will receive fencing will be determined using a cost benefit analysis of fence installation versus use of tree guards over the six year management timeframe;
- Initial Revegetation Works (Year 2):
    - Pre-planting weed control in early winter;
    - Direct seeding at 3 kg / ha (for sites where soil can be scarified and direct seeding identified as appropriate);

  - Tubestock installation, mainly using understorey shrubs and sedges if revegetation site includes the wetland zone of the Brook. Density of initial planting to be 0.5 plants / m^2;
  - Tree guards if fencing is impractical or site is very small;
- Maintenance (Years 2 – 6):
  - Five years of maintenance which includes weed control up to four times per year, infill planting of tubestock as required to maintain plant densities and species richness, and fence maintenance as required.

Note that most sites in Area D are scheduled for seeding and planting in winter 2018, but there are several that are likely to commence in winter 2019 after a second year of weed control to reduce competition. Sites that are scheduled for planting in 2019 are D1, D12, D13, D14 and D15. These are the sites with very high cover of Watsonia.

Bank stabilisation may be required at site D15. This may be in the form of rocks, jute mat, and / or coir logs to divert or reduce velocity of overland water flow.

5 ADVANCE PLANNING AND MANAGEMENT

5.1 Native Seed Collection

It is unlikely that a significant soil seed bank exists that will naturally contribute to plant establishment at any of the revegetation sites, given the long history of disturbance. Topsoil from good condition *Banksia* woodlands can deliver 80% of soil-stored species and 60% of total community species (Rokich et al, 2016). In the absence of a high-quality topsoil at Bushmead, it is necessary to collect seed for both direct seeding and propagating seedlings (tubestock) for revegetation works.

In advance of the revegetation works, a seed collection program commenced in the summer of 2014/15, and has continued in 2015/16 and 2016/17. Collections will continue for at least one further summer to increase seed quantities. Seed is being stored in a temperature and humidity controlled facility under conditions appropriate for medium term storage (10 years plus). All seed collection shall be undertaken by a company accredited for seed collection under the Revegetation Industry Association of Western Australia (RIAWA) accreditation program.

Past clearing practices, historical use of the site for grazing, and current impact of kangaroos has resulted in the understorey vegetation being relatively sparse. This does affect the quantity and diversity of recoverable seed of understorey species, which are the main target for revegetation activities at the site. Shortfalls in seed recovered from site will be made up for with commercial stocks from the next closest available provenance sources.

5.2 Dieback Management

The confirmed occurrence of dieback on site (Glevan Consulting, 2016) means that all revegetation and weed management activities require dieback management protocols. Recommendations from the Glevan Consulting (2016) report have been incorporated into the Construction Management Plan (Strategen 2017), and must be adhered to. The following will be implemented to reduce the chance of dieback being spread around the site:

- Prior to entering the site:
  - Ensure all vehicles and machinery, including planting tubes, are free of mud / soil / vegetation[1] when arriving and leaving the site;
  - Obtain up-to-date maps of dieback infested areas and dieback wash down points.
- While working on the site:
  - Any mud or dirt adhering to vehicles, tools or personnel will be brushed off at the site where it was gathered, before moving between areas within Bushmead. Wherever practical, works will commence in uninfested areas first, before moving to infested areas on the same day;
  - Ensure all vehicles, machinery and shoes are free of mud / soil / vegetation when entering any dieback uninfested areas within the conservation area;

[1] This does not apply to tubestock; however, tubestock must be free of disease and be sourced from nurseries that have Nursery Industry Accreditation

- Maintain a hygiene register, including records of daily inspections to document the hygiene measures undertaken;
- Ensure any mulch used on site is dieback-free.

Revegetation and weed management contractors must be provided a copy of updated dieback occurrence assessments as soon as they are produced.

6 IMPLEMENTATION METHODOLOGY

6.1 Scheduling

Site preparation works for revegetation at Bushmead is scheduled to commence in spring / summer of 2017.

An indicative schedule of works to be completed is provided in Appendix 8. This schedule will guide the revegetation program, but activities such as weed control will occur at times which are most suitable for the target species.

Most revegetation sites are scheduled to receive a year of weed control prior to revegetation works commencing. There are some sites which will receive two years of weed control prior to planting and seeding. The details for which sites receive the later planting are described in Section 4, and are shown in Appendix 8.

6.2 Weed Management

Weed management on the site is complex given the large area covered by the site, the range of topography and soil types, diversity of weeds, and previous land use history that first introduced and then exacerbated the weed issues.

6.2.1 Weed Survey

Weeds were surveyed across the site in October 2015 following the DBCA Standard Operating Procedure to identify and map the most serious or invasive weeds (DEC, 2011). A list of weeds observed on site is provided in Appendix 4. Of these, the woody and priority weeds listed in Table 1 were mapped individually to provide a baseline for weed cover prior to the project commencing.

Cover classifications were used that provided a finer detail than the SOP, so that improvements to the weed cover could be monitored once management of the weeds begins. The following cover classes were used:

- ≤ 5%;
- 5 – 10%;
- 11 – 20%;
- 21 – 50%;
- 51 – 80%; and
- > 80%.

Appendix 5 shows the results of the survey across the site.

6.2.2 Site-Wide Objective

The aim of weed management at Bushmead is to reduce weed density across the site so that intact vegetation communities may self-regenerate and degraded sites can be revegetated using the strategies outlined in this plan.

The priority and woody weeds listed in Table 1 will be targeted for control across the whole conservation area. Completion targets for weed cover are presented in Section 3.4.

6.2.3 Herbicides

Where there are several options for control, the method and / or herbicide selected will be that most appropriate for the target species and to reduce the chances of undesirable impacts to the environment. For example, Round-up Biactive (or similar) will be used instead of regular glyphosate within close proximity of open water bodies, as it has a lesser effect on aquatic fauna.

The broad spectrum herbicide glyphosate will be used for most spot spraying weed control, while metsulfuron methyl and / or 2,2-DPA may be used for control of some geophytes. A grass selective herbicide, such as fluazifop-p, may be used for controlling grassy weeds in intact bushland, such as TEC 20a.

Woody weeds will be targeted using glyphosate or triclopyr, as appropriate for the size of the plant and species to be targeted.

A summary table has been provided in Appendix 4 which lists weed species observed on site and recommended methods and timing of control. Given the size of the site and number and diversity of weeds to be controlled, the choice of herbicide will be partly based on it being effective against a range of species so that many plants can be targeted during a single visit to an area.

6.2.4 Woody Weed Control

Woody weed control will initially concentrate on killing existing mature shrubs that occur in the revegetation sites, and for the populations identified in the TECs and mapped in Appendix 5. On-going spot spraying of any germinating or re-sprouting weeds will be required during the following years of vegetation management.

Woody weeds will either be removed from site or killed and left *in situ* depending on the time of year and whether plants are holding seed. Those holding seed will be removed from site.

6.3 Surface Preparation

For the revegetation program to have the greatest likelihood of success, the soil surface must be adequately prepared to promote natural recruitment, and also ensure that seedling survival and development rates are maximised. Scalping may be undertaken in some areas that are devoid of native vegetation and are likely to have a significant weed seed load in the topsoil. Ripping will be undertaken in all appropriate areas to maximise water infiltration and alleviate compaction issues created by repeated vehicle access, past stock movement, or decommissioning of tracks.

6.3.1 Scalping

Scalping involves complete removal of the surface soil to a depth of approximately 5 – 10 cm from a revegetation site. This technique results in instantaneous removal of weed biomass and any weed seeds that exist in the surface layer of topsoil, and can be an effective method of weed control where a significant weed seed load occurs on site (Rokich and Newton, 2016). Scalping is usually done using a front-end loader or grader, depending on the size of the revegetation site.

Material removed from revegetation areas is either taken off site and disposed of, buried on site to a depth where weed seeds are unlikely to germinate, or mounded into windrows on the revegetation site. The windrows are then intensively sprayed to manage the emerging weeds. For Bushmead, there may be scope to move the scalped material into the development area to either use as fill, or for it to be removed by the civil contractors.

6.3.2 Ripping

Ripping the ground is done by using tines attached to a tractor or other larger earthmoving equipment. The purpose of ripping is to fracture the earth to a depth of approximately 0.5 m. It is used when the ground is considered to be compacted which may impede plant root development, and also creates microhabitats for seedling establishment (Rokich, 2016).

Ripping is undertaken in late summer or early autumn for sites with heavier soils, or late autumn / early winter for sandy soils. Ripping for heavier soils should occur when they are dry so that the profile is 'fractured', whereas sandy soils should be slightly damp before ripping otherwise the ripping action is largely ineffective.

For revegetation sites that have slopes, ripping is conducted along the contour so that any water movement down slope is slowed and doesn't lead to channelling and subsequent soil erosion. This applies to any ripping done in revegetation site C2L. Where slopes do not occur on the site, ripping should be undertaken in a random, curved pattern if possible, rather than straight lines as are used in forestry planting. This curved pattern should result in a more naturalistic pattern of plant establishment. However, in sandy sites, planting should be possible into areas between the rip lines, so the ripping acts to break up subsoil compaction and shouldn't be used to determine where the plants are being placed. Ripping provides a soil surface that is easier to plant for harder soils such as gravels and laterite.

6.3.3 Scarification

Scarification is the act of 'roughening' the soil surface prior to broadcasting seed to create microhabitat on the soil surface that provides a niche for the seed to settle and germinate. Scarification is usually done using a tractor-mounted spring-loaded scarifier or harrows to create small scratches on the soil surface. Scarification will be undertaken immediately prior to direct seeding (usually the same day), as wind and rain very quickly flatten the scratches on the soil surface.

Where a site has been ripped, or lightly mulched with the mulch incorporated into the soil, this is sometimes sufficient as a seed bed for direct seeding. As many of the sites at Bushmead will be ripped prior to any revegetation works, they will be assessed for the need to scarify prior to direct seeding. Particularly for sandy sites, the rip lines can weather in the months between ripping and direct seeding, and may therefore not be suitable as a seed bed. Rip lines in gravelly soils tend to maintain their attributes for longer and may still be a suitable seed bed some months after ripping.

6.4 Mulch

The use of mulch has been recommended for sites B5 and C1 which are in highly visible locations near the main entrance to the southern development cell. Mulch has also been recommended for site A2b, to be incorporated into the soil.

Use of mulch must be from certified dieback-free suppliers, or by using mulch from the site sourced from areas that have been identified as dieback-free. Where neither option is considered practical, revegetation works will have to take place without the use of mulch.

The depth of mulch will be approximately 75 mm for sites B5 and C1 and 50 mm for site A2b. The depth of spreading is less at A2b because it is designed to add some organic matter to the soil, rather than provide a barrier on the surface.

The mulch used will be coarse mulch that allows rainfall to flow through to the soil but reduces water loss from the soil through evaporation.

6.5 Installation of Logs

Hollow (if readily available) and solid logs of various thicknesses will be installed onto revegetation sites in Areas A, B and C to provide habitat for fauna. The Kadina Brook (Area D) already has logs in many areas, and being able to access the brook with machinery to place more logs would be impractical and destructive to native vegetation. Logs will be sourced from on-site, such as from areas cleared for the development, where possible. Logs for placement in dieback-free areas will also need to be sourced from dieback-free areas. Where this cannot be guaranteed, log placement will be removed from the scope of works to avoid translocation of the pathogen.

6.6 Species Selection

All species have been selected based on observations made during the detailed site inspections, and from investigations of species lists provided in consultants reports for the Bushmead site (Bennett Environmental Consulting 2006; Environmental Resources Management Australia 2006; Markey 1997; Ecologia Environmental Consultants 1991; Keighery and Trudgen 1992; Dames and Moore 1989). For revegetation sites close to FCT 20a and 20c, reference has been made to Gibson et al (1994) for typical and common species. For sites in Conservation Area C, reference

has been made to Markey (1997). This has been necessary because the understorey across the site is sparse, and therefore the diversity of species on the site is low.

Appendix 6 contains a list of species that either occur on site, have been observed on site through flora surveys, or are provided in the lists of common species for the FCTs that occur on site. This list will be used to compile the seed mixes and tubestock lists for planting in each of the Conservation Areas, should they be available either as seed or tubestock. Prior to commencing revegetation works on a particular site, the species mix will be devised based on this list. Permission will be sought from DBCA for any additional species not listed in Appendix 6 that the revegetation contractor wishes to include. The exception to this is where seed is collected from a native species that occurs on site but is not listed in Appendix 6, it will automatically be included in the approved species list for the revegetation sites that are most edaphically appropriate.

The occurrence of dieback on site (Glevan Consulting, 2016) affects the selection of species for particular revegetation sites. Where dieback occurs or is likely to occur, the use of susceptible species, such as those in the Proteaceae family, may be limited or omitted completely. This may impact on the ability to meet completion targets for trees (of which *Banksia* species would make up a high proportion). The strategy for species selection on these sites will be agreed in consultation with DBCA.

6.7 Seedling Propagation

Where possible, seedlings will be propagated from seed collected on site, which is currently being held by Tranen in a seed bank. There may be some species that will need to be sourced from nursery stock, seeds of which have not been collected on site, or which are normally propagated from cuttings. Tissue culture and / or division may also be required for some species. Preferentially, the material for tissue culture or plant divisions will be sourced from the Bushmead site. The provenance of any species purchased from nursery stock will be from as close as possible to the local area.

Seedlings will be propagated either in forestry tubes (50 mm x 50 mm x 125 mm) or deep cells (34 mm x 34 mm x 90 mm) where possible. These air-pruning root-training pots produce seedlings of good root ball size and transfer well from pot to final environment, maximising survival rates.

Plant orders will be ideally placed in spring the year before planting to ensure sufficient seedlings are available (subject to seed availability and species propagation timing). Seedlings will be grown by nurseries that are accredited by the Nursery Industry Accreditation Scheme of Australia (NIASA) which will guarantee the quality of supplied material. Seedlings will be supplied true to industry standards:

- Soil in containers at the time of delivery will be free of weeds, insects and disease;
- All plants will be true to species name, well-formed and hardened off nursery stock;
- The root system will be fibrous and firmly established but not root bound and with no large roots growing out of the container; and
- Leaves to be of normal size, colour and texture for the specified species.

6.8 Seedling Planting

Planting of seedlings will commence after the season's first major rains occur (typically May / June) when the soil is sufficiently wet to plant without the need for additional watering. All planting work should be completed by the end of winter, with June and July being most ideal (depending on weather patterns) to take maximum advantage of the seasonal rainfall. Allowance must be made for infill planting during the maintenance period to account for losses that occur over summer.

6.9 Direct Seeding

Seed for direct seeding will be obtained from the Bushmead seedbank. If it is identified that shortfalls exist in the quantity and / or diversity of seed, it may be necessary to purchase other locally collected seed. Before broadcasting, seeds will be pre-treated to break dormancy using appropriate methods for those species that require it. This will include aerosol smoke treatment, mechanical scarification, and hot water treatment as appropriate to individual species.

Seed will be applied at a rate of 3 kg/ha after the site has been scarified. Seed will be combined with a bulking agent to ensure even distribution across the site. Seed will be broadcast by hand, as this technique will ensure even dispersal of all seed sizes, which can be an issue with some types of mechanical spreaders. Clean yellow sand provides good mixing and distribution properties for this purpose.

Seed broadcasting will commence as soon as possible after surface preparation activities and subsequent weed control have been completed. The seed does not need to be covered with soil after broadcasting, as soil settlement by rainfall will facilitate this.

6.10 Plant Protection – Fences and Tree Guards

During the site inspection it was noted that kangaroos are significantly impacting on plant health. It will therefore be imperative to protect plants from grazers. Rabbits are also very likely to occur on the site.

Two methods for plant protection will be employed at Bushmead. Fencing is the most effective at preventing herbivory, and is also the most cost effective control method for a site of this size. However, where fencing is impractical because of pathways, roads or other infrastructure, plants will be protected by using rigid tree guards. The decision on which method to use for a given site will depend on the potential for the fence to be compromised, and will be discussed with the client during the planning phase for the given site.

6.10.1 Fence Specifications

A fence will be erected around each of the revegetation sites where it is practical to do so. This should apply to all revegetation sites except a number of sites in Kadina Brook, and for B5 and C1 where it is anticipated the construction of walk trails will make fencing unattractive and impractical. The fence must be installed prior to any direct seeding or tubestock planting.

Fences will be 1.8 m tall and made of either chainmesh or ringlock, supported by solid steel posts for corners and star pickets along each edge. A rabbit-proof skirting will be installed along the bottom of the fence using 30 mm rabbit netting which extends a minimum of 90 cm above the ground and is buried to a depth of 30 cm below ground where practical. In Conservation Area C, burying the rabbit skirt may be impractical due to the hard soil; in this case the skirt will be bent into an L shape and the horizontal part secured to the ground using short star pickets and/or rocks.

Depending on the size of the revegetation site, at least one access gate (with rabbit skirt) large enough to allow a vehicle to enter for weed control will be installed. In most cases, at least two gates will be installed.

No allowance for fence removal has been made under this plan. It is anticipated that the installation of gates on the fence will allow for future access by kangaroos and other wildlife, at a time when DBCA consider the revegetated sites to be resilient to grazing.

6.10.2 Tree Guard Specifications

Tree guards will be constructed of corflute and be installed using a single hardwood stake driven into the ground (a second hardwood or bamboo stake may be used in highly exposed areas where the guards can blow around and rotate around a single stake). Corflute provides a rigid guard that kangaroos cannot push down to eat the plant, though they can still access any leaves growing out of the top of the guard. Tree guards are typically left on the plant until the end of the first summer after planting. However, because of the strong presence of kangaroos on site, guards may be retained longer than this.

7 MONITORING, MAINTENANCE AND CONTINGENCIES

To ensure the project is a success in the longer term, each revegetation / management site will be monitored throughout the works program to ensure the completion targets are met. At the end of the maintenance period, assuming all targets have been achieved, the sites will be handed over to DBCA for ongoing maintenance.

7.1 Monitoring

Monitoring at Bushmead will include formal monitoring for data collection at each revegetation site to determine success of establishment against the completion criteria, weed monitoring across the site to determine effectiveness of weed management, and informal monitoring (observations only). The description for monitoring has been divided into three headings below:

- Revegetation monitoring for Conservation Areas A, B and C;
- Restoration monitoring for the Kadina Brook (Conservation Area D); and
- Weed monitoring across the whole conservation reserve.

Where monitoring plots are established for formal monitoring, their location will be permanently marked with galvanised fence droppers and their location recorded with a GPS. The placement of plots will be as per a stratified random sampling design, where plots are located randomly but differences in topography, soils and other edaphic factors taken into consideration to sample the variation across revegetation sites sufficiently and to ensure that the plots adequately represent the vegetation and weed cover within the revegetation area.

Informal monitoring will also be undertaken at various times throughout the revegetation program. The purpose of informal monitoring is to visually monitor progress, and to identify and counter potential issues such as weed growth before they have a chance to develop.

Monitoring is preferably undertaken against reference sites of the same vegetation type in a normal healthy state (Miller et al. 2016; EPA 2006). Unfortunately for Bushmead, the vegetation types represented on site have a long history of disturbance and are unlikely to be a true reference site for the purposes of establishing a goal for the revegetation works.

7.1.1 Revegetation Monitoring (Areas A, B and C)

The progress of each revegetation site will be formally monitored twice per year to ensure progress towards completion targets. Formal monitoring will take place in autumn and spring of each year. The purpose of the formal monitoring is to assess the progress of the revegetation against the completion criteria, and then initiate remedial action if required. The autumn monitoring will assess plant survival over summer to assist with planning for upcoming revegetation works in winter. Both the autumn and spring monitoring results will be presented in a single formal monitoring report to be provided after the spring assessment.

Where practical, monitoring plots will be established prior to any planting works being undertaken. Formal monitoring will continue until the site is handed over to DBCA.

The results of each formal monitoring assessment will be compared against previous data and the completion targets to determine growth and mortality rates, and provide a quantitative measure of progress.

Monitoring will involve different sampling areas for different measures related to the completion targets, established in a nested design where the dimensions of the revegetation site allow it (see Table 3 for details and Figure 19 for nested design):

- Tree density will be sampled using 400 m^2 plots;
- Shrub and groundcover density will be measured using four 25 m^2 plots (100 m^2 in total); and
- Species richness (trees, shrubs, groundcovers) will be measured across the whole revegetation site.

To provide an indication of seedling germination from broadcast seed and / or the soil seed bank, quadrats measuring 2 m x 1 m will also be established. Plots used to score new germinants may only be required in the first year or two following revegetation activities, as a means to count the numerous seedlings that may emerge following direct seeding. It is anticipated that the number of germinants observed will reduce as time progresses, and shrub / understorey density will be assessed adequately in the 25 m^2 plots.

The data that will be collected and methods for collection during formal monitoring are presented in Table 3 below.

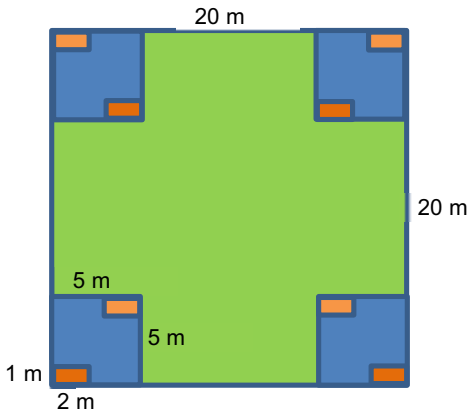

Figure 19 Nested Design of Monitoring Quadrats
Green + Blue + Orange = trees
Blue + Orange = shrubs / groundcovers (tubestock or plants > 1 yr old)
Orange = new seedlings from germination

Table 3 Data Collection for Formal Monitoring of Revegetation Sites

Completion Target / Data Collected	Plot Used	Method	Target at Plot Scale	Minimum No. Quadrats per Revegetation Site	Timing and Duration
Shrub / groundcover density in revegetation sites Areas A, B, C: 1 plant / m^2 or Foliar cover ≥ 50%; Area D: 1 plant / 2 m^2 or Foliar cover ≥ 30%	25 m^2 plots	• All shrub and groundcover plants counted (new tubestock or plants > 1 year old); • Foliar cover of shrubs / groundcovers estimated (% of plot covered by live foliage); • Calculate average density and foliar cover per site.	Data combined from 25 m^2 and 2 m^2 plots for plant density. Minimum 25 plants to be observed, or foliar cover to be ≥ 50% for Areas A, B and C. Minimum 12.5 plants to be observed, or foliar cover to be ≥ 30% for Area D.	4	**Spring** (Sept – Nov) and **Autumn** (Mar – May) For five years. (Report provided after Spring monitoring)
	2 m^2 (two per 25 m^2 plot)	• All shrub and groundcover seedlings counted (new germinants only, not tubestock); • Calculate average number of germinants per m^2.		8	
Tree density in revegetation sites 300 stems / ha	400 m^2	• All trees counted (includes mature trees and seedlings / tubestock); • Calculate average tree density per ha. • Each tree species to be counted separately.	Minimum 12 tree stems in a 400 m^2 plot for total trees. Individual tree species density as listed in Table 2	1	
Minimum species richness 60% of FCT equivalents	Conservation Area	• List all species observed within each 25 m^2 plot area; • Count combined species list for all 25 m^2 plots and from observations of remainder of sites within an Area.	60% of species richness from Gibson et al. (1994) or Markey (1997) FCTs as quantified in Table 2 .	n/a	
Minimum species richness 30% of FCT equivalents	Four x 25 m^2 plots (100 m^2 in total)	• Combine presence / absence data for all species observed in four 25 m^2 plots.	30% of species richness from Gibson et al. (1994) or Markey (1997) FCTs as quantified in Table 2 .	1 FCT equivalent (100 m^2)	
Foliar cover of woody weeds 0%	Whole site	Inspection across revegetation site for presence of woody weeds	0% cover	n/a	
Maximum foliar cover of priority weeds from List 1[1] 0%	Whole site	Inspection across revegetation site for presence of List 1 weeds	0% cover	n/a	

Completion Target / Data Collected	Plot Used	Method	Target at Plot Scale	Minimum No. Quadrats per Revegetation Site	Timing and Duration
Maximum foliar cover of priority weeds from List 2[1] 10% or 5% (depends on species)	400 m^2	• Estimate foliar cover of List 2 weeds in plot; • Calculate averaged cover across all plots in a site.	≤ 10% cover or ≤ 5% cover (see Table 1 for cover targets for individual species)	1	

[1] Refer to Table 1 for List 1 and List 2 Priority weeds

7.1.2 Kadina Brook Restoration Monitoring (Area D)

Monitoring of Kadina Brook will be conducted using two methods:

1. Monitoring of revegetation sites against the completion targets for plant densities and weed cover (see Table 2 on page 12 for targets); and
2. Monitoring of the Brook as a whole using the foreshore condition assessment survey method produced by the Water and Rivers Commission (1999).

Monitoring of Kadina Brook revegetation sites will follow a similar method to that for revegetation sites in Areas A, B and C. Thus, most parameters and methods shown in Table 3 will apply to Kadina Brook, except the requirement to monitor trees in 400 m^2 plots. The requirement for a minimum of four 25 m^2 quadrats applies for density counts. Species richness should be measured over the whole revegetation site, as shown in Table 3 above. Foliar cover of priority weeds from List 2 can be measured in a 400 m^2 area if the site is big enough – though many sites can be assessed as whole for this parameter.

Monitoring of the Brook as a whole using the foreshore condition assessment survey is designed to assess improvements in the condition of the brook over the period of stream restoration works. The survey assesses four components of foreshore condition: (1) bank stability; (2) foreshore vegetation; (3) stream cover; and (4) habitat diversity, which are combined into an overall stream condition index (Water and Rivers Commission, 1999). The assessments will be undertaken at the following times:

- Spring 2017, prior to stream restoration commencing (baseline condition);
- Spring 2020, three years after commencing works (half-way point); and
- Spring 2023 at the completion of the project.

Methods and monitoring forms used for the assessments can be found in the River Restoration Manual under the chapter for *Foreshore condition assessment in urban and semi-rural areas of south-west Western Australia* (Water and Rivers Commission, 1999).

7.1.3 Weed Monitoring (Whole Site)

A comprehensive weed survey across the Bushmead Conservation Areas will be formally undertaken every three years during late winter or early spring. The observations will be compared against the baseline monitoring data which is

presented in Appendix 5. The final dataset for weed monitoring in the Conservation Area for Bushmead will therefore be:

1. Baseline weed cover (as presented in Appendix 5 of this plan);
2. Weed cover three years after commencement of weed control (spring 2020); and
3. Weed cover six years after commencement of weed control (spring 2023), at the completion of the revegetation and weed management works.

Monitoring methods will follow the DBCA Standard Operating Procedure 22.1 (DEC 2011), modified slightly to incorporate more classifications of weed cover, as described below.

Weed foliar cover is to be estimated as one of the following classifications:

- < 5 %;
- 5 – 10%;
- 11 – 20%;
- 21 – 50%;
- 51 – 80%;
- > 80%.

Weed mapping will be completed for the priority and woody weeds listed in Table 1 and in a general sense for groups of weeds as below:

- Grass and herbaceous weeds;
- Geophyte weeds; and
- Woody weeds.

This weed survey technique provides information for progress of weed control to meet completion targets for priority and woody weeds, and to determine changes for general weed groups.

Weed monitoring in revegetation sites will occur during the autumn and spring monitoring events, specifically to assist with maintaining weed populations to enhance likelihood of revegetation success.

7.1.4 Data Analysis

Monitoring data will be analysed to compare data with:

- Completion targets (to assess how the site is tracking); and
- Previous monitoring data (to identify changes/ trajectories).

As there are no suitable reference sites with which to compare data, analysis is a relatively simple comparison of average monitoring parameters against the defined completion target. Data will either be 'meeting' or 'not meeting' the target for the given parameter.

As more monitoring data is collected, a time series can be plotted to show the changes in given parameters. These will help in determining the likelihood of meeting the completion targets (e.g. if time series data indicate a trend of a given parameter increasing or decreasing), and assist with revising completion targets if necessary (see Section 7.3).

7.2 Site Maintenance Activities

Maintenance of the revegetation sites will continue after the initial seedling planting and direct seeding program with all activities to be conducted in response to the formal monitoring. Maintenance of the remaining Conservation Areas (bushland) is tied to the commencement of revegetation works, and will commence at the same time as site preparation works commence for revegetation areas, and continue until the completion of revegetation works. Likely commencement date is spring 2017, and completion in spring 2023. Maintenance of the revegetation sites includes:

- Weed control;
- Infill planting of tubestock;
- Tree guard removal; and
- Fence maintenance.

Maintenance in the bushland areas is limited to weed control. Activities such as rubbish removal have not been included in this plan, and are referred to in the Conservation Management Plan (RPS 2016).

A schedule of maintenance activities for the project is presented in Appendix 8. Fence maintenance and repair has not been included in this schedule, as it will be done as required. Fence maintenance can be undertaken at any time of the year, provided access to the site is not flooded or impeded by construction activities associated with the development.

It is anticipated that weed control will be required up to four times per year for most revegetation sites and bushland areas (spring, summer, autumn and winter). The extent of the control requirements (i.e. target species, area affected, etc.) will be determined through the monitoring program.

Infill planting will be carried out throughout the five year maintenance period as required for each revegetation site. The quantities required for infill planting will be calculated through monitoring each year to ensure the site remains on track to meet completion targets. Infill planting numbers will be determined by comparing actual plant densities to the required plant densities, and installing the necessary number of plants to maximise the likelihood of meeting the completion targets in the longer term. Similarly, if species richness is not meeting completion targets, infill planting will concentrate on increasing species richness.

Where tree guards are used, maintenance is essential to ensure the guards do not collapse and become wind-borne rubbish, maintain an effective protection for the seedlings, and do not impede plant development. Tree guards will be maintained regularly until their removal, generally either the end of the first summer, or until the plant growth becomes restricted by the guard, whichever is sooner. All guard materials no longer required will be removed from site and recycled / disposed of appropriately.

Fences and gates may also need maintenance from time to time. This will occur on an as-needs basis.

7.3 Contingency Actions

The following contingency actions have been incorporated in the event that revegetation works are not tracking towards the completion targets within the specified timeframes:

- Annual meetings with DBCA staff to inspect the revegetation works. The purpose of these meetings is to allow DBCA to inspect progress and for the revegetation contractor to highlight problems or issues that are occurring on site.
- At these meetings, the revegetation contractor can discuss with DBCA any alterations to the implementation of this revegetation plan which may result in better outcomes.
- Alterations may include:
    - Changes to species lists;
    - Altered weed control scheduling;
    - Altered herbicides or weed management techniques; and / or
    - Pest management.
- At site meetings, or subsequent meetings, alterations to the completion targets may also be discussed and agreed upon. The revegetation contractor must provide evidence that the completion targets are unlikely to be met, despite their best efforts to do so, for changes to be considered by DBCA.
- Any changes to completion targets agreed to by DBCA will then become the targets for the revegetation works, and upon meeting them within the specified timeframe, the site will be handed over to DBCA.

7.4 Reporting

Reports must be provided by the revegetation contractor to the developer following each monitoring event, and following all activities (including maintenance). The developer must provide a copy of the annual monitoring reports, weed monitoring reports and foreshore condition assessments to the DBCA and other identified stakeholders, along with any shapefiles and monitoring data provided from the revegetation contractor in spreadsheet format.

Reports for formal monitoring of revegetation sites must be provided once per year and include:

- Previous works summary, for example:
    - Number of seedlings installed;
    - Details on direct seeding undertaken;
    - Weed control events undertaken; and
    - Other works.
- Current status of the site against completion targets;
- Summary of data tables or graphs;
- Photographs from fixed monitoring points;
- Recommendations for maintenance work required over next 12 months.

Reports for monitoring weeds in bushland areas shall be provided at three year intervals after weed control works commence. Reports will include:

- Weed control history across the site;
- Current status of the site against completion targets for weed cover;
- Photographs from fixed monitoring points;
- Recommendations for maintenance work required over next three years.

Reports for foreshore condition assessments of Kadina Brook are to be provided to the developer:

- For a baseline condition assessment of the whole brook (prior to works commencing) – approximately September 2017;
- Three years after work commences – approximately September 2020; and
- Six years after work commences (final report) – approximately September 2023.

Maintenance reports are to be provided by the revegetation contractor to the developer as maintenance items are completed. Reports for maintenance activities should be limited to a summary of what was done, where it was done, and details of quantities or items related to the activity. For example, tubestock installation should include a species list and quantities, site preparation undertaken (e.g. ripping), and reference to the revegetation site that was planted.

8 ACKNOWLEDGEMENTS

In compiling this report, Tranen acknowledges the following for input during the process:

- The DBCA Banksia Woodland Restoration Project Team, particularly Vanda Longman, for compiling species lists from survey reports and discussing species lists, and for comments on previous versions of this plan.
- The DBCA Perth Hills District and Swan Regional staff for input on previous versions of the plan.

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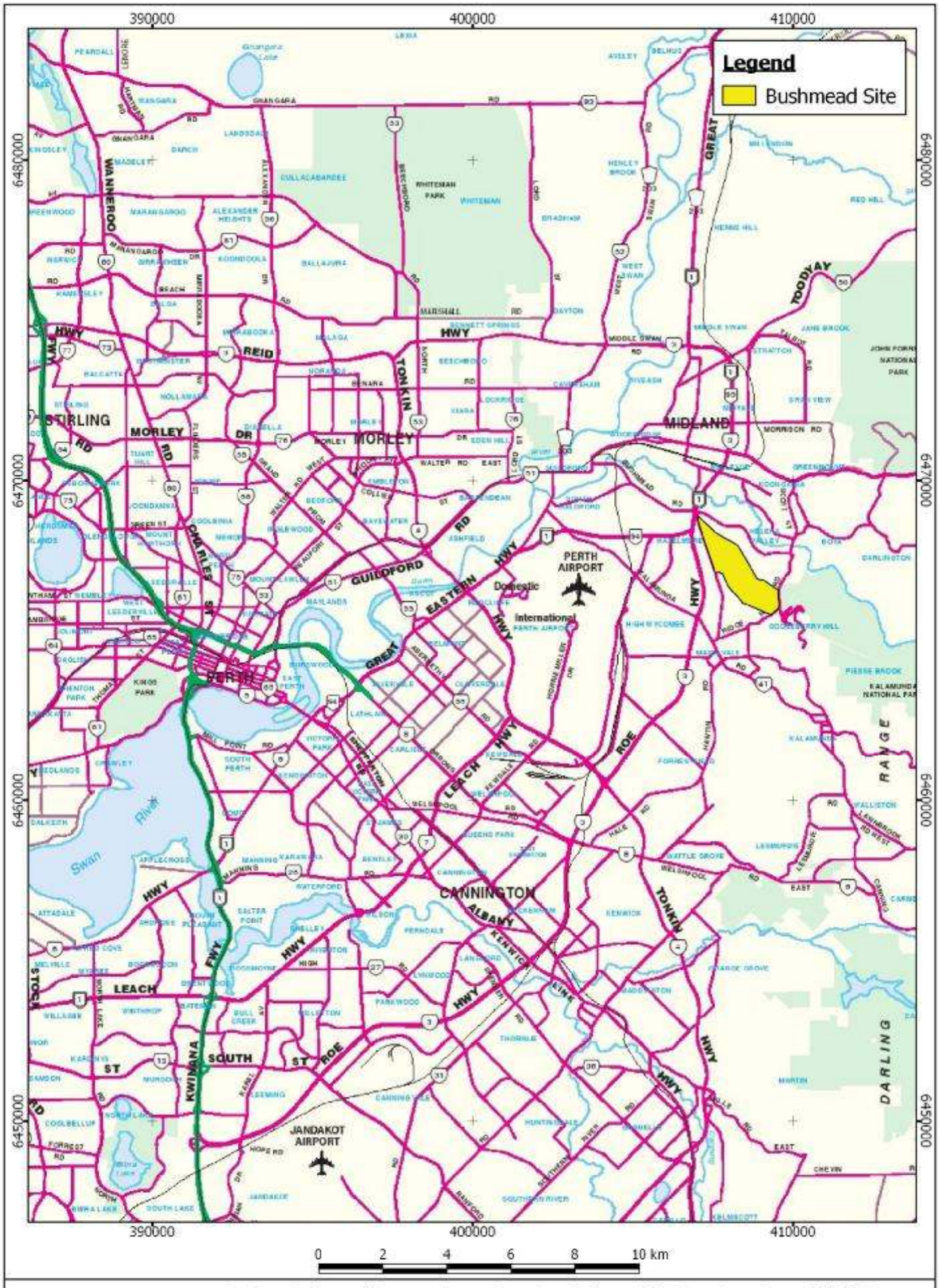
Appendix 1 Site Location



tranen revegetation systems

Project: Bushmead Revegetation
Project Number: P648B
Client: Cedar Woods

Drawing: Bushmead Site Location
Drawing Number: P648B-01
Revision: 0

Date: 22/12/15
Drawn By: RSW

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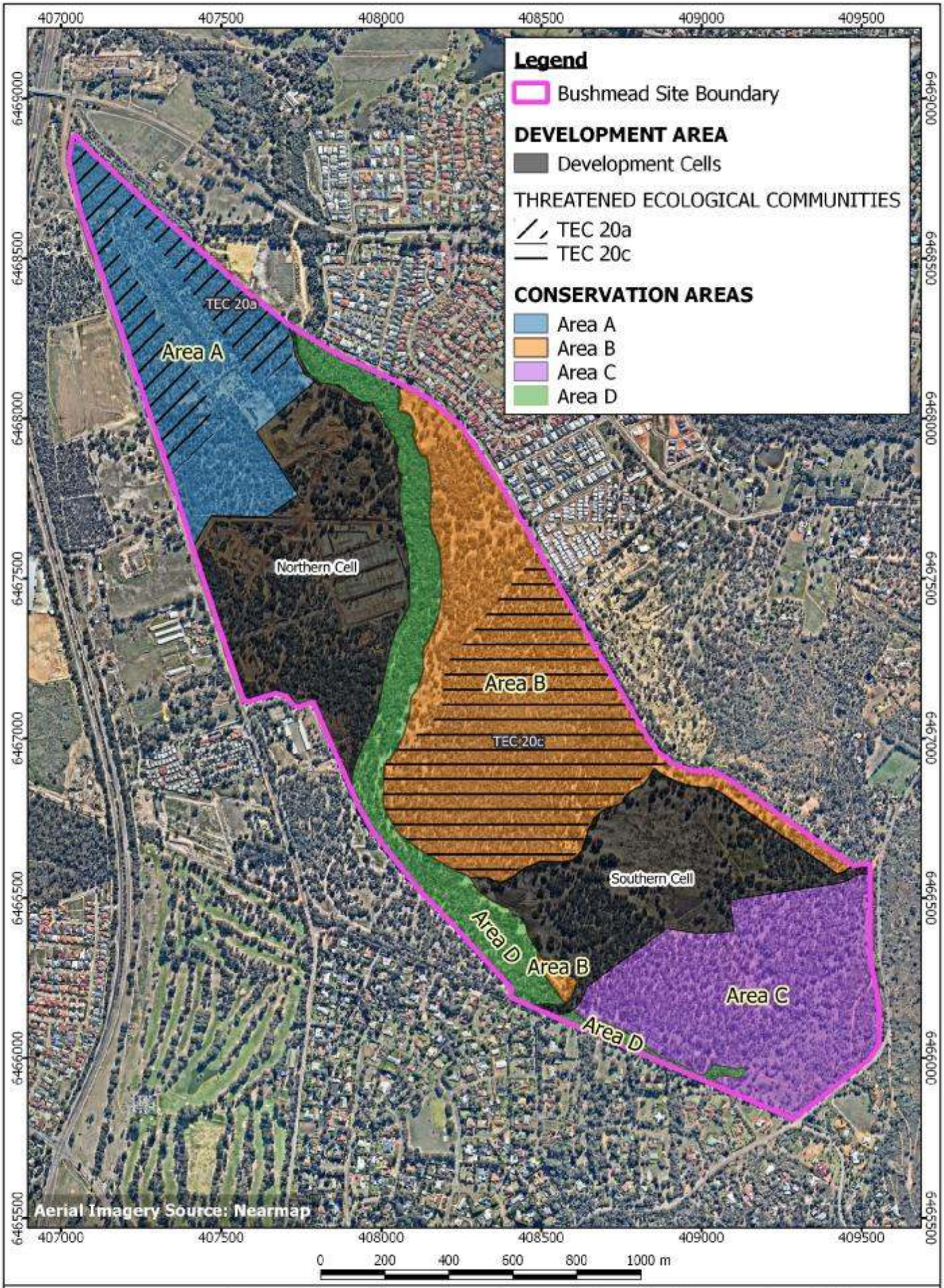
Appendix 2 Bushmead Conservation Areas and Threatened Ecological Communities



tranen revegetation systems

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Project Number: P648
Client: Cedar Woods

Drawing: Bushmead TECs & Conservation Areas
Drawing Number: P648B-02
Revision: 2

Date: 03/08/17
Drawn By: RSW

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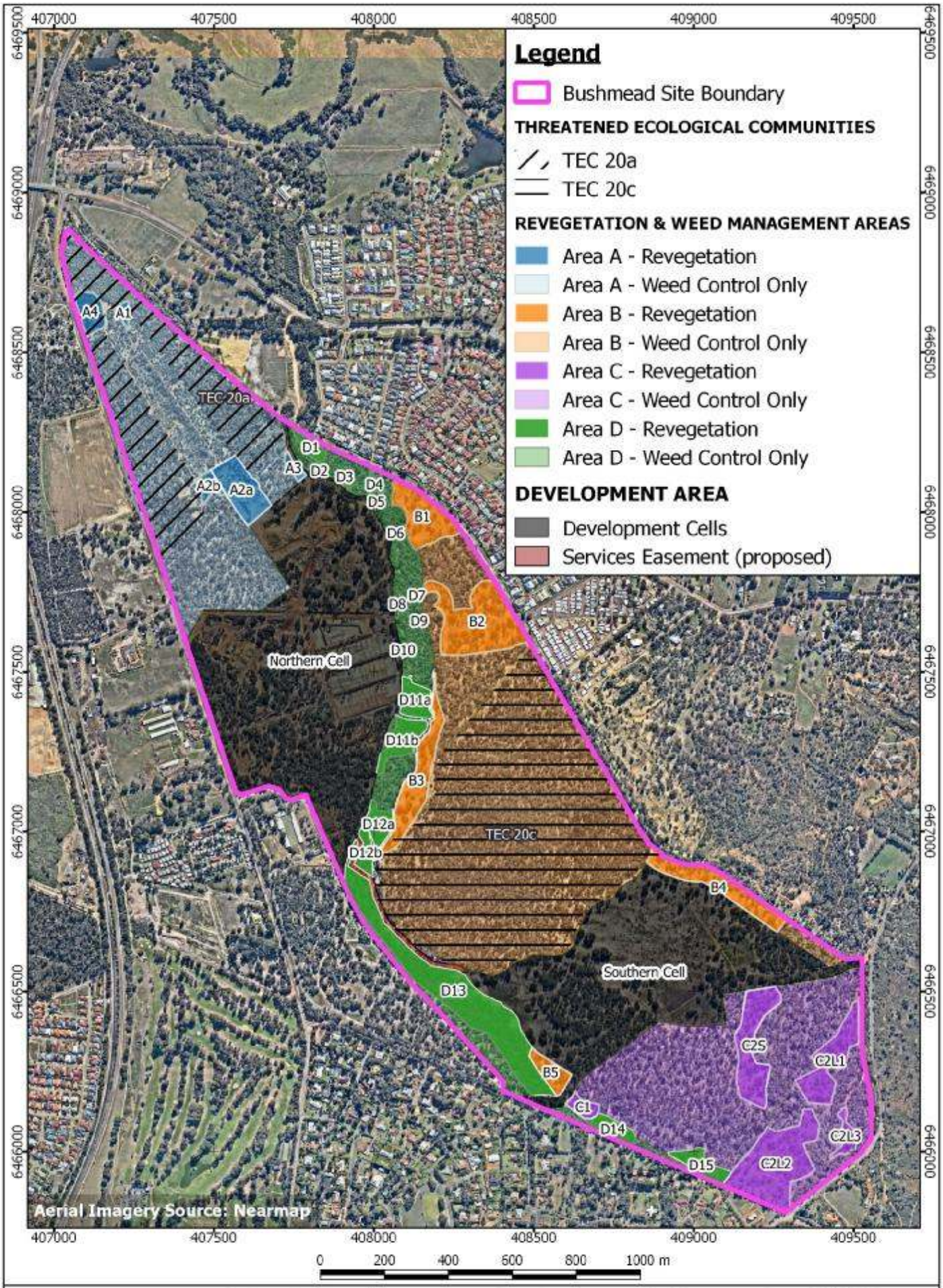
Appendix 3 Revegetation Sites



tranen revegetation systems

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Project Number: P648
Client: Cedar Woods

Drawing: Revegetation Sites
Drawing Number: P648B-03 (p1)
Revision: 2

Date: 03/08/17
Drawn By: RSW

tranen revegetation systems

Project: Bushmead Revegetation
Project Number: P648
Client: Cedar Woods

Drawing: Revegetation Sites
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Date: 02/08/17
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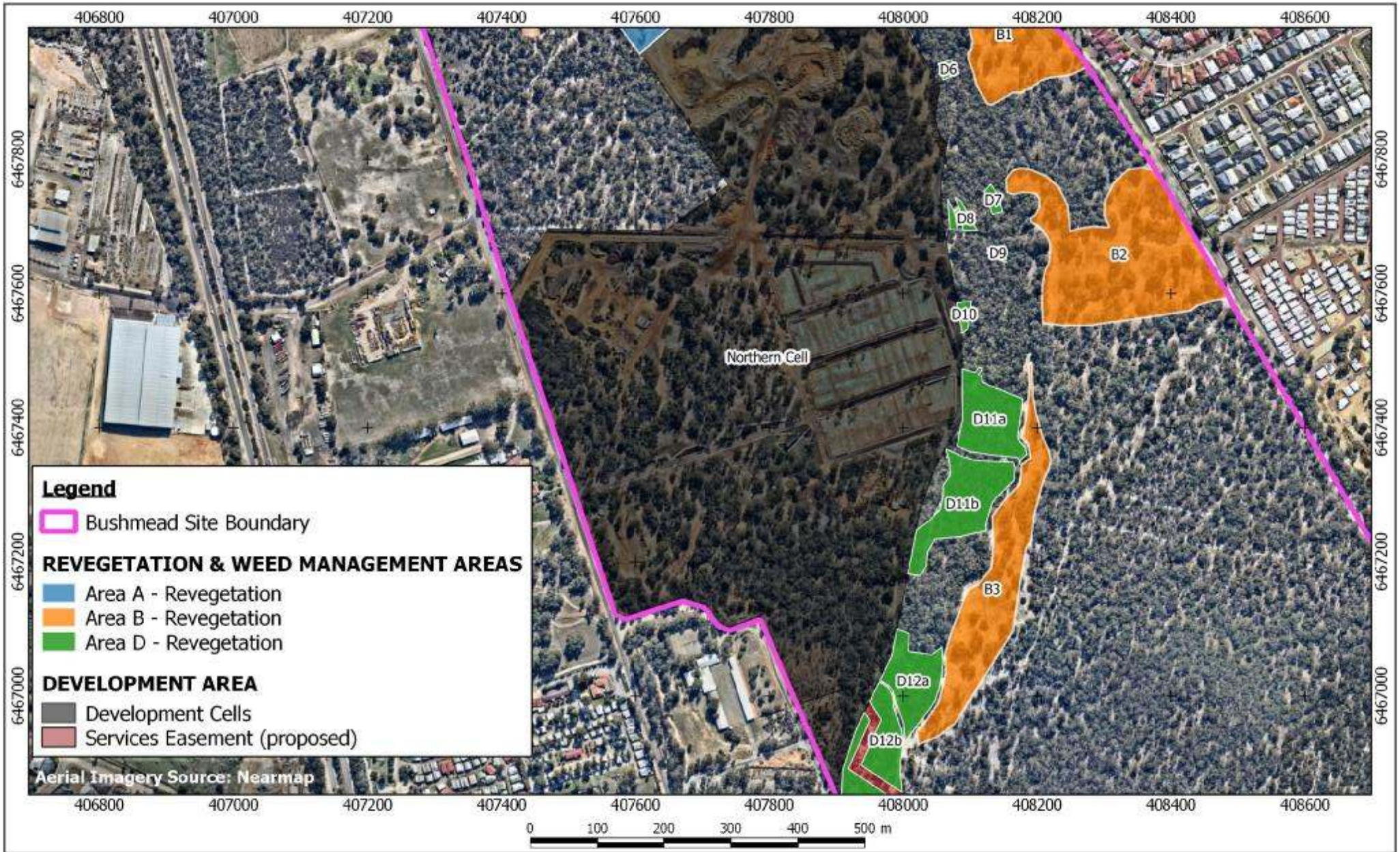

tranen revegetation systems

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Project Number: P648
Client: Cedar Woods

Drawing: Revegetation Sites
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Date: 02/08/17
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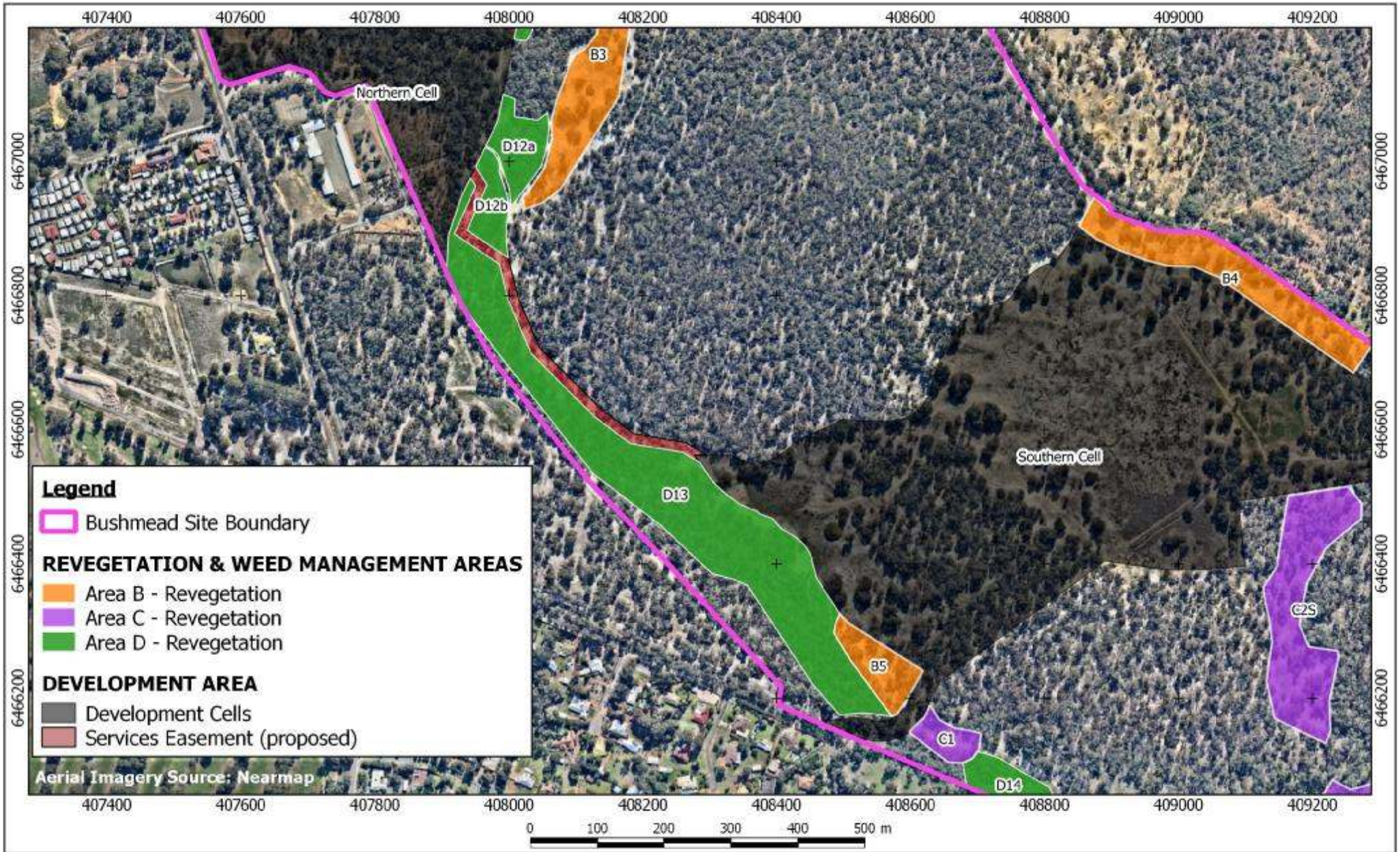

tranen revegetation systems

Project: Bushmead Revegetation
Project Number: P648
Client: Cedar Woods

Drawing: Revegetation Sites
Drawing Number: P648B-03 (p4)
Revision: 0

Date: 02/08/17
Drawn By: RSW

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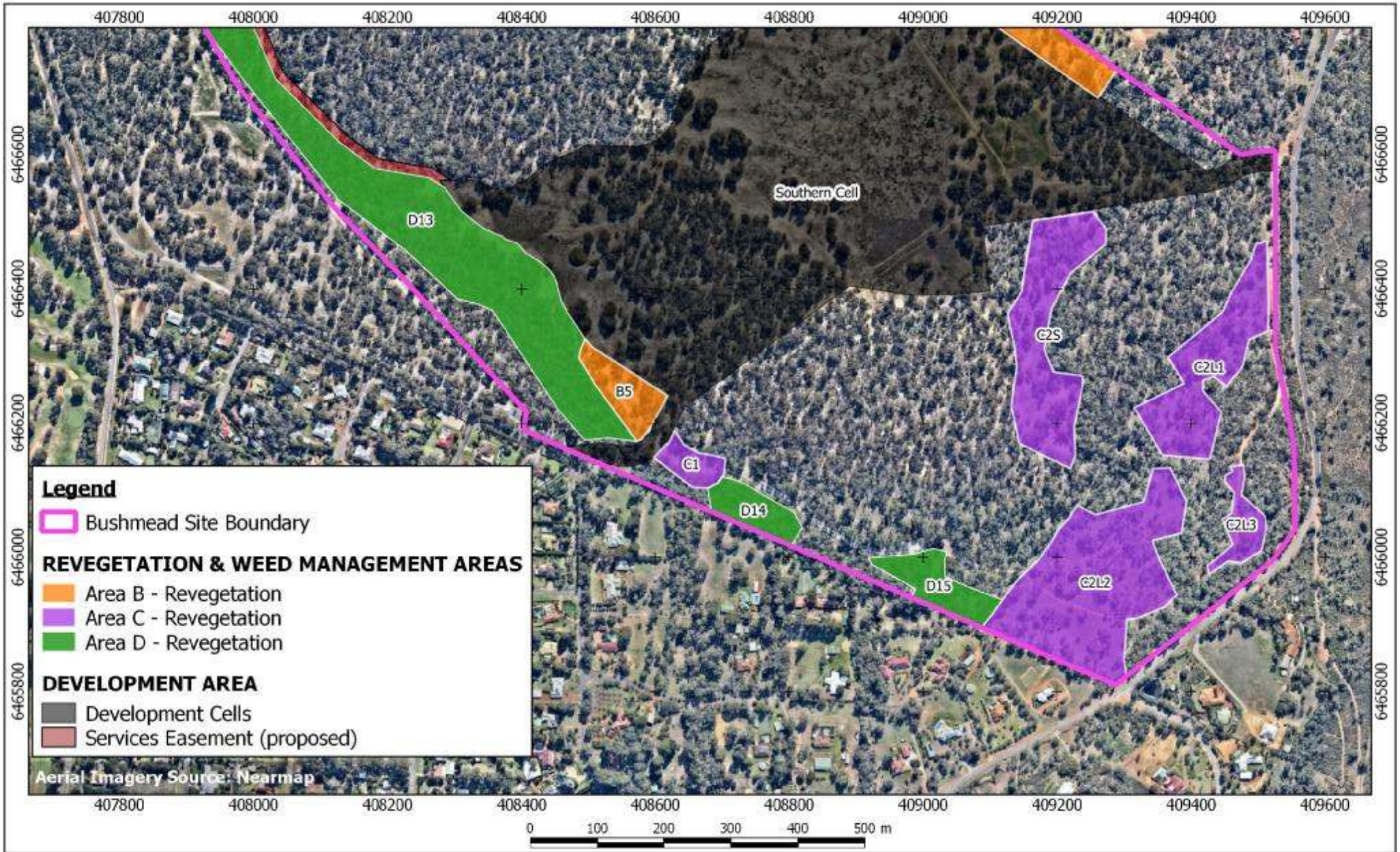

tranen revegetation systems

Project: Bushmead Revegetation
Project Number: P648
Client: Cedar Woods

Drawing: Revegetation Sites
Drawing Number: P648B-03 (p5)
Revision: 0

Date: 02/08/17
Drawn By: RSW

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Appendix 4 List of Weed Species Observed and Control Methods

Table 4 List of Weed Species Observed (Surveyed October 2015) and Control Methods

(A key to control methods and herbicides is provided at the foot of the table)

Species	Common Name	Area A	Area B	Area C Laterite	Area C Sand	Area D	Likely Control Method	Herbicide	Timing
Acacia decurrens					■		C&P	T, G50	Anytime
Acacia ?floribunda				■			C&P	T, G50	Anytime
Acacia iteaphylla	Flinders Ranges Wattle	■	■	■	■	■	C&P	T, G50	Anytime
Acacia longifolia	Sydney Golden Wattle	■	■		■	■	C&P	T, G50	Anytime
Acacia podalyriifolia	Queensland Silver Wattle		■	■		■	C&P	T, G50	Anytime
Agapanthus praecox	Agapanthus	■					H	G,M	May-Sept
Agonis flexuosa	Peppermint	■			■		C&P	T, G50	Anytime
Arctotheca calendula	Cape Weed	■	■	■	■		H	G	Jun-Nov
Asparagus asparagoides	Bridal Creeper			■			H	M	Jul-Aug
Avena barbata / fatua	Wild Oat	■	■	■	■	■	H	F1 or G	Jul-Oct
Bromus diandrus	Great Brome	■	■	■	■		H	F1 or G	Jul-Oct
Briza maxima	Blowfly Grass	■	■	■	■	■	H	F1 or G	Jul-Oct
Chamaecytisus palmensis	Tagasaste	■	■	■	■	■	C&P	T, G50	Anytime
Chamelaucium uncinatum	Geraldton Wax	■		■			C&P	T, G50	Anytime
Citrullus lanatus	Pie Melon	■					H	T or M and 2,4-D	Nov-Jan
Conyza spp.	Fleabane	■	■	■	■	■	H	G4	Jun-Sep
Cortaderia selloana	Pampas Grass		■			■	H	G4	Jul-Nov
Corymbia citriodora	Lemon-Scented Gum	■					C&P	T, G50	Anytime
Cynodon dactylon	Couch Grass	■					H	F8 or G	Nov-Feb
Dysphania ambrosioides	Mexican Tea	■					MR	Herbicide resistant	Jan-Dec
Echium plantagineum	Paterson's Curse	■	■	■	■	■	H	G,M	May-Sept
Ehrharta calycina	Perennial Veldt Grass	■	■		■		H	F8 or G	Jun-Sept
Ehrharta longiflora	Annual Veldt Grass	■	■	■	■	■	H	F1 or G	Jul-Oct
Eragrostis curvula	African Lovegrass	■	■		■	■	H	G	Oct-May
Erodium botrys	Long Storksbill	■					H	L	May-Jul
Erythrina × sykesii	Coral Tree	■					C&P	T, G50	Anytime
Eucalyptus erythrocorys	Illyarrie / Red-capped Gum	■					C&P	T, G50	Anytime
Ficus carica	Common Fig					■	C&P	T, G50	Anytime
Freesia alba × leichtlinii	Freesia	■	■	■			H	M	Jul-Aug
Fumaria capreolata	Whiteflower Fumitory			■			H	M or G	Jul-Sep
Gladiolus caryophyllaceus	Wild Gladiolus	■					W	G10	Jul-Sep
Gomphocarpus fruticosus	Narrowleaf Cottonbush		■	■	■	■	H or C&P	H at G1.5 or C&P at G50	Sep-Dec
Hyparrhenia hirta	Tambookie Grass			■			H	G	Nov-May
Hypochaeris glabra	Smooth Catsear	■	■	■	■		MR or H	L10	May-Sep
Ipomoea cairica	Coast Morning Glory	■					MR or C&P	G50	Jan-May
Leptospermum laevigatum	Coast Teatree	■	■				C&P	T, G50	Anytime
Lolium rigidum	Wimmera Ryegrass			■	■		H	For G	Jun-Oct
Lupinus cosentinii	Blue Lupin	■	■				H	M	Jun-Sep
Lysimachia arvensis	Pimpernel	■	■	■	■	■	H	2,4-D	NA
Melaleuca nesophila	Mindiyed	■					C&P	T, G50	Anytime
Melia azedarach	White Cedar / Cape Lilac	■					C&P	T, G50	Anytime
Melilotus indicus	Common Melilot	■					MR	NA	Jul-Dec
Monoculus monstrosus	Stinking Roger	■					H	G	Jul-Sep
Moraea flaccida	One-Leaf Cape Tulip	■	■	■	■		H	M	Jul-Aug
Nerium oleander	Oleander	■					C&P	G50	Anytime
Olea europaea	Olive			■		■	C&P	T, G50	Anytime

Species	Common Name	Area A	Area B	Area C Laterite	Area C Sand	Area D	Likely Control Method	Herbicide	Timing
Orobanche minor	Lesser Broomrape						H	G	NA
Oxalis purpurea	Largeflower Wood Sorrel						H	M or G	May-Jun
Oxalis pes-caprae	Soursob						H	M or G	May-Jun
Physalis angulata	Wild Gooseberry						H	G	NA
Phytolacca octandra	Red Ink Plant						H	G	Oct-Dec
Ricinus communis	Castor Oil Plant						H or C&P	H at G or C&P at G50	Dec-May
Romulea rosea	Guildford Grass						H	M	Jul-Aug
Schinus terebinthifolius	Japanese Pepper						C&P	T, G50	Anytime
Solanum hoplopetalum	Thorny Solanum						H	S or 2,4-D	Jul-Dec
Solanum linnaeanum	Apple of Sodom						H	S or 2,4-D	Jul-Dec
Solanum nigrum	Blackberry Nightshade						H	S or 2,4-D	Jul-Dec
Sonchus oleraceus	Common Sowthistle						H	L10	Jun-Aug
Tropaeolum majus	Garden Nasturtium						H	G2	NA
Ursinia anthemoides	Ursinia						H	G	Jun-Aug
Wahlenbergia capensis	Cape Bluebell						H	G	Jun-Aug
Watsonia meriana var. *bulbillifera*	Bulbil Watsonia						W or H	G10 or 2,2-DPA	Sept
Watsonia meriana var. *meriana*	Watsonia						W or H	G10 or 2,2-DPA	Sept
Zantedeschia aethiopica	Arum Lily						H	M4	Jul-Sep

NA = no data available

Key to control methods:

Abbreviation	Method
MR	Manual removal
C&P	Cut and paint
H	Herbicide
W	Wipe

Key to herbicides: (note: most herbicides to be applied with wetting agent)

Abbreviation	Herbicide and Rate
G	Glyphosate (1%)
G1.5	Glyphosate (1.5%)
G2	Glyphosate (2%)
G4	Glyphosate (4%)
G10	Glyphosate (10%)
G50	Glyphosate (50%)
T	Triclopyr (10%)
2,2-DPA	2,2 dichloropropionic acid 10 g/L
M	Metsulfuron methyl 0.2 g / 15 L
M4	Metsulfuron methyl 0.4 g / 15 L
F1	fluazifop-p (0.1%)
F8	fluazifop-p (0.8%)
2,4-D	2,4-Dichlorophenoxyacetic acid (2%)
L	Lontrel at 6 ml/10 L
L10	Lontrel at 10 ml/10 L
+W	And wetting agent
S	Starane 20ml/10L

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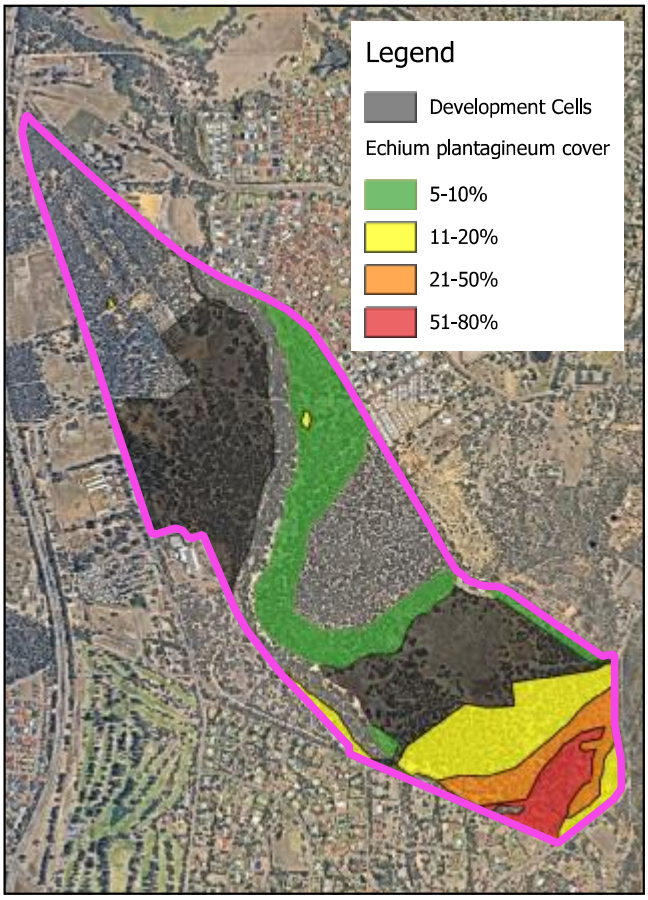
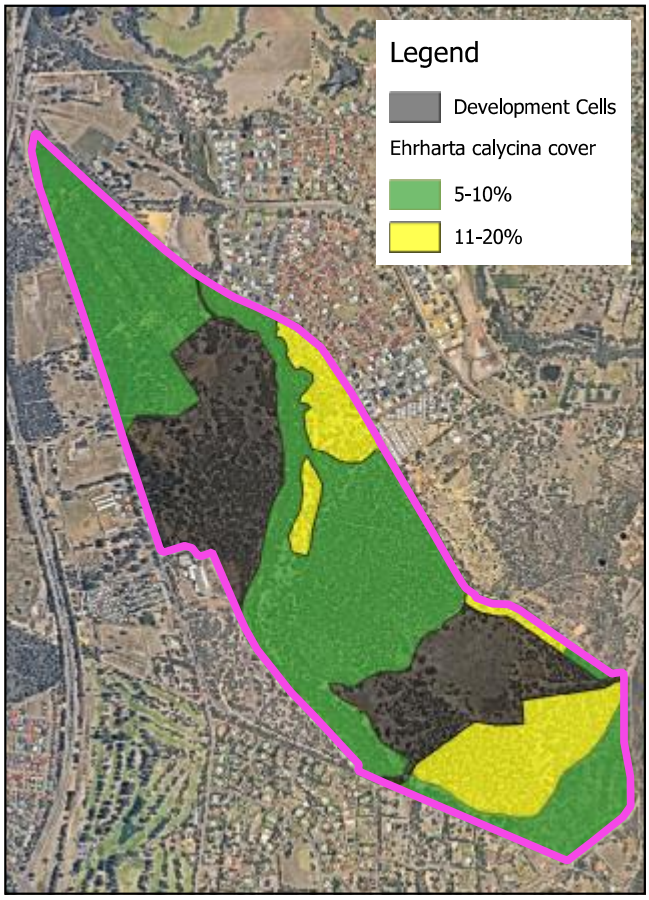
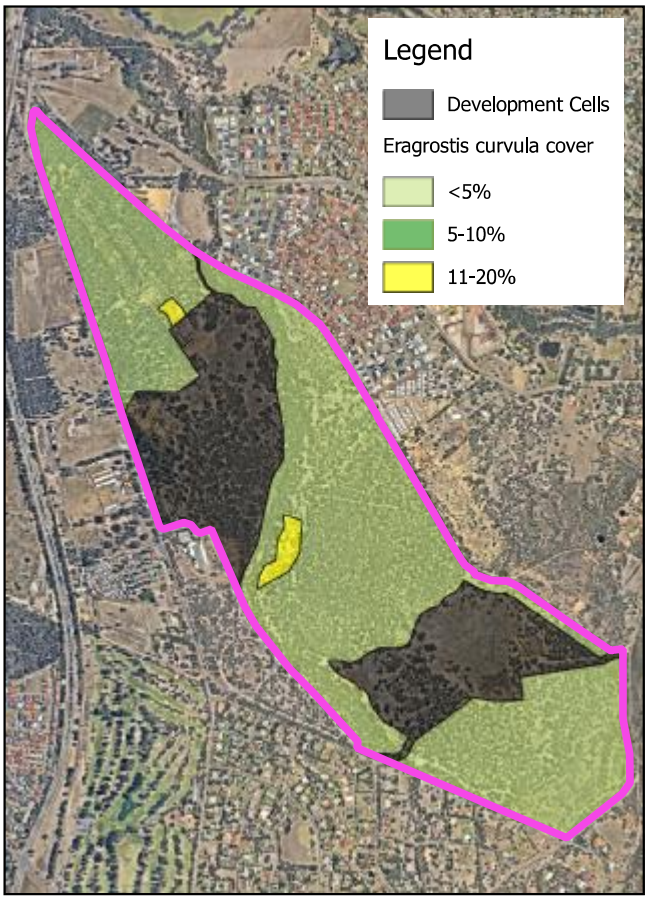
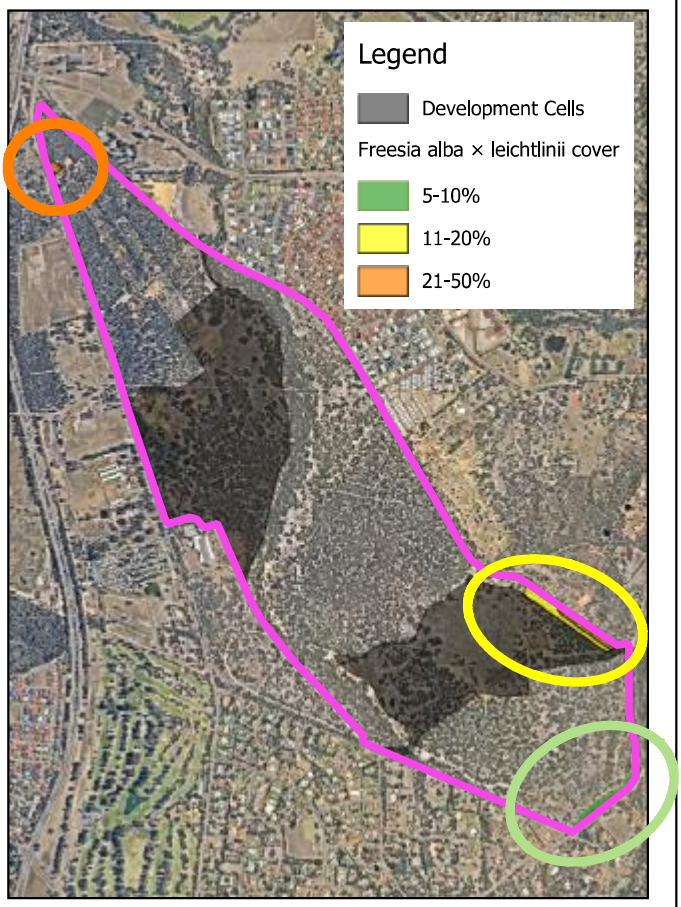
Appendix 5 Weed Maps









0 1 2 3 km

tranen revegetation systems

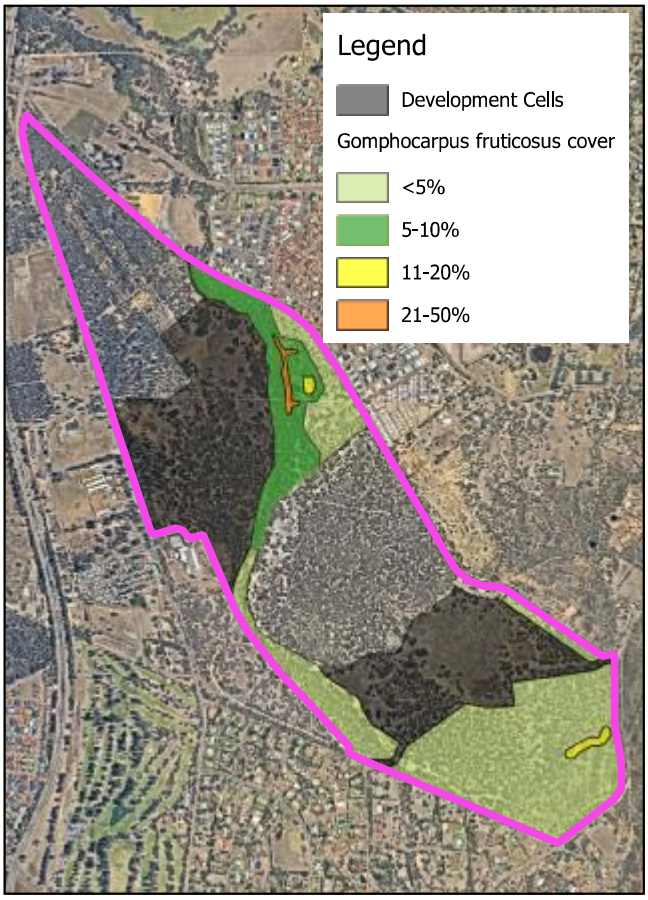
Project: Bushmead Revegetation
Project Number: P648
Client: Cedar Woods

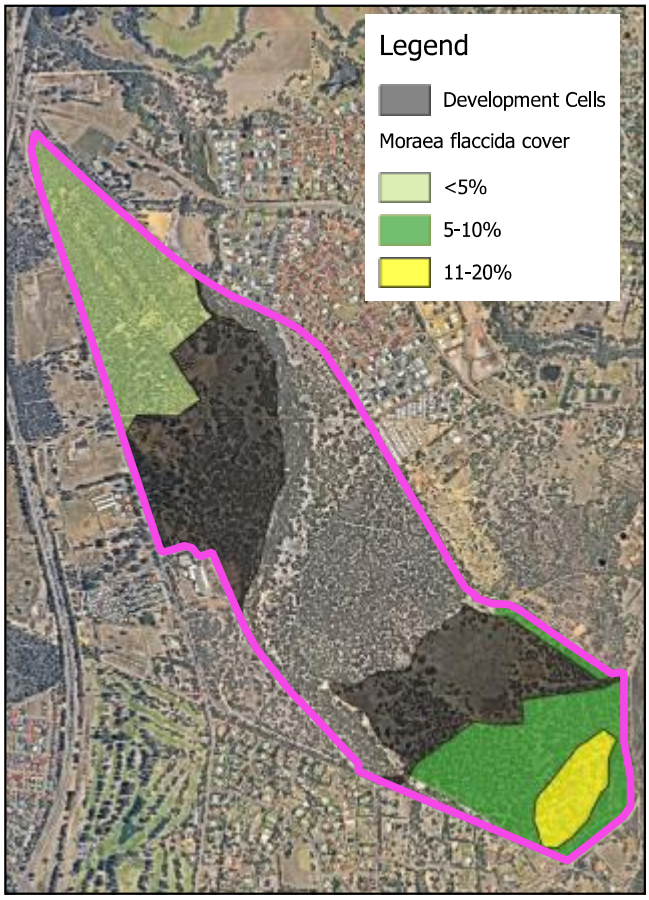
Drawing: Weed Maps (page 1)
Drawing Number: P648B-08
Revision: 1

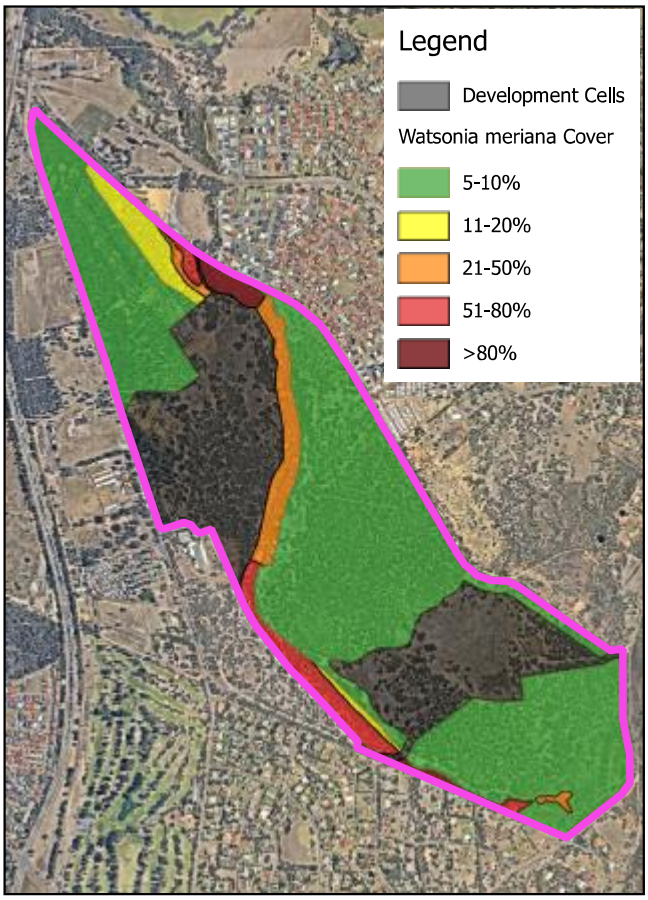
Date: 03/08/17
Drawn By: RSW

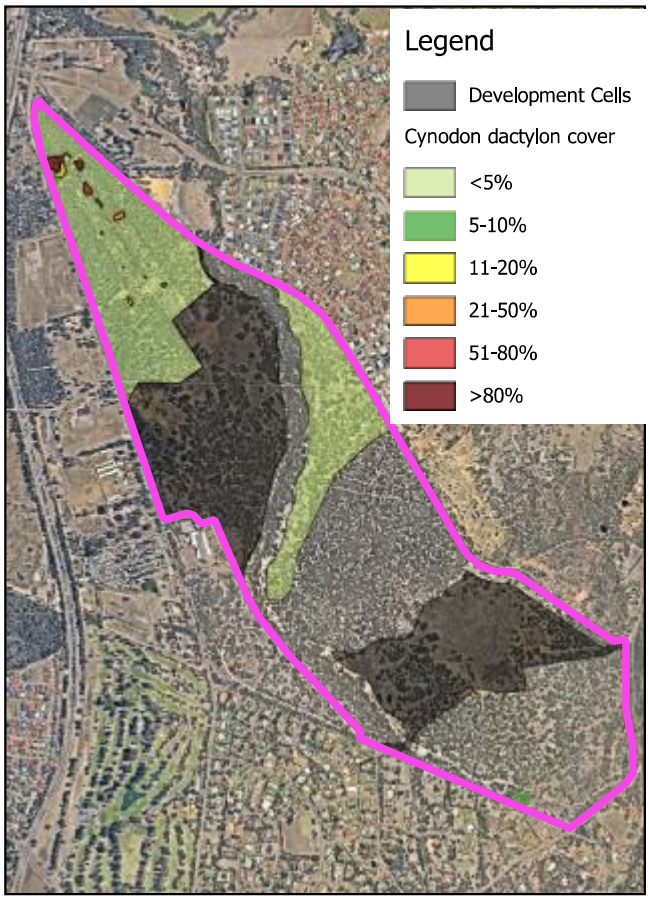
Aerial Imagery Source: Nearmap

N









0 1 2 3 km

tranen revegetation systems

Project: Bushmead Revegetation
Project Number: P648
Client: Cedar Woods

Drawing: Weed Maps (page 2)
Drawing Number: P648B-08
Revision: 1

Date: 03/08/17
Drawn By: RSW

Aerial Imagery Source: Nearmap

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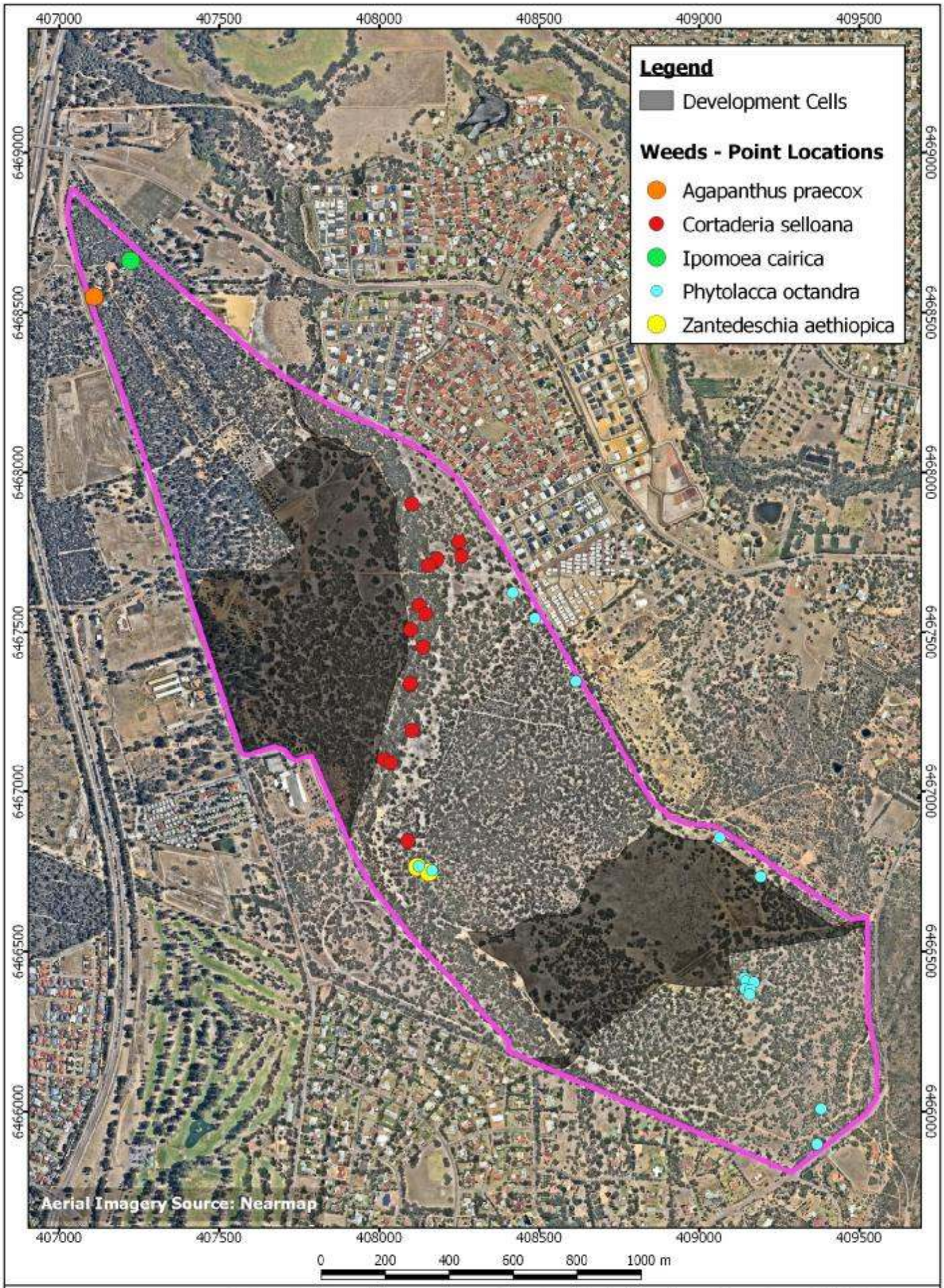

tranen revegetation systems

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Project Number: P648
Client: Cedar Woods

Drawing: Weeds Maps (page 3)
Drawing Number: P648B-08
Revision: 1

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Drawn By: RSW

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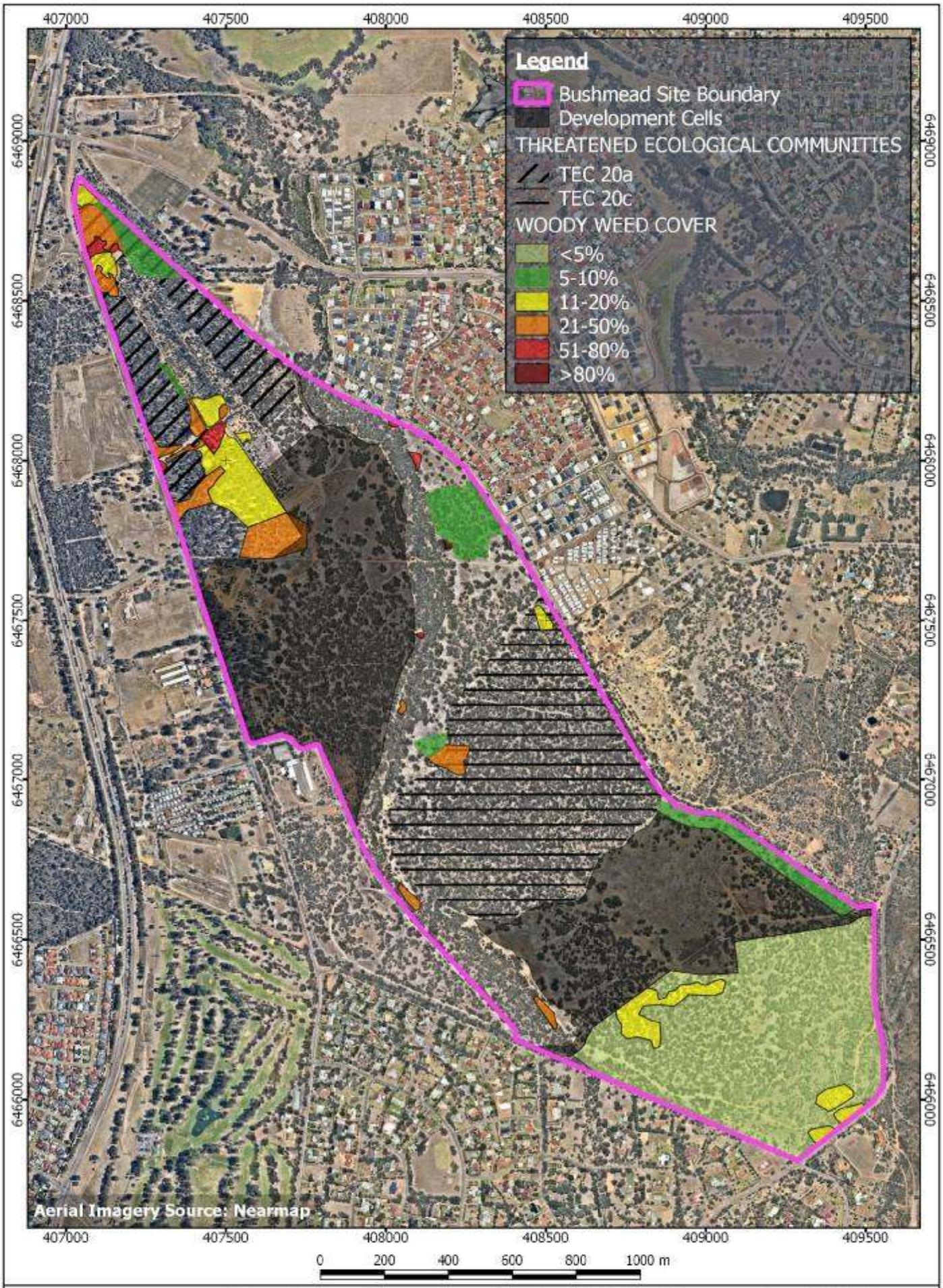

tranen revegetation systems

Project: Bushmead Revegetation
Project Number: P648
Client: Cedar Woods

Drawing: Woody Weed Cover
Drawing Number: P648B-06
Revision: 2

Date: 03/08/17
Drawn By: RSW

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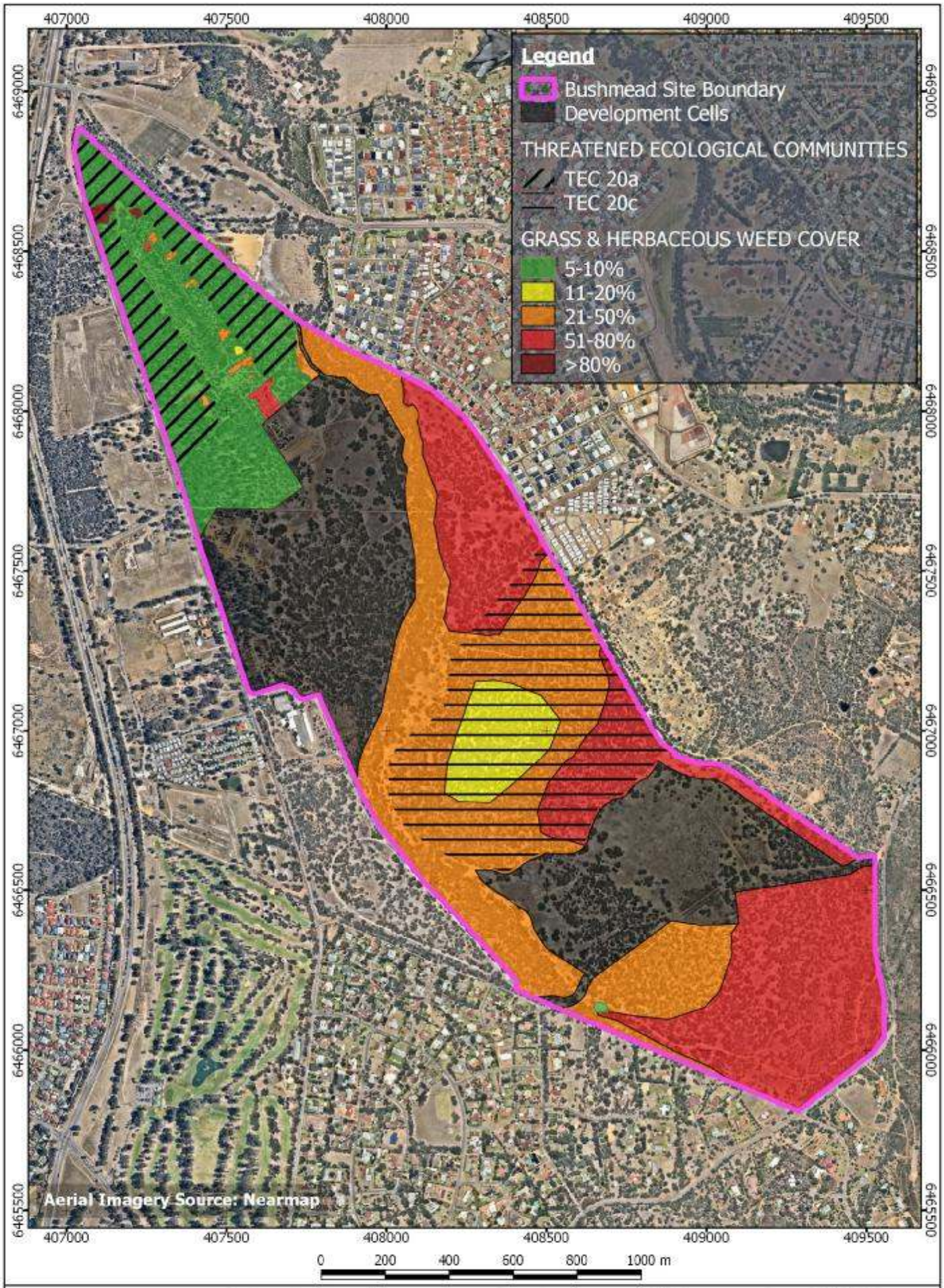

tranen revegetation systems

Project: Bushmead Revegetation
Project Number: P648
Client: Cedar Woods

Drawing: Grass and Herbaceous Weed Cover
Drawing Number: P648B-04
Revision: 2

Date: 03/08/17
Drawn By: RSW

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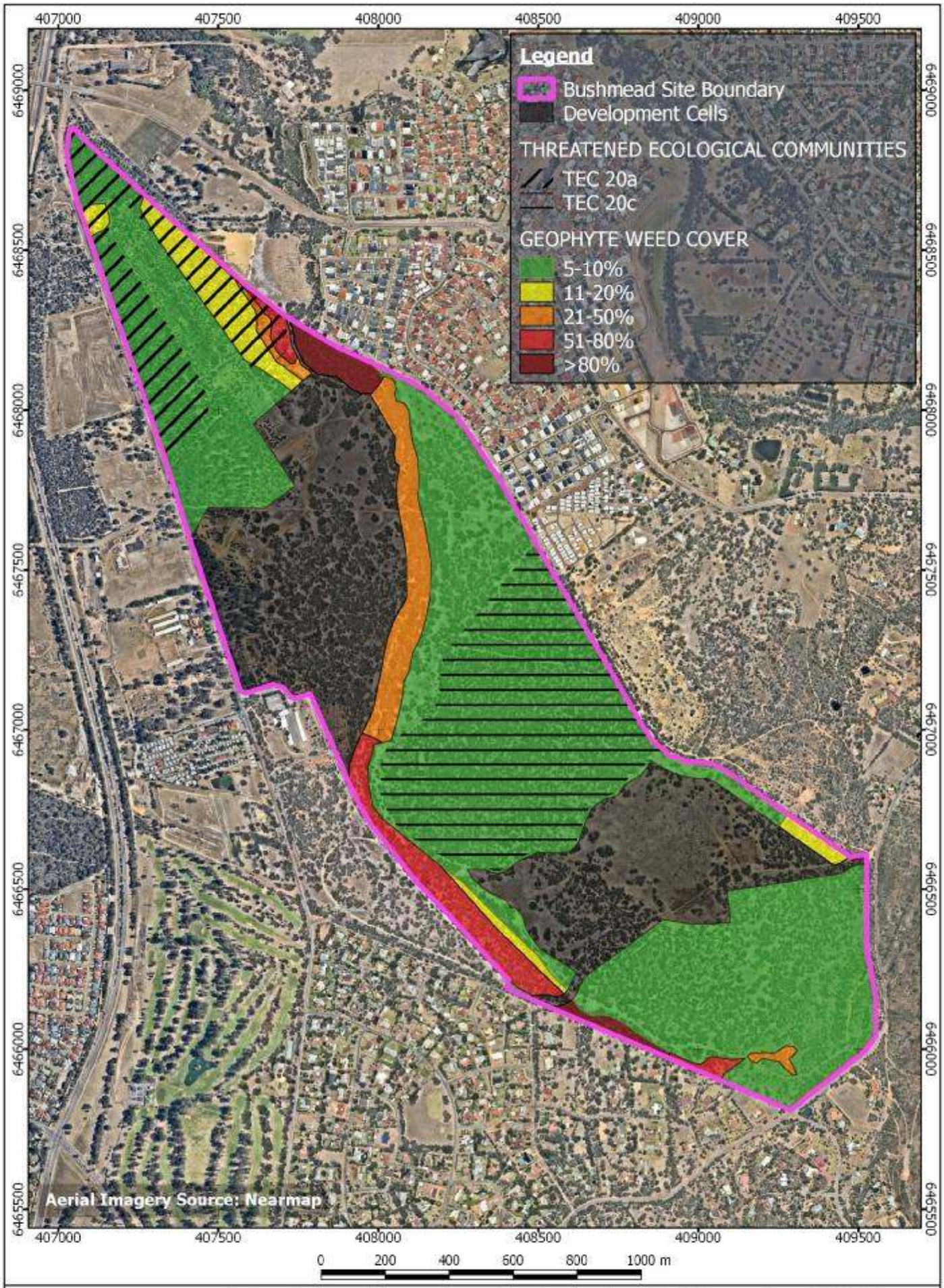

tranen revegetation systems

Project: Bushmead Revegetation
Project Number: P648
Client: Cedar Woods

Drawing: Geophyte Weed Cover
Drawing Number: P648B-05
Revision: 2

Date: 03/08/17
Drawn By: RSW

N

Appendix 6 Species List

Bushmead species list from flora surveys, FCT information and Tranen seed collections or field observations

Indicates Tranen observed on site; not listed in flora survey references

SPECIES	Area A	Area B	Area C	Area D	Currently held in Bushmead seed bank? (as at July 2017) Y = Yes, Blank = No	Likelihood of obtaining tubestock &/or seed from commercial stocks, or collecting seed on site
Acacia alata			1	1		LOW
Acacia applanata		1	1	1		MEDIUM
Acacia auronitens		1	1	1		LOW
Acacia huegelii	1	1				MEDIUM
Acacia lasiocarpa var. sedifolia	1	1	1			LOW
Acacia nervosa	1					LOW
Acacia pulchella	1	1	1	1	Y	HIGH
Acacia saligna	1	1	1	1		HIGH
Acacia sessilis	1	1	1		Y	HIGH
Acacia teretifolia			1			LOW
Acacia willdenowiana			1	1		LOW
Acanthocarpus preissii	1	1				HIGH
Adenanthos cygnorum	1	1	1			HIGH
Agrostocrinum scabrum		1	1	1		LOW
Alexgeorgea nitens	1					LOW
Allocasuarina fraseriana	1	1	1		Y	HIGH
Allocasuarina humilis	1	1	1	1	Y	HIGH
Amphipogon turbinatus	1	1	1			MEDIUM
Anigozanthos humilis	1	1	1	1		HIGH
Anigozanthos manglesii	1	1	1	1		HIGH
Arnocrinum preissii			1			LOW
Astroloma ciliatum			1			LOW
Astroloma glaucescens				1		LOW
Astroloma pallidum		1				LOW
Astroloma stomarrhena	1	1				LOW
Astroloma xerophyllum	1				Y	HIGH
Austrostipa campylachne			1			LOW
Austrostipa compressa	1				Y	HIGH
Austrostipa elegantissima	1		1	1		LOW
Austrostipa flavescens	1					MEDIUM
Austrostipa pycnostachya		1				LOW
Babingtonia camphorosmae	1	1	1	1	Y	HIGH
Banksia armata var. armata			1		Y	HIGH
Banksia attenuata	1	1	1		Y	HIGH
Banksia dallanneyi	1	1	1	1		MEDIUM
Banksia grandis	1	1	1		Y	HIGH
Banksia ilicifolia	1			1	Y	HIGH
Banksia menziesii	1	1	1		Y	HIGH
Banksia sessilis		1	1		Y	HIGH
Banksia squarrosa subsp. squarrosa			1			MEDIUM
Billardiera fraseri	1			1		LOW
Billardiera heterophylla			1	1		LOW
Blancoa canescens	1	1				LOW
Bossiaea eriocarpa	1	1	1	1		HIGH
Bossiaea ornata			1	1		LOW
Burchardia congesta	1	1	1	1	Y	HIGH
Burchardia multiflora	1		1	1		LOW
Caesia micrantha			1			LOW
Caladenia discoidea	1					LOW
Caladenia flava	1	1				LOW
Caladenia longicauda subsp. longicauda			1			LOW
Calectasia narragara	1					LOW
Calothamnus quadrifidus		1	1	1	Y	HIGH
Calothamnus sanguineus			1		Y	HIGH
Calytrix aurea	1					LOW
Calytrix fraseri	1					MEDIUM
Cassytha racemosa	1	1	1	1		MEDIUM
Caustis dioica		1				LOW
Centrolepis aristata	1					LOW
Centrolepis drummondiana	1		1			LOW
Chamaescilla corymbosa	1	1	1			MEDIUM
Chamaescilla versicolor			1			LOW
Comesperma calymega		1		1		LOW
Conospermum acerosum	1					LOW
Conospermum polycephalum				1		LOW
Conospermum stoechadis	1					LOW
Conostephium pendulum	1			1		MEDIUM
Conostylis aculeata	1	1	1			HIGH
Conostylis aurea	1	1				MEDIUM
Conostylis juncea		1	1			MEDIUM
Conostylis setigera	1	1	1			MEDIUM
Conostylis setosa	1					MEDIUM
Corymbia calophylla	1	1	1	1	Y	HIGH
Crassula colorata	1					LOW
Cristonia biloba	1		1			LOW
Cyathochaeta avenacea			1	1		LOW
Cyathochaeta clandestina	1					LOW
Dampiera linearis	1	1	1	1		HIGH
Dasypogon bromeliifolius	1	1		1	Y	HIGH
Dasypogon obliquifolius	1	1				LOW
Daucus glochidiatus	1	1	1			LOW
Daviesia angulata	1	1			Y	HIGH
Daviesia decurrens	1			1		LOW
Daviesia divaricata	1	1	1	1	Y	HIGH
Daviesia gracilis	1					LOW
Daviesia horrida				1		LOW
Daviesia incrassata	1					LOW
Daviesia nudiflora	1	1				LOW
Daviesia physodes	1	1	1	1	Y	MEDIUM
Daviesia polyphylla			1			LOW
Daviesia preissii	1			1		LOW
Daviesia triflora	1					MEDIUM
Desmocladus fasciculatus	1	1	1	1		LOW
Desmocladus flexuosus	1	1	1	1		LOW
Dianella revoluta var. divaricata	1	1	1	1	Y	MEDIUM
Dichopogon capillipes			1		Y	HIGH
Diuris brumalis			1			LOW
Drosera erythrorhiza	1					LOW
Drosera macrantha		1				LOW
Drosera menziesii subsp. penicillaris						LOW
Drosera pallida			1			LOW
Drosera porrecta	1	1				LOW

SPECIES	Area A	Area B	Area C	Area D	Currently held in Bushmead seed bank? (as at July 2017) Y = Yes, Blank = No	Likelihood of obtaining tubestock &/or seed from commercial stocks, or collecting seed on site
Drosera rosulata			1			LOW
Eremaea asterocarpa subsp. asterocarpa		1				MEDIUM
Eremaea fimbriata	1					LOW
Eremaea pauciflora	1	1	1		Y	HIGH
Eremaea violacea	1					LOW
Eryngium pinnatifidum subsp. pinnatifidum MS			1			LOW
Eucalyptus marginata	1	1	1	1	Y	HIGH
Eucalyptus rudis		1	1	1	Y	HIGH
Eucalyptus todtiana	1	1			Y	HIGH
Eucalyptus wandoo			1	1	Y	HIGH
Euchilopsis linearis	1					LOW
? Gahnia sp. (collected from site - no definite ID)				1		LOW
Gastrolobium capitatum	1	1	1	1		MEDIUM
Gastrolobium cuneatum				1		LOW
Gastrolobium dilatatum			1			LOW
Gompholobium aristatum				1		LOW
Gompholobium capitatum	1					LOW
Gompholobium knightianum				1		LOW
Gompholobium polymorphum			1	1		LOW
Gompholobium scabrum				1		LOW
Gompholobium shuttleworthii		1				LOW
Gompholobium tomentosum	1	1	1	1	Y	HIGH
Gonocarpus cordiger			1			LOW
Grevillea pilulifera		1	1	1		LOW
Grevillea vestita				1		MEDIUM
Grevillea wilsonii				1		LOW
Haemodorum laxum	1	1	1	1	Y	HIGH
Haemodorum paniculatum	1					LOW
Haemodorum simplex			1			LOW
Haemodorum spicatum	1	1	1		Y	HIGH
Hakea erinacea			1	1	Y	HIGH
Hakea lissocarpha	1	1	1	1	Y	HIGH
Hakea marginata	1	1				LOW
Hakea petiolaris	1					LOW
Hakea prostrata	1	1	1	1	Y	HIGH
Hakea ruscifolia	1	1	1	1	Y	HIGH
Hakea stenocarpa			1	1	Y	MEDIUM
Hakea trifurcata		1	1	1	Y	HIGH
Hakea undulata	1	1	1	1	Y	HIGH
Hemiandra pungens	1					HIGH
Hemigenia sericea			1			LOW
Hemiphora bartlingii	1			1		LOW
Hibbertia acerosa			1	1		LOW
Hibbertia aurea	1					LOW
Hibbertia commutata			1			LOW
Hibbertia huegelii	1	1		1	Y	HIGH
Hibbertia hypericoides	1	1	1	1		MEDIUM
Hibbertia racemosa	1	1	1			MEDIUM
Hovea pungens		1	1	1	Y	HIGH
Hovea trisperma	1		1	1		MEDIUM
Hyalosperma cotula			1			MEDIUM
Hybanthus calycinus	1	1		1	Y	HIGH
Hydrocotyle callicarpa			1			LOW
Hypocalymma angustifolium			1	1	Y	HIGH
Hypolaena exsulca	1					LOW
Isopogon asper			1			LOW
Isopogon divergens				1		LOW
Isopogon drummondii	1				Y	HIGH
Isopogon dubius			1		Y	HIGH
Isotoma hypocrateriformis	1					LOW
Isotropis cuneifolia	1	1				LOW
Jacksonia floribunda	1	1	1		Y	HIGH
Jacksonia furcellata		1	1			HIGH
Jacksonia restioides	1					LOW
Jacksonia sternbergiana	1	1	1	1	Y	HIGH
Johnsonia pubescens	1	1				LOW
Juncus holoschoenus				1		MEDIUM
Juncus kraussii			1	1		HIGH
Juncus pallidus		1	1	1	Y	HIGH
Kennedia prostrata	1	1	1	1		HIGH
Kunzea glabrescens	1					HIGH
Labichea punctata		1	1			LOW
Lagenophora huegelii			1			LOW
Lambertia multiflora var. darlingensis	1				Y	HIGH
Laxmannia sessiliflora subsp. australis		1				LOW
Laxmannia squarrosa	1		1	1	Y	HIGH
Lechenaultia biloba				1		MEDIUM
Lepidosperma angustatum		1				LOW
Lepidosperma leptostachyum	1	1	1			LOW
Lepidosperma longitudinale				1		HIGH
Lepidosperma scabrum			1	1		LOW
Lepidosperma squamatum	1	1		1		LOW
Leporella fimbriata		1				LOW
Leptospermum erubescens	1	1	1	1	Y	HIGH
Leptospermum spinescens	1				Y	HIGH
Leucopogon conostephioides	1			1		LOW
Leucopogon racemulosus				1		LOW
Levenhookia stipitata		1		1		LOW
Lepyrodia muirii				1		LOW
Lomandra caespitosa	1	1				LOW
Lomandra hermaphrodita	1	1				LOW
Lomandra nigricans	1	1	1			LOW
Lomandra preissii	1	1	1	1		LOW
Lomandra spartea			1			LOW
Lomandra suaveolens	1			1		LOW
Loxocarya cinerea			1			LOW
Luzula meridionalis			1	1		LOW
Lyginia barbata	1	1	1	1		LOW
Lysinema ciliatum	1	1	1	1		LOW
Macarthuria australis	1	1			Y	HIGH
Macrozamia riedlei	1	1	1	1		HIGH
Marianthus bicolor			1			LOW
Marianthus drummondianus			1			LOW
Melaleuca ?parviceps	1	1	1		Y	HIGH

SPECIES	Area A	Area B	Area C	Area D	Currently held in Bushmead seed bank? (as at July 2017) Y = Yes, Blank = No	Likelihood of obtaining tubestock &/or seed from commercial stocks, or collecting seed on site
Melaleuca rhaphiophylla				1		HIGH
Melaleuca seriata	1	1	1		Y	HIGH
Mesomelaena pseudostygia	1	1	1	1		LOW
Mesomelaena tetragona	1	1				LOW
Millotia tenuifolia var. tenuifolia			1			LOW
Mirbelia ramulosa				1		LOW
Monotaxis grandiflora	1					LOW
Neurachne alopecuroidea	1	1	1	1	Y	HIGH
Nuytsia floribunda	1	1	1	1		HIGH
Olearia paucidentata		1	1	1		LOW
Opercularia vaginata	1	1		1		MEDIUM
Patersonia occidentalis	1	1	1	1	Y	HIGH
Patersonia pygmaea	1					LOW
Pauridia occidentalis			1			LOW
Persoonia elliptica	1	1	1		Y	HIGH
Persoonia saccata	1		1			MEDIUM
Persoonia sulcata			1			LOW
Petrophile biloba			1			LOW
Petrophile linearis	1	1			Y	HIGH
Petrophile macrostachya	1			1	Y	HIGH
Petrophile media	1					LOW
Petrophile seminuda	1	1		1	Y	MEDIUM
Petrophile striata				1		LOW
Philotheca nodiflora			1			LOW
Philotheca spicata	1	1	1			MEDIUM
Phlebocarya ciliata	1	1				MEDIUM
Phyllangium paradoxum	1					LOW
Phyllanthus calycinus	1	1	1	1	Y	HIGH
Pimelea imbricata			1			LOW
Pimelea leucantha	1					LOW
Pimelea suaveolens	1				Y	MEDIUM
Pimelea sulphurea	1					MEDIUM
Poa porphyroclados	1					LOW
Podolepis gracilis		1				LOW
Podotheca gnaphalioides	1	1	1		Y	HIGH
Poranthera microphylla	1					LOW
Pterochaeta paniculata	1	1	1		Y	HIGH
Pterostylis recurva		1				LOW
Pterostylis sanguinea			1			LOW
Pterostylis vittata	1					LOW
Ptilotus drummondii		1				MEDIUM
Ptilotus polystachyus		1	1		Y	HIGH
Pyrorchis nigricans	1	1		1		LOW
Rhodanthe citrina	1					LOW
Rytidosperma caespitosum	1			1		LOW
Rytidosperma occidentale	1					LOW
Rytidosperma setaceum			1			LOW
Scaevola canescens	1					LOW
Scaevola repens	1	1	1			MEDIUM
Schoenus brevisetis	1	1				LOW
Schoenus caespititius	1	1				LOW
Schoenus curvifolius			1	1		LOW
Schoenus efoliatus		1				LOW
Scholtzia involucrata	1	1	1		Y	HIGH
Stachystemon vermicularis	1					LOW
Stackhousia monogyna				1		LOW
Stenanthemum tridentatum				1		LOW
Stirlingia latifolia	1	1	1		Y	HIGH
Stylidium amoenum			1			LOW
Stylidium brunonianum	1	1	1	1	Y	HIGH
Stylidium bulbiferum			1			LOW
Stylidium calcaratum	1					LOW
Stylidium caricifolium			1			LOW
Stylidium diuroides	1					LOW
Stylidium piliferum	1	1		1		LOW
Stylidium schoenoides	1			1		LOW
Styphelia tenuiflora	1					LOW
Synaphea petiolaris	1		1	1		LOW
Synaphea spinulosa	1					LOW
Tetraria octandra	1	1	1	1		LOW
Thelymitra benthamiana			1			LOW
Thomasia foliosa			1	1		LOW
Thomasia grandiflora		1		1		LOW
Thysanotus arbuscula			1		Y	MEDIUM
Thysanotus manglesianus			1		Y	MEDIUM
Thysanotus multiflorus	1					MEDIUM
Thysanotus sparteus	1	1				LOW
Thysanotus thyrsoideus		1				LOW
Thysanotus triandrus	1	1	1	1		LOW
Trachymene pilosa	1	1	1	1		MEDIUM
Trichocline spathulata		1	1			LOW
Tricoryne elatior		1				LOW
Tripterococcus brunonis	1			1		LOW
Trymalium ledifolium		1	1			LOW
Verticordia densiflora	1	1	1	1	Y	HIGH
Wahlenbergia preissii	1		1		Y	MEDIUM
Waitzia suaveolens	1					LOW
Xanthorrhoea brunonis	1	1				LOW
Xanthorrhoea gracilis			1			MEDIUM
Xanthorrhoea preissii	1	1	1	1	Y	HIGH
Xanthosia candida			1	1		LOW
Xanthosia huegelii	1		1			LOW
Xylomelum occidentale	1	1	1			MEDIUM
TOTAL	**180**	**139**	**161**	**120**		**300**
TOTAL HIGH LIKELIHOOD	**64**	**62**	**63**	**46**		**83**
TOTAL MEDIUM LIKELIHOOD	**30**	**23**	**25**	**16**		**43**
TOTAL LOW LIKELIHOOD	**86**	**54**	**73**	**58**		**174**

HIGH likelihood means has either been collected as seed on site in reasonable quantity, or seed commercially available, or tubestock commercially available
MEDIUM likelihood means has either been collected as seed on site in low quantities, seed sometimes commercially available, and/or tubestock sometimes commercially available.
LOW likelihood means has not been collected from site, seed usually unavailable commercially, and / or tubestock not usually available commercially

Additional species recommended by Tranen for inclusion:

SPECIES	Area A	Area B	Area C	Area D	Justification for inclusion	Likelihood of obtaining tubestock &/or Seed
Acacia extensa			1		Jarrah forest and Swan Coastal Plain - near damp areas	HIGH
Allocasuarina huegeliana			1		Rock She-oak suitable for shallow soils on escarpment	HIGH
Aotus gracillima				1	Widespread shrub associated with damp areas	HIGH
Astartea scoparia				1	Widespread shrub associated with damp areas	HIGH
Banksia littoralis				1	Widespread tree associated with creeklines, Black Cockatoo species	HIGH
Callistemon phoeniceus			1	1	Widespread shrub often on watercourses and sandy, laterite soils	HIGH
Calothamnus rupestris			1		Found on gravelly, skeletal soils, granite outcrops, hillsides.	HIGH
Grevillea bipinnatifida			1		Found on granitic soils, laterite, Black Cockatoo species	HIGH
Hakea amplexicaulis			1		Laterite soils	HIGH
Hakea varia		1	1	1	Widespread shrub prefers damp soils	HIGH
Hibbertia subvaginata		1	1	1	Widespread, laterite and sand soils	HIGH
Hypocalymma robustum		1	1	1	Jarrah forest and Swan Coastal Plain distribution	HIGH
Kennedia coccinea			1	1	Northern Jarrah Forest species	HIGH
Melaleuca trichophylla		1	1	1	Jarrah forest and Swan Coastal Plain distribution	HIGH
Taxandria linearifolia				1	Borders watercourses in Jarrah Forest and Swan Coastal Plain	HIGH
TOTAL	**0**	**4**	**11**	**10**		**15**

OVERALL TOTAL (survey list + Tranen list)	**180**	**143**	**172**	**130**	TOTAL NUMBER OF SPECIES IN THE LIST (incl. Tranen recommdations)	**315**

Total - HIGH likelihood (incl. Tranen recommendations)	**98**
Total - MEDIUM likelihood (incl. Tranen recommendations)	**43**
Total - LOW likelihood (incl. Tranen recommendations)	**174**

HIGH likelihood means has either been collected as seed on site in reasonable quantity, or seed commercially available, or tubestock commercially available
MEDIUM likelihood means has either been collected as seed on site in low quantities, seed sometimes commercially available, and/or tubestock sometimes commercially available.
LOW likelihood means has not been collected from site, seed usually unavailable commercially, and / or tubestock not usually available commercially

Appendix 7 Revegetation Requirements Summary Matrix

tranen revegetation systems

Bushmead
Revegetation Requirements Summary Matrix

Name	Conservation Area	Area (ha)	Approx. Weed Control Area (ha)*	Reveg Area (ha)	Woody Weed Removal	Scalp Volume at 50 mm Depth (m3)	Ripline Length (km)	Scarify (ha)	Mulch Depth (mm)	Total Mulch Volume (m3)	Direct Seeding Rate (kg/ha)	Seed Quantity (kg)	Tubestock Planting Density (plants/m2)	Tubestock Total	Exclusion Fence	Tree Guards
FCT20a	Area A	21.86	2.19		Y											
A1	Area A	0.22	0.22	0.22	Y	110	1.1	0.22			3	0.660	0.5	1,100	Y	
A2a	Area A	1.95	1.95	1.95	Y	175	9.8	1.95			3	5.850	0.5	9,750	Y	
A2b	Area A	0.47	0.47	0.47	Y	235	2.4	0.47	50	235	3	1.410	0.5	2,350	Y	
A3	Area A	0.23	0.23	0.23			1.2	0.23			3	0.690	0.5	1,150	Y	
A4	Area A	0.90	0.90	0.90	Y	450	4.5	0.90			3	2.700	0.5	4,500	Y	
A Balance	Area A	16.34	1.63		Y											
FCT20c	Area B	50.23	5.02		Y											
B1	Area B	2.36	2.36	2.36	Y	1,180	11.8	2.36			3	7.080	0.5	11,800	Y	
B2	Area B	4.60	4.60	4.60		2,300	23.0	4.60			3	13.800	0.5	23,000	Y	
B3	Area B	2.68	2.68	2.68	Y		13.4	2.68			3	8.040	0.5	13,400	Y	
B4	Area B	2.37	2.37	2.37	Y	1,185	11.9	2.37			3	7.110	0.5	11,850	Y	
B5	Area B	0.83	0.83	0.83	Y		16.6		75	623			2.0	16,600		16,600
B Balance	Area B	10.16	1.02		Y											
C1	Area C	0.46	0.46	0.46			9.2		75	345			2.0	9,200		9,200
C2L1	Area C	2.41	2.41	2.41	Y		12.1	2.41			3	7.230	0.5	12,050	Y	
C2L2	Area C	4.85	4.85	4.85	Y		24.3	4.85			3	14.550	0.5	24,250	Y	
C2L3	Area C	0.58	0.58	0.58	Y		2.9	0.58			3	1.740	0.5	2,900	Y	
C2LWC	Area C	6.34	6.34		Y											
C2S	Area C	2.84	2.84	2.84	Y		14.2	2.84			3	8.520	0.5	14,200	Y	
C Balance	Area C	26.25	7.88		Y											
D1	Area D	0.43	0.43	0.43									0.5	2,150	Y	
D2	Area D	0.07	0.07	0.07									0.5	350		350
D3	Area D	0.10	0.10	0.10									0.5	500		500
D4	Area D	0.16	0.16	0.16			0.8	0.16			3	0.480	0.5	800	Y	
D5	Area D	0.02	0.02	0.02									0.5	100		100
D6	Area D	0.05	0.05	0.05									0.5	250		250
D7	Area D	0.07	0.07	0.07									0.5	350		350
D8	Area D	0.09	0.09	0.09									0.5	450		450
D9	Area D	0.04	0.04	0.04									0.5	200		200
D10	Area D	0.07	0.07	0.07			0.4						0.5	350		350
D11	Area D	2.13	2.13	2.13			1.5						0.5	10,650	Y	
D12	Area D	1.37	1.37	1.37			0.8	0.10			3	0.30	0.5	6,850	Y	
D13	Area D	7.25	7.25	7.25	Y		2.5	0.28			3	0.84	0.5	36,250	Y	
D14	Area D	0.74	0.74	0.74									0.5	3,700	Y	
D15	Area D	0.94	0.94	0.94	Y		2.8	0.20			3	0.60	0.5	4,700	Y	
D Balance	Area D	12.96	12.96		Y											
Total		**185.42**	**78.31**	**41.28**		**5,635**	**167.2**	**27.20**		**1,203**		**81.600**		**225,750**		**28,350**

*Estimate 10% of TEC and 'Balance' areas require weed control in Areas A and B, and 30% of 'Balance' in Area C

Appendix 8 Indicative Works Schedule

Bushmead Revegetation Schedule

Indicative Revegetation Schedule - shading indicates timeframe when works could take place

Year	Conservation Area	Site(s)	Revegetation Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	All	n/a	Provenance seed collection											■	■
	A	TEC & remnant veg	Woody weed control									■	■	■	■
	A	A1,A2,A3,A4	Woody weed control									■	■	■	■
	A	A1,A2,A3,A4	Weed control (all weeds)									■	■	■	■
	B	TEC & remnant veg	Woody weed control									■	■	■	■
	B	B1,B2,B3,B4,B5	Woody weed control									■	■	■	■
	B	B1,B2,B3,B4,B5	Weed control (all weeds)									■	■	■	■
	C	C1,C2S,C2L	Woody weed control									■	■	■	■
	C	C1,C2S,C2L	Weed control (all weeds)									■	■	■	■
	C	Remnant veg	Woody weed control									■	■	■	■
	C	Remnant veg	Control of priority weeds									■	■	■	■
	D	Whole of Area D	Foreshore Condition Assessment (Baseline)									■	■		
	D	Whole of Area D	Woody weed control									■	■	■	■
	D	Whole of Area D	Weed control (all weeds)									■	■	■	■
2018	All	n/a	Provenance seed collection	■	■	■								■	■
	A	TEC & remnant veg	Woody weed control	■	■	■	■	■	■	■	■	■	■	■	■
	A	TEC & remnant veg	Control of priority weeds	■	■	■	■	■	■	■	■	■	■	■	■
	A	A1,A2,A3,A4	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	A	A2,A3	Site preparation (scalping, ripping, fence, logs)	■	■	■	■	■							
	A	A2,A3	Direct seeding					■	■						
	A	A2,A3	Tubestock Planting (Initial Installation)					■	■	■	■				
	A	A1,A2,A3,A4	Revegetation Monitoring			■	■	■				■	■	■	
	B	TEC & remnant veg	Woody weed control	■	■	■	■	■	■	■	■	■	■	■	■
	B	TEC & remnant veg	Control of priority weeds	■	■	■	■	■	■	■	■	■	■	■	■
	B	B1,B2,B3,B4,B5	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	B	B1,B2,B3,B4,B5	Site preparation (scalping, ripping, fence, logs)	■	■	■	■	■							
	B	B1,B2,B3,B4	Direct seeding					■	■						
	B	B1,B2,B3,B4,B5	Tubestock Planting (Initial Installation)					■	■	■	■				
	B	B1,B2,B3,B4,B5	Revegetation Monitoring			■	■	■				■	■	■	
	C	Whole of Area C	Woody weed control	■	■	■	■	■	■	■	■	■	■	■	■
	C	Remnant veg	Control of priority weeds	■	■	■	■	■	■	■	■	■	■	■	■
	C	C1,C2S,C2L	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	C	C1,C2S,C2L	Site preparation (scalping, ripping, fence, logs)	■	■	■	■	■							
	C	C2S,C2L	Direct seeding					■	■						
	C	C1,C2S,C2L	Tubestock Planting (Initial Installation)					■	■	■	■				
	C	C1,C2S,C2L	Revegetation Monitoring			■	■	■				■	■	■	
	D	Whole of Area D	Woody weed control	■	■	■	■	■	■	■	■	■	■	■	■
	D	Remnant veg	Control of priority weeds	■	■	■	■	■	■	■	■	■	■	■	■
	D	D1 - D15 (all sites)	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	D	D2 - D11	Site preparation (ripping, fence, logs)	■	■	■	■	■							
	D	D4	Direct seeding					■	■						
	D	D2 - D11	Tubestock Planting (Initial Installation)					■	■	■	■				
	D	D1 - D15 (all sites)	Revegetation Monitoring			■	■	■				■	■	■	

Bushmead Revegetation Schedule

Indicative Revegetation Schedule - shading indicates timeframe when works could take place

Year	Conservation Area	Site(s)	Revegetation Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2019	All	n/a	Provenance seed collection (if required)	■	■	■								■	■
	A	TEC & remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	A	A1,A2,A3,A4	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	A	A1,A4	Site preparation (scalping, ripping, fence, logs)	■	■	■	■	■							
	A	A1,A4	Direct seeding					■	■						
	A	A1,A4	Tubestock Planting (Initial Installation)					■	■	■	■				
	A	A2,A3	Tubestock Planting (Infill planting as required)					■	■	■	■				
	A	A1,A2,A3,A4	Revegetation Monitoring			■	■	■				■	■	■	
	B	TEC & remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	B	B1,B2,B3,B4,B5	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	B	B1,B2,B3,B4,B5	Tubestock Planting (Infill planting as required)					■	■	■	■				
	B	B1,B2,B3,B4,B5	Revegetation Monitoring			■	■	■				■	■	■	
	C	Remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	C	C1,C2S,C2L	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	C	C1,C2S,C2L	Tubestock Planting (Infill planting as required)					■	■	■	■				
	C	C1,C2S,C2L	Revegetation Monitoring			■	■	■				■	■	■	
	D	Remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	D	D1 - D15 (all sites)	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	D	D1,D12,D13, D14,D15	Site preparation (ripping, fence, logs as appropriate)	■	■	■	■	■							
	D	D12,D13,D15	Direct seeding					■	■						
	D	D1,D12,D13, D14,D15	Tubestock Planting (Initial Installation)					■	■	■	■				
	D	D2 - D11	Tubestock Planting (Infill planting as required)					■	■	■	■				
	D	D1 - D15 (all sites)	Revegetation Monitoring			■	■	■				■	■	■	
2020	All	n/a	Provenance seed collection (if required)	■	■	■								■	■
	All	Whole Conservation Area	Weed survey (2nd survey)								■	■			
	A	TEC & remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	A	A1,A2,A3,A4	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	A	A1,A2,A3,A4	Tubestock Planting (Infill planting as required)					■	■	■	■				
	A	A1,A2,A3,A4	Revegetation Monitoring			■	■	■				■	■	■	
	B	TEC & remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	B	B1,B2,B3,B4,B5	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	B	B1,B2,B3,B4,B5	Tubestock Planting (Infill planting as required)					■	■	■	■				
	B	B1,B2,B3,B4,B5	Revegetation Monitoring			■	■	■				■	■	■	
	C	Remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	C	C1,C2S,C2L	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	C	C1,C2S,C2L	Tubestock Planting (Infill planting as required)					■	■	■	■				
	C	C1,C2S,C2L	Revegetation Monitoring			■	■	■				■	■	■	
	D	Remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	D	D1 - D15 (all sites)	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	D	D1 - D15 (all sites)	Tubestock Planting (Infill planting as required)					■	■	■	■				
	D	D1 - D15 (all sites)	Revegetation Monitoring			■	■	■				■	■	■	
	D	Whole of Area D	Foreshore Condition Assessment (2nd survey)								■	■	■		

Bushmead Revegetation Schedule

Indicative Revegetation Schedule - shading indicates timeframe when works could take place

Year	Conservation Area	Site(s)	Revegetation Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021	All	n/a	Provenance seed collection (if required)	■	■	■								■	■
	A	TEC & remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	A	A1,A2,A3,A4	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	A	A1,A2,A3,A4	Tubestock Planting (Infill planting as required)					■	■	■	■				
	A	A1,A2,A3,A4	Revegetation Monitoring			■	■	■				■	■	■	
	B	TEC & remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	B	B1,B2,B3,B4,B5	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	B	B1,B2,B3,B4,B5	Tubestock Planting (Infill planting as required)					■	■	■	■				
	B	B1,B2,B3,B4,B5	Revegetation Monitoring			■	■	■				■	■	■	
	C	Remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	C	C1,C2S,C2L	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	C	C1,C2S,C2L	Tubestock Planting (Infill planting as required)					■	■	■	■				
	C	C1,C2S,C2L	Revegetation Monitoring			■	■	■				■	■	■	
	D	Remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	D	D1 - D15 (all sites)	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	D	D1 - D15 (all sites)	Tubestock Planting (Infill planting as required)					■	■	■	■				
	D	D1 - D15 (all sites)	Revegetation Monitoring			■	■	■				■	■	■	
2022	All	n/a	Provenance seed collection (if required)	■	■	■									
	A	TEC & remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	A	A1,A2,A3,A4	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	A	A1,A2,A3,A4	Tubestock Planting (Infill planting as required)					■	■	■	■				
	A	A1,A2,A3,A4	Revegetation Monitoring			■	■	■				■	■	■	
	B	TEC & remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	B	B1,B2,B3,B4,B5	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	B	B1,B2,B3,B4,B5	Tubestock Planting (Infill planting as required)					■	■	■	■				
	B	B1,B2,B3,B4,B5	Revegetation Monitoring			■	■	■				■	■	■	
	C	Remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	C	C1,C2S,C2L	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	C	C1,C2S,C2L	Tubestock Planting (Infill planting as required)					■	■	■	■				
	C	C1,C2S,C2L	Revegetation Monitoring			■	■	■				■	■	■	
	D	Remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■	■	■	■
	D	D1 - D15 (all sites)	Weed control (all weeds)	■	■	■	■	■	■	■	■	■	■	■	■
	D	D1 - D15 (all sites)	Tubestock Planting (Infill planting as required)					■	■	■	■				
	D	D1 - D15 (all sites)	Revegetation Monitoring			■	■	■				■	■	■	
2023	A	TEC & remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■			
	A	A1,A2,A3,A4	Weed control (all weeds)	■	■	■	■	■	■	■	■	■			
	A	A1,A2,A3,A4	Tubestock Planting (Infill planting as required)					■	■	■	■				
	A	A1,A2,A3,A4	Revegetation Monitoring			■	■	■				■			
	B	TEC & remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■			
	B	B1,B2,B3,B4,B5	Weed control (all weeds)	■	■	■	■	■	■	■	■	■			
	B	B1,B2,B3,B4,B5	Tubestock Planting (Infill planting as required)					■	■	■	■				
	B	B1,B2,B3,B4,B5	Revegetation Monitoring			■	■	■				■			
	C	Remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■			
	C	C1,C2S,C2L	Weed control (all weeds)	■	■	■	■	■	■	■	■	■			
	C	C1,C2S,C2L	Tubestock Planting (Infill planting as required)					■	■	■	■				
	C	C1,C2S,C2L	Revegetation Monitoring			■	■	■				■			
	D	Remnant veg	Woody & priority weed control	■	■	■	■	■	■	■	■	■			
	D	D1 - D15 (all sites)	Weed control (all weeds)	■	■	■	■	■	■	■	■	■			
	D	D1 - D15 (all sites)	Tubestock Planting (Infill planting as required)					■	■	■	■				
	D	D1 - D15 (all sites)	Revegetation Monitoring			■	■	■				■			
	D	Whole of Area D	Foreshore Condition Assessment (Final)								■	■			
	All	Whole Conservation Area	Weed survey (Final)								■	■			
	All	Whole Conservation Area	Handover to DBCA and Final Report									■			

Appendix 9
Potential Black Cockatoo Habitat surrounding Bushmead

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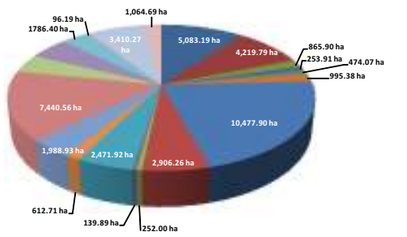
LEGEND

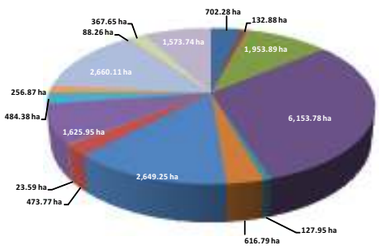
- 25 km from Site Centre
- 15 km from Site Centre
- 5 km from Site Centre
- Site Boundary
- Bush Forever Sites
- DPaW Managed Estates
- Local Reserves

Vegetation Complexes containing Potentential Black Cockatoo Habitat in Local Reserves, Bush Forever Sites and DPaW Managed Estates (48,921ha) within 15-25km of Bushmead



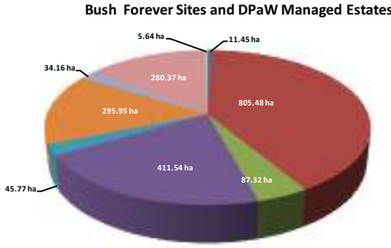
- Bassendean Complex - Central and South
- Bassendean Complex - North
- Bassendean Complex - North Transition Vegetation Complex
- Cook Complex
- Cottesloe Complex - Central and South
- Darling Scarp Complex
- Dwellingup Complex in Medium to High Rainfall
- Dwellingup Yalanbee and Hester Complex in Low to Medium Rainfall
- Forrestfield Complex
- Guildford Complex
- Helena Complex in Low to Medium Rainfall
- Helena Complex in Medium to High Rainfall
- Karrakatta Complex - Central and South

Vegetation Complexes containing Potentential Black Cockatoo Habitat in Local Reserves, Bush Forever Sites and DPaW Managed Estates (19,891ha) within 5 -15km of Bushmead



- Bassendean Complex - Central and South
- Cook Complex
- Darling Scarp Complex
- Dwellingup Complex in Medium to High Rainfall
- Forrestfield Complex
- Guildford Complex
- Helena Complex in Low to Medium Rainfall
- Helena Complex in Medium to High Rainfall
- Karrakatta Complex - Central and South
- Murray and Bindoon Complex in Low to Medium Rainfall
- Murray Complex in Medium to High Rainfall
- Pindalup and Yarragil Complex in Low to Medium Rainfall
- Southern River Complex
- Vasse Complex
- Yarragil Complex (Maximum Development Swamps) in Medium to High Rainfall
- Yarragil Complex (Minimum Development Swamps) in Medium to High Rainfall

Vegetation Complexes containing Potentential Black Cockatoo Habitat in Local Reserves, Bush Forever Sites and DPaW Managed Estates (1,977ha) with 5km of Bushmead



- Cook Complex
- Darling Scarp Complex
- Dwellingup Yalanbee and Hester Complex in Low to Medium Rainfall
- Forrestfield Complex
- Guildford Complex
- Helena Complex in Low to Medium Rainfall
- Murray and Bindoon Complex in Low to Medium Rainfall
- Southern River Complex
- Yarragil Complex (Minimum Development Swamps) in Medium to High Rainfall

WANNEROO
JOONDALUP
SWAN
TOODYAY
STIRLING
BAYSWATER
BASSENDEAN
MUNDARING
VINCENT
CAMBRIDGE
SUBIACO
PERTH
NEDLANDS
SPECIAL CASE
BELMONT
CLAREMONT
VICTORIA PARK
COTTESLOE
PEPPERMINT GROVE
SOUTH PERTH
KALAMUNDA
YORK
MOSMAN PARK
EAST FREMANTLE
CANNING
MELVILLE
FREMANTLE
GOSNELLS
COCKBURN
ARMADALE
BEVERLEY

RPS

ob Number: L1010806
Doc Number: EPRF-008
Date: 14.10.14
Scale: 1:200,000 @ A3
Created by: MA
Source: Orthophoto - Landgate, 2014 Managed Lands - DPaW, 2014 Bush Forever - DPI, 2009 Local Reserves - MRS, 2014

GDA 1994 MGA Zone 50
0 1.25 2.5 5 7.5 10 km

Figure 8

Potential Black Cockatoo Habitat Surrounding Bushmead

Appendix 10
LWMS (JDA, 2015)

Cedar Woods Properties Limited

Lot 911 Midland Rd, Hazelmere

Local Water Management Strategy

August, 2015

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DISCLAIMER

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JDA does not take responsibility for checking landscape and engineering plans attached to this report for accuracy or consistency with this report.

This Report is based on the current edition of Australian Rainfall & Runoff – A Guide to Flood Estimation (Engineers Australia, 1987).

Engineers Australia are currently revising this Document with a plan released date of December 2015. The new version of Australian Rainfall & Runoff may include different design methods and data for flood estimation in Australia including rainfall intensity, rainfall temporal patterns, rainfall runoff coefficients as well as a guideline for taking into account the effect of climate change on design rainfall and hence design floods depending on projected design life of land development. The revised version of Australian Rainfall & Runoff may include information which may require this Report to be revised.

QUALITY ASSURANCE

JDA provides quality assurance through all aspects of the company operation and is endorsed to AS/NZS ISO 9001:2008 Quality Assurance Accreditation, with third party certification to Bureau Veritas Quality International.

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Checked by	Scott Wills		31 August 2015
Approved by	Jim Davies		31 August 2015

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APPENDICES

EXECUTIVE SUMMARY

This Local Water Management Strategy (LWMS) is prepared by JDA Consultant Hydrologists on behalf of Cedar Woods in support of the Local Structure Plan (LSP) for Lot 911 Midland Road, Hazelmere. The lot is situated within the north-eastern corridor of the Perth Metropolitan Region, approximately 22 km north-east of the Perth CBD.

Lot 911 is approximately 271.9 ha with a developable area of 85.76 ha, referred to as the Study Area. The Study Area includes two portions of land located north and south of Kadina Brook, an ephemeral water course running through Lot 911.

The land has been rezoned from "Public Purposes: Commonwealth Government" to "Urban" under the Metropolitan Region Scheme (MRS). Town Planning Scheme (TPS) No. 17 Amendment 81 has been endorsed by the City of Swan (City of Swan, 2014). A Local Structure Plan is currently being considered by the City and the WAPC.

This LWMS provides the framework for the application of total water cycle management to the proposed urban structure, consistent with Department of Water (DoW) principles of Water Sensitive Urban Design (WSUD) as described in the Stormwater Management Manual of WA (DoW, 2007).

The preparation of this LWMS is consistent with the WAPC (2008) Better Urban Water Management framework and demonstrates the Study Area is capable of achieving appropriate water management outcomes with an urban land use.

Key Guiding Principles	
• Facilitate implementation of sustainable best practice urban water management. • Provide integration with planning processes and clarity for agencies involved with implementation. • Minimise public risk, including risk of injury or loss of life.	• Protect infrastructure and assets from flooding and inundation. • Encourage environmentally responsible development. • Facilitate adaptive management responses to the monitored outcomes of development.
Category	**LWMS Criteria**
Surface Water Management	• Manage surface water flows from major events to protect infrastructure and assets from flooding and inundation. • Maximise infiltration opportunities (where possible) for frequent events. • Maintain 1yr ARI event post development discharge relative to pre-development conditions • Manage 5yr and 100yr ARI peak flows from the Study Area.
Groundwater Management	• Minimise changes in groundwater levels and groundwater quality following development. • Subsurface drainage (subsoil drainage) and drainage infrastructure set at or above the AAMGL, although existing inverts below this level may remain. • Subsoil drainage outlets to be free draining.
Water Conservation	• Irrigated areas will be watered at an average rate of 6750 kL/ha/yr. • Use of water efficiency initiatives such as: • Hydro-zoning, • Use of drought-tolerant plants, • Rainwater harvesting and reuse, and • Community education initiatives.
Monitoring and Implementation	• Design methodology based on Water Sensitive Urban Design (WSUD) treatment train including: • Retention of 1yr 1hr ARI event, • Structural treatment measures (infiltration storages, bio-retention/treatment structures sized to minimum 2% of connected impervious area), and • Non-structural measures to reduce applied nutrient loads. • Maintain groundwater quality at pre-development levels (median winter concentrations) and, if possible, improve the quality of water leaving the Study Area to maintain and restore the ecological function of Kadina Brook

JDA has contacted Shire of Mundaring regarding the design capacity of the Helena Valley Rd crossing. The Shire has advised JDA that they have limited information available on the design capacity of the culverts. Analysis by JDA indicates that Lot 9500, a subdivision downstream of the Study Area, will jeopardise the serviceability of Helena Valley Road. JDA recommends City of Swan advise Shire of Mundaring that if Lot 9500 subdivision proceeds a detailed assessment of the Helena Valley Rd culverts level of service is undertaken.

1. INTRODUCTION

1.1 Background

This Local Water Management Strategy (LWMS) was prepared by JDA Consultant Hydrologists on behalf of Cedar Woods in support of the Local Structure Plan (LSP) for Lot 911 Midland Road, Hazelmere City of Swan. A portion of the lot will be developed as part of the LSP herein referred to as the Study Area (Figure 1).

The LWMS provides the framework for the application of total water cycle management to the proposed urban structure, consistent with the Department of Water (DoW) principles of Water Sensitive Urban Design (WSUD), described in the Stormwater Management Manual (DoW, 2007).

1.2 Statutory Framework

1.2.1 District Planning

A District Water Management Strategy (DWMS) was prepared by RPS (2012) and accepted by the City of Swan (CoS) and the Department of Water (DoW). This document provides guidance on water reuse options, sizing of stormwater treatment measures, water quality monitoring and vegetation treatments for stormwater structures.

The DWMS supports the MRS rezoning application from 'Public Purpose: Commonwealth Government' to 'Urban' in order to permit residential development of the site.

The DWMS is consistent with Metropolitan Region Scheme (MRS) Amendment 1242/41 and Amendment 81 to Town Planning Scheme (TPS) 17. MRS Amendment 1242/41 rezoned Lot 911 from 'Public Purpose: Commonwealth Government' to 'Urban'. TPS Amendment 81 rezoned Lot 911 from 'Public Purpose: Commonwealth Government' to 'Special Use', 'General Rural' and 'Regional Reserve' zones.

1.2.2 Local Structure Plan

The Local Structure Plan (LSP) (Roberts Day, 2015) is presented to fulfil commitments made in the TPS which allow for the development of the Study Area.

The LWMS is presented in support of the LSP as part of the Better Urban Water Management Framework.

The LWMS addresses the LSP area and provides a refinement of the flood modelling, surface water management and groundwater management presented in the DWMS. This LWMS is consistent with water sensitive urban design practises as described in the Stormwater Management Manual of WA (DoW, 2007).

1.3 Key Principles and Objectives

The LWMS uses the following documents to define its key principles and objectives:

- Stormwater Quantity Management Manual for WA (Department of Water, 2007)
- Better Urban Water Management (WAPC, 2008).
- Liveable Neighbourhoods Edition 4 (WAPC, 2009)
- District Water Management Strategy (RPS, 2012)

A summary of the key design principles and objectives from these documents is provided in Table 1 and summarised below.

1.3.1 Stormwater Quality Management Manual for WA (DoW, 2007)

The Water and Rivers Commission, now the Department of Water (DoW), released *A Manual for Managing Urban Stormwater Quality in Western Australia* in 1998 to define Best Management Practices (BMP's) necessary to reduce pollutant and nutrient inputs to stormwater drainage systems. The Manual also provides guidelines for the incorporation of water sensitive design principles into urban planning and design, to promote the improvement of water quality from urban development.

The document was released to provide a guideline for best planning and management practices for use by Water and Rivers Commission, other State and Local Government Authorities and sectors of the urban development industry.

DoW completed a major review of the Manual in consultation with a working team comprising industry and government representatives, published in August 2007.

Principle objectives for managing urban water in Western Australian are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within the Study Area relative to pre-development conditions.
- Water Quantity: To maintain the total water cycle balance within the Study 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 systems that are economically viable in the long term.
- Public Health: To minimise the public risk, including risk of injury or loss of life to the community.
- Protection of Property: To protect the built environment from flooding and waterlogging.
- Social Values: To ensure 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.

1.3.2 Better Urban Water Management (WAPC, 2008)

The guideline document Better Urban Water Management (WAPC, 2008), focuses on the process of integration between land use and water planning and specifying the level of investigations and documentations required at various decision points in the planning process, rather than the provision of any specific design objectives and criteria for urban water management.

This LWMS complies with the BUWM process.

1.3.3 Liveable Neighbourhoods (WAPC, 2009)

The LWMS has been developed in accordance with regional and local principles and objectives of Integrated Urban Water Management (IUWM) established in the guideline document, Liveable Neighbourhoods (WAPC, 2009).

IUWM (also known as total water cycle management) is defined as promoting '*management of the urban water cycle as a single system in which all urban water flows are recognised as a potential resource and where the interconnectedness of water supply, stormwater, wastewater, flooding, water quality, waterways, estuaries and coastal waters is recognised*'.

IUWM also promotes water conservation measures, reuse and recycling of water and best practice in stormwater management.

The objectives in the LWMS are consistent with Liveable Neighbourhoods.

1.3.4 Lot 911 Midland Road, District Water Management Strategy (RPS, 2012)

The DWMS was prepared to support rezoning of Lot 911, Hazelmere and demonstrate that the Study Area was capable of supporting the proposed urban zoning.

The aim of the DWMS as summarised in the strategy is to:

1. Define land area requirements for conveyance of flood flows and protection of future development from peak flood events;
2. Propose a drainage design strategy appropriate for local conditions in the strategy area that incorporates best practice water sensitive urban design measures. This strategy should identify Water Sensitive Urban Design (WSUD) practices to be implemented within both private allotments and the public domain, and the legal mechanisms by which all identified practices will be implemented;
3. Prescribe the design criteria for water quantity and water quality for each catchment;
4. Outline the hydrologic and hydraulic framework parameters and subsequently develop the overall drainage network concept;
5. Define an implementation framework for the drainage design objectives; and
6. Recommend monitoring programs for water quantity and water quality at pre-development, development and post-development stages as well as for ensuring hydraulic performance over the lifetime of the drainage structures.

TABLE 1: SUMMARY OF LWMS PRINCIPLES AND OBJECTIVES

Key Guiding Principles		
• Facilitate implementation of sustainable best practice in urban water management. • Provide integration with planning processes and clarity for agencies involved with implementation. • To minimise public risk, including risk of injury or loss of life. • Protection of infrastructure and assets from flooding and inundation. • Encourage environmentally responsible development. • Facilitate adaptive management responses to the monitored outcomes of development.		
Category	**DWMS Objectives**	**LWMS Criteria**
Surface Water Management	• Minimise changes in hydrology to prevent impacts on receiving environments. • Manage water flows from major events to protect infrastructure and assets. • Apply the Principles of WSUD. • Adopt nutrient load reduction design objectives for stormwater runoff. • Floodplain management and urban drainage.	• Manage 5yr and 100yr ARI peak flows from the Study Area. • First 15mm of rainfall to be infiltrated at source where possible. • Manage surface water flows from major events to protect infrastructure and assets from flooding and inundation. • Use swales, living streams and ephemeral storage areas (buffers, POS, etc) to attenuate and infiltrate prior to discharge into Kadina Brook
Groundwater Management	• Manage groundwater levels to protect infrastructure and assets. • Maintain groundwater regimes for the protection of groundwater-dependent ecosystems. • Protect the value of groundwater resources. • Adopt nutrient load reduction design objectives for discharges to groundwater.	• Minimise changes in groundwater levels and groundwater quality following development. • Subsurface drainage (subsoil drainage) and drainage infrastructure set at or above the AAMGL, although existing inverts below this level may remain. • Subsoil drainage outlets to be free draining.
Water Conservation	• Develop a water conservation strategy. • Progress water supply and sewage disposal strategy.	• Irrigated areas will be watered at an average rate of 6750 kL/ha/yr. • Use of water efficiency initiatives such as: • Hydro-zoning, • Use of drought-tolerant plants, • Rainwater harvesting and reuse, and • • Community education initiatives.
Monitoring and Implementation	• Adopt an adaptive management approach. • Maintain drainage and treatment structures.	• Design methodology based on Water Sensitive Urban Design (WSUD) treatment train including: • Retention of the first 15mm of rainfall, • Structural treatment measures (infiltration storages, bio-retention/treatment structures sized to minimum 2% of connected impervious area), and • Non-structural measures to reduce applied nutrient loads. • Maintain groundwater quality at pre-development levels (median winter concentrations) and, if possible, improve the quality of water leaving the Study Area to maintain and restore the ecological function of Kadina Brook.

2. PROPOSED DEVELOPMENT

The total site area (Lot 911) is approximately 271.9 ha with development over the Study Area (85.8 ha). The Study Area is made up of 49.9 ha in the north and 35.9 ha in the south of the site. Lot 911 is situated within the north-eastern corridor of the Perth Metropolitan Region, approximately 22 km north-east of the Perth CBD.

Lot 911 is bounded by Midland Road to the west, Sadler Drive to the south and mostly cleared or developed land to the east (Figure 1). Kadina Brook, a minor tributary of the Helena River flows through the centre of the site.

The proposed land use is for residential development consistent with regional planning. The Local Structure Plan for the Study Area (Roberts Day, 2014) is included as Appendix B.

Key elements of the Structure Plan related to urban water management include:

- Use of bio-retention treatment basins and swales for detention and treatment of stormwater;
- Retention of the Kadina Brook alignment and hydraulic capacity through the site including the implementation of a 50 m vegetation buffer;
- Use of higher density urban residential zonings to reduce landscape nutrient input at a domestic scale, and
- The extensive use of local native species in open spaces, streetscapes and vegetation buffers.

3. PRE-DEVELOPMENT ENVIRONMENT

3.1 Existing Land Use

Historically, Lot 911 has been used as a rifle and pistol range by the Commonwealth Department of Defence and the Western Australian Police Department since it was established in 1915 (RPS, 2012). Midland Abattoirs also held a licence for the disposal of livestock effluent in the south-eastern portion of the site from 1970 to 1982. This coincided with the majority of the site being leased for the grazing of livestock.

The site is no longer leased for grazing of livestock and does not function as a rifle range.

Site investigation by Golder Associates (2014) evaluated existing site conditions within the Lot. The north Study Area varies from cleared sandy surfaces with sparse grass cover and scattered stands of eucalyptus trees to relatively thick bushland towards the south. The majority of the south Study Area is open grassland, with small stands of large mature trees scattered over a significant portion of the area. Heavily vegetated bushland exists to the east (Figure 2).

An existing Water Corporation easement traverses through the centre of the Lot in an east to west direction.

3.2 Topography

Topographic contours at 1m intervals indicate that ground levels across the north Study Area generally grades from south to north, with a highpoint of 36 mAHD at the southern boundary to 21 mAHD in the northern corner. The south Study Area generally grades from east to west, with natural surface at 90 mAHD along the eastern boundary sloping to 37 mAHD near Kadina Brook in the western corner (Figure 2).

Topographic contours for the remaining area of Lot 911 are based on the Department of Planning (2008) data set, available in 5m intervals. The accuracy of this data is considered appropriate for decision making at the LWMS level.

3.3 Climate

The site is characterised by a Mediterranean climate with warm dry summers and cool wet winters.

Rainfall data provided is from the nearby Bureau of Meteorology Perth Airport station (Site No. 9021).

The long term average annual rainfall for this site is 770 mm. The average annual rainfall has decreased since 1975, with the average annual rainfall of 720 mm, reflecting a 6% reduction compared to the long term average.

The seasonal rainfall distribution has altered since 1975, with a reduction of average monthly totals in the winter months from April to October, and an increase in monthly rainfall in the drier summer months from November to March.

The average annual pan evaporation for Upper Swan is approximately 2,080 mm (Luke et al., 1988).

3.4 Surface Geology

Surface geology mapping by Gozzard (1986) is shown on Figure 3.

The north Study Area is underlain by Bassendean Sands (S8) and Bassendean Sands overlying clays of the Guildford Formation (S10). The Bassendean Sands are characterised as “very light at surface, yellow at depth, fine to medium grained, sub-rounded quartz moderately well sorted of Aeolian origin” (Gozzard, 1986).

The south Study Area is primarily underlain by the Yoganup Formation (S12), with gravel (G2) located on the western edge, and laterite (LA1) at the eastern edge. The Yoganup Formation is characterised as “yellow, fine to medium grained, sub-angular to rounded quartz, with some feldspar, well sorted, variable silt content, of colluvial origin” (Gozzard, 1986).

Preliminary geotechnical investigation conducted by Golder Associates between 12 and 20 February 2014 included the excavation of 100 test pits (TP01 to TP100, see Figure 3) extending from depths of 0.4m to 3.0m. Results for both the north and south Study Areas are generally in accordance with Gozzard (1986) mapping. The geotechnical report is included on CD as Appendix C.

The north Study Area is summarised by Golder Associates as:

- Topsoil – Sand: fine to medium grained, grey, dark grey and grey-black, with some silt, generally minor organic content, abundant roots and rootlets at some locations, loose, extending to depths of between about 0.1 m to 0.2 m (not present in all locations),overlying
- Sand: fine to medium grained, pale-grey locally becoming pale yellow at depth, trace silt, some locations containing large roots in part, generally becoming medium dense to dense, extending to depths of between about 0.1 m and the maximum depth investigated of about 2.5 m (generally about 0.5 m to 1.0 m thick but not encountered at some locations), overlying
- Gravelly sand/ sand gravel/ silty sandy gravel: fine to coarse, very well cemented laterite gravel, grey and brown, fine to coarse grained sand, variable fines content up to about 15% non-plastic silt, becoming clayey sandy gravel at depth at some locations, gravel content increasing with depth, medium dense to dense, present at the surface at some locations across the southern part of the area, extending to depths of between about 0.5 m and 1.5 m where present (not present at all locations), overlying
- Silty sand/ clayey sand/ cemented clayey sand/ clayey gravelly sand: fine to coarse grained, mottled blue-grey, orange-brown and red, generally between about 15% and 30% low plasticity fines (up to between about 30% and 40% clayey fines at some locations), with variable amounts of fine to coarse, colluvial gravel, dense to very dense, very weakly cemented in part, extending to the maximum depths investigated of 2.5 m and often caused shallow refusal of the backhoe when cemented (as shallow as 0.4 m on some locations).

The south Study Area is summarised by Golder Associates as:

- Topsoil – Sand: fine to medium grained, grey, dark grey and grey-black, with some silt, generally minor organic content, abundant roots and rootlets at some locations, loose, extending to depths of up to 0.2 m (not present in all locations),overlying
- Sand: fine to medium grained, pale-grey locally becoming pale yellow, trace/with some silt, some locations containing large roots in part, generally loose becoming medium dense to dense, extending to depths of between about 0.6 m and the maximum depth investigated of 2.5 m, overlying

- Clayey sand/ silty clayey sand/ sand: fine to medium grained, yellow-orange, between about 10% and 15% low plasticity fines, extending to depths of between about 1.1 m and the maximum depth investigated of 3.0 m, overlying
- Cemented clayey sand/ clayey sand: fine to medium grained, yellow-orange, about 15% to 30% low plasticity fines, generally medium dense to very dense, very weakly to moderately cemented at some locations, not encountered at all locations, generally extending to the maximum depths investigated between 1.9 m and 2.6 m.

RPS (2012) conducted a preliminary Phosphorus Retention Index (PRI) assessment of the soil. The PRI indicates the ability of the soil to absorb phosphorus and thus preventing nutrients being leached into the groundwater. Measured PRI varied significantly from 0.2 to 849. The low PRI generally corresponds to fine to medium-grained sands while a high PRI is generally associated with clay (due to the presence of iron).

3.5 Acid Sulphate Soils

According to mapping published by the Department of Water (2010), the majority of the Study Area has a moderate to low risk of ASS occurring less than 3m from surface in the central to northern portion of the Lot.

Regional Acid Sulphate Soil mapping is shown on Figure 4.

The Environmental Protection Authority (EPA) determined that no environmental assessment was necessary for the proposed MRS and TPS rezonings (WAPC, 2013). EPA's assessment did not raise any concerns regarding ASS.

Detailed ASS investigations will be undertaken at the time of subdivision. In the event that any ASS is encountered an Acid Sulphate Soil Management Plan will be prepared and implemented as part of the subdivision process in accordance with WAPC bulletin No. 64 (WAPC, 2003).

A preliminary ASS assessment (Golder Associates, 2014) indicates that ASS is absent within the Study Area to the maximum depth of investigation of 2.5m. Results suggest that soil conditions in the Study Area may be naturally acidic due to the presence of organic acids from the oxidisation of organic matter. No further investigations for ASS are suggested at this stage unless excavation below 2.5m of the current ground surface occurs.

3.6 Surface Water Hydrology

3.6.1 Existing Surface Drainage

The Lot is intersected by Kadina Brook, an ephemeral water course which generally flows during the wetter winter months. Natural drainage lines branch from the brook with excavated drains at the southern end of the north Study Area providing discharge from various sites to Kadina Brook (Figure 5).

Due to the low permeability soils, rainfall runoff is likely to occur as lateral sheet flow or shallow sub-surface flow towards low lying or depressed areas.

The Department of Water has confirmed that no flood modelling is available for Kadina Brook (RPS, 2012). In order to determine the capacity of the pre-development Kadina Brook system a catchment flood model was developed by JDA (Appendix D) which estimates Kadina Brook 100yr ARI flows of 7.22 m^3/s and 7.18 m^3/s upstream and downstream of the Study Area respectively (Figure 6). The Helena Valley Rd crossing, downstream of the Study Area, remains serviceable during the 100yr ARI flow. The 100yr ARI flow at Helena Valley Rd culvert is attenuated to 4.48 m^3/s, with no overflow of the road.

3.6.2 Surface Water Quality

Surface water quality in Kadina Brook was measured upstream and downstream of the Study Area by RPS on two occasions (August 2011; included in the DWMS and August 2013; after the DWMS) as part of pre-development monitoring. Water quality data is presented in Table 2.

TABLE 2: PRE-DEVELOPMENT SURFACE WATER QUALITY SUMMARY

Parameter	*ANZECC Guideline Trigger Value*[1]	Swan Canning WQIP[2]	Upstream		Downstream	
			August 2011	August 2013	August 2011	August 2013
Physical Properties						
pH	*6.5 - 8.0*	-	-	6.79	-	6.81
EC (ms/cm)	*0.12 - 0.30*	-	-	0.33	-	0.38
Nutrients						
Total N (mg/L)	*1.2*	*1.0*	0.70	1.50	0.60	0.20
TKN (mg/L)	-	-	0.20	1.00	0.30	0.20
NO_x_N (mg/L)	*0.15*	-	0.48	0.49	0.29	<0.01
Ammonia_N (mg/L)	*0.08*	-	-	0.11	-	0.04
Total P (mg/L)	*0.065*	*0.1*	0.37	0.50	0.33	0.12
PO_4_P (FRP) (mg/L)	*0.04*	-	-	0.14	-	0.01

1. Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) - Trigger values for freshwater for a 95% level of protection (slightly to moderately disturbed ecosystem), values adopted for Lowland River, South West Australia.
2. Swan Canning Water Quality Improvement Plan (WQIP) (Swan River Trust, 2009) - Water quality and nutrients load targets, Table 14, Target for median TP and TN concentrations, Helena River.
3. Shaded values exceed ANZECC guideline values.

Compared to ANZECC (2000) water quality guideline trigger values for lowland river ecosystems water quality in Kadina Brook generally exceeds trigger values with the exception of TN which only exceeded trigger values on one occasion. Results indicate that water quality improves from the upstream to the downstream site, possibly associated with dilution of previous abattoir effluent disposed in the south east corner of the Study Area.

3.7 Wetlands

Apart from Kadina Brook no other wetlands exist within the site (Figure 7). Conservation and Resource Enhancement Wetlands are located outside the Lot towards the confluence of Kadina Brook and Helena River (DEC, 2012).

Bush Forever Site (BFS) 213 currently occupies a large portion of the total Lot area (Figure 7). MRS Amendment 1242/41 resulted in an update to the BFS 213 site boundaries, reducing the extent of BFS 213 in Lot 911 and including the 50m buffer around Kadina Brook, up to the Study Area boundary (WAPC, 2013).

3.8 Groundwater Hydrology

The geological formations have been grouped into two distinct aquifers, each being assigned the name of the major geological unit contributing to it. In descending order of depth from natural surface they are:

- Superficial Aquifer (unconfined)
- Leederville Aquifer (confined)

3.8.1 Superficial Aquifer

At the Study Area, the Superficial Formation comprises clayey sediments of the Guildford Clay that inter-fingers to the west with sandy sediments of the Bassendean Sand. The Superficial Formation forms an unconfined aquifer containing generally fresh groundwater (250 to 500 mg/L Total Dissolved Solids).

The Study Area is within the Cloverdale groundwater flow system (Davidson, 1995). Recharge in this flow area is estimated at approximately 4% of rainfall (Davidson, 1995).

Previous groundwater monitoring in the Study Area was reported by RPS (2012) for a period of 18 months.

To further refine regional groundwater design levels over the Study Area, local groundwater investigations by JDA commenced April 2014 and will continue for 12 months. In total 21 shallow (s) and deep (d) groundwater monitoring bores have been installed across Lot 911 (Figure 8). Water levels are now measured quarterly in all 21 bores with 5 bores having water level loggers installed for continuous monitoring (Table 3).

To date, the highest groundwater level in all bores was recorded on 15 July 2014, as presented in Table 3.

Groundwater bore logs are provided in Appendix E.

TABLE 3: DETAILS OF GROUNDWATER MONITORING BORES

Bore ID	Date Installed (Mth-Yr)	Company	GDA Coordinates		Natural Surface (mAHD)	Total Depth (mBTOC)	Top of Casing (mAHD)	Screened Interval (mBTOC)	Water Level 15 July 2014 (mAHD)	AAMGL (mAHD)
			Easting	Northing						
B1A[1]	Mar-06	ERM	407512	6468075	26.95	11.39	27.6	6.0 – 11.0	16.96	18.13
B1B	Mar-14	JDA	408024	6467696	26.25	12.00	26.19	9.0 – 12.0	19.42	20.59
B2(s)	Oct-10	RPS	407968	6467132	32.05	5.14	32.79	0.5 – 4.5	<27.65	<28.82
B2(d)	Mar-14	JDA	407970	6467135	32.09	13.00	32.67	10.0– 13.0	21.35	22.52
B4	-	-	408465	6466472	38.22	15.90	38.61	-	<22.71	<23.88
B5	Oct-10	RPS	407532	6467384	33.45	13.40	34.00	10.0 –13.0	20.71	21.88
B06[2]	-	-	407177	6468748	20.91	10.50	21.55	-	14.58	15.75
B07[2]	-	-	407150	6468386	23.91	13.44	24.52	-	16.44	17.61
B08[2]	-	-	407379	6468553	22.59	7.81	23.12	-	15.93	17.1
B8(s)	Apr-14	JDA	407496	6467658	28.46	1.60	29.13	1.1 – 1.6	26.98	28.15
B8(d)	Mar-14	JDA	407497	6467657	28.48	11.5	29.10	5.5 – 12.0	18.61	19.78
B9(s)	Apr-14	JDA	407769	6467789	26.36	1.20	26.99	0.7 – 1.2	<25.79	<26.96
B9(d)	Mar-14	JDA	407771	6467789	26.36	12.00	26.91	6.0 – 12.0	18.2	19.37
B10(s)	Apr-14	JDA	407823	6468075	22.29	2.00	22.99	1.5 – 2.0	<20.99	<22.16
B10(d)	Mar-14	JDA	407825	6468073	22.38	12.00	22.89	6.0 – 12.0	17.46	18.63
B12A[2]	-	-	407514	6467701	30.21	18.69	30.79	-	18.13	19.3
B12B[2]	-	-	407602	6467487	29.86	3.17	30.42	-	<27.25	<28.42
B13[1]	Mar-06	ERM	407992	6466739	31.36	9.70	31.97	4.5 – 10.6	22.95	24.12
B14[1]	Mar-06	ERM	407591	6468121	25.26	10.65	25.71	5.0 – 10.0	16.97	18.14
B15[2]	-	-	407556	6468124	25.41	4.07	26.02	-	<21.95	<23.12
B16[1]	Mar-06	ERM	407745	6467917	25.65	7.07	26.09	2.5 – 6.3	<19.02	<20.19

mAHD = metres Australian Height Datum.
mBNS = metres below natural surface.
mBTOC = metres below top of casing.
[1] Bores B1, B13, B14 and B16 previously known as MW1, MW4, MW2 and MW3 respectively.

[2] No bore logs exist for B4, B06, B07, B08, B12A, B12B and B15. Highlighted bores contain water level loggers

[3]Bore details were surveyed in July 2014 by McMullen Nolan

To estimate the average annual maximum groundwater level (AAMGL) for the regional water table, water levels recorded in July 2014 were correlated to historic data from bores B1 and B5. RPS peak winter readings from 2011 occurred during an average rainfall were used for correction, given the absence of nearby DoW long-term monitoring bores. Based on the water levels recorded in bores B1 and B5 during winter 2011 (Table 4) a correction of +1.17 m was applied to the water levels measured in the monitoring bores on the 15 July 2014 to estimate the AAMGL (Table 3). AAMGL contours are shown in Figure 8.

TABLE 4: PRE-DEVELOPMENT AAMGL CORRECTION

Bore	Annual Maximum Groundwater Level (mAHD)		Correction (m)
	2011	2014	
B1	18.29	16.96	+1.33
B5	21.72	20.71	+1.01
Average			**+1.17**

Investigations by RPS (2012) and Golder Associates (2014) identified a low permeability layer which may cause a shallow perched groundwater table to form. Figure 8 shows the depth to the low permeability layer.

JDA investigated a shallow perched groundwater table above the regional groundwater table in six paired bores (B1, B2, B8, B9, B10 and B12). Initial results indicate perching is evident in bores B1, B8 and B12 with the perched layer persisting for different periods of time. The perched watertable will be further assessed and documented in future UWMPs.

For the purposes of design of the groundwater and surface water management systems the top of the low permeability layer is used as the design groundwater level until further investigations are completed. This level should also be the reference point for specifying fill levels required to meet design criteria.

3.8.2 Water Quality

Groundwater quality was monitored quarterly between October 2010 and February 2012 by RPS (2012) providing a dataset based on 6 sampling occasions across 5 bores (B1, B1B, B2, B4 and B5). Results from the investigation are presented in Table 5.

TABLE 5: AVERAGE PRE-DEVELOPMENT GROUNDWATER QUALITY

Parameter	*ANZECC Guideline Trigger Value*	Swan Canning WQIP[4]	B1 (deep)	B1B (shallow)	B2 (shallow)	B4 (deep)	B5 (deep)
Total N (mg/L)	*1.20*	1.00	0.98	2.10	3.40	1.35	1.14
TKN (mg/L)	-	-	0.98	0.85	1.85	1.17	1.98
NOx-N (mg/L)	*0.15*	-	0.04	1.25	1.54	0.20	0.03
NH_3 (mg/L)	*0.08*	-	0.07	0.02	0.23	0.08	0.10
Total P (mg/L)	*0.065*	0.10	1.94	3.61	5.00	1.38	0.66
PO_4-P (FRP) (mg/L)	*0.040*	-	0.03	0.03	0.03	0.09	0.03

1. Values adopted for Lowland River, South West Australia.
2. ANZECC (2000) trigger values for freshwater for a 95% level of protection (slightly to moderately disturbed ecosystem).
3. Shaded values exceed ANZECC guideline values.
4. Swan Canning Water Quality Improvement Plan (WQIP) (Swan River Trust, 2009) - Water quality and nutrients load targets, Table 14, Target for median TP and TN concentrations, Helena River.

Results show that groundwater quality is generally worse than both the Swan Canning WQIP water quality targets and the ANZECC (2000) water quality guideline values for lowland river ecosystems. Historical contamination of the site from former land uses including the disposal of livestock effluent and grazing of livestock is likely to be the cause of current groundwater quality (RPS, 2012).

The DWMS identifies that groundwater is not a component of Kadina Brook hydrology. In the southern cell, groundwater is greater than 15.9m below natural surface and contaminated groundwater will not be mobilised to the brook.

3.8.3 Leederville Aquifer

The Leederville Aquifer is of Cretaceous age and consists of inter-bedded sandstone, siltstone and shales made up by the Mariginiup, Wanneroo and Pinjar members. The Leederville Aquifer is a major regional aquifer reserved for public water supply and new allocations are generally not permitted. The groundwater

in the Leederville Formation is confined with the potentiometric surface in this area at approximately ground level (Davidson, 1995).

3.8.4 Groundwater Resources for Irrigation

Public Open Spaces

Water Resource Allocation records provided by DoW indicated the Superficial Aquifer is currently over allocated in the Swan South Sub-Area, with 374% of the allocation limit (349,300 kL) already allocated and committed.

Cedar Woods is currently negotiating confidentially to purchase groundwater licence holders in the area.

The development has adopted various measures to minimise irrigation requirements such as:

- Irrigation rate of 6,750 kL/ha/yr consistent with DoW irrigation targets;
- Reducing POS to an 8% provision across the Local Structure Plan Area;
- Use of native species and xeriscaping; and
- Mandating the incorporation of rainwater tanks for each dwelling plumbed into the dwelling.

4. LOCAL WATER MANAGEMENT STRATEGY

4.1 Water Balance

The water balance of Lot 911 will be influenced by the frequency and intensity of rainfall and evapotranspiration. The site has been considered on a regional scale with average annual estimates of rainfall, evaporation, transpiration and recharge used, considering the site as a whole.

Pre-development Water Balance Assumptions

- Rainfall based on the long term annual average for Perth Airport Station of 770 mm.
- Recharge is 4% of rainfall as estimated in Davidson (1995).
- Evapotranspiration is 57% of rainfall.
- The balance of inputs is discharged as surface runoff to Kadina Brook.

Post-development Water Balance Assumptions

- Recharge is 4% of rainfall as estimated in Davidson (1995).
- Evapotranspiration decreases to 37% due to reduction of vegetation.
- The balance of inputs will be discharged via subsoil drainage.

Results of the water balance are presented in Table 6.

TABLE 6: TOTAL SITE (LOT 911) WATER BALANCE

Pre-Development		Use	Area (ha)	Quantity (mm/yr)		Total (kL/yr)	% (Approx)
Inputs	Rainfall		272	770		2,094,400	100
					Input total	2,094,400	
Outputs	Evapotranspiration	*Bush*	217	400		868,000	41
		Cleared Pasture	55	600		330,000	16
	Superficial aquifer recharge					83,776	4
	Surface Runoff					812,624	39
	Total		272		**Output total**	2,094,400	100
					Balance	0	
Post-Development		**Use**	**Area (ha)**	**Quantity (mm/yr)**		**Total (kL/yr)**	**% (Approx)**
Inputs	Rainfall		272	760		2,094,400	98
	Irrigation of POS		7.7[1]			51,975[2]	2
					Input total	2,146,375	100
Outputs	Evapotranspiration	*Residential gardens*	5.0	1,200		60,000	3
		POS	10	1,200		12,000	1
		Bush	188	400		752,000	35
	Superficial aquifer recharge					83,776	4
	Surface Runoff					1,066,889	49
	Subsoil Discharge					171710	8
	Total		272		**Output total**	2,146,375	100
					Balance	0	

Notes: [1] Preliminary estimate of POS irrigation areas. [2] Water requirement based on 6,750 kL/ha/yr.

4.2 Water Supply and Wastewater

Public Open Spaces

Considering the fit for purpose strategy, water for irrigation of public open spaces is proposed to be sourced from groundwater allocation. Based on a preliminary estimate of 6.41 ha of POS and road verges for irrigation at 6750 kL/ha/yr, the total required allocation is 43,257 kL/yr (Appendix F). If more groundwater is secured (see section 3.8.4), landscaping arrangements may be revised to increase the irrigation area.

Residential Lots

Water supply to households is to be via extension of the scheme water system. The project civil engineer will negotiate the extension of the system with Water Corporation.

Wastewater from households will be removed via extension of Water Corporation's Sewer System. The project engineer will negotiate the extension of the system with Water Corporation.

4.3 Water Efficiency Measures

Public Open Spaces

The Study Area has a POS area of 110,043 m^2 (11.00 ha).

Landscaped Public Open Space areas are to be at least 80% native plants, with a water wise irrigation system design. POS landscaping concepts are attached as Appendix G with the estimated irrigated area attached as Appendix F.

Residential Lots

To achieve water efficiency targets, households are to be built consistent with current BCA water efficiency standards. Water efficiency initiatives are proposed to reduce potable water demand for irrigation of residential lots. These include:

- Minimising turf areas,
- Selection of predominantly local native, drought tolerant plants,
- Use of waterwise gardens, restricted lawn areas and water wise lawn varieties,
- Rainwater harvesting and reuse at lot-level, and
- Community education initiatives on water conservation and reuse.

Consistent with Cedar Woods' sustainability objectives for the project, lots 300m^2 and over will be provided with rainwater tanks to further assist in retaining small rainfall events on site. Cedar Woods has also advised that it will mandate, through covenants/sales contracts, a requirement for rainwater tanks to be plumbed into the dwelling for toilet flushing.

4.4 Stormwater Management

4.4.1 Local Stormwater Management

The stormwater drainage system has been designed using a major/minor approach. The major drainage system includes the use of roads, swales, drainage reserves, detention basins and open spaces to provide safe passage of stormwater runoff from major storm events greater than 5yr ARI and up to the 100yr ARI. The major drainage system is described below with the key elements of the drainage system shown in Figure 9.

Major Drainage System

Key points of the major drainage system strategy are as follows:

- Roads graded to direct flow overland to the lowest point in each catchment. The ultimate road low point will be adjacent to POS, with overflow flood storage provided within the POS. The POS design should aim to create flood storage in an informal manner, minimising formal drainage basin areas;
- All lot finished levels will have a minimum 0.3 m clearance above the estimated 100yr ARI flood level in the road and POS;
- Overflow of rainfall events greater than 15mm to Kadina Brook.
- Post-development peak flow of Kadina Brook contained within the 50 m conservation buffer of Kadina Brook;
- Flood detention storage located in N3 and S2 to reduce overflow to Kadina Brook during major events (Table 10);
- Crossings of Kadina Brook (vehicle and pedestrian) to be used to manage the 100yr ARI flow by restricting flow where appropriate (Section 4.4.3); and
- All lot finished levels will have a minimum 0.5 m clearance above the estimated 100yr ARI flood level of the detention storages and Kadina Brook (Section 4.4.2 and 4.4.3).

The design strategy is consistent with the objectives provided in the DWMS (RPS, 2012) and the adopted Conservation Management Plan (Epcad, 2015).

Minor Drainage System

The minor drainage system is defined as the series of swales, kerbs (flush or no kerb), pipes and gutters designed to convey runoff generated by minor storms up to and including the 5yr ARI storm event. The minor drainage system incorporates a treatment train of best management practice (BMP) water quality structural controls such as vegetated swales and storage systems that provide water quality treatment in the Study Area.

Key points of the minor drainage system strategy are as follows:

- Where depth to AAMGL is greater than 1.5 m and soils are sandy (Class A lots), lots will use soakwells to infiltrate the 1yr 1hr ARI storm event;
- Lots with insufficient depth to AAMGL (<1.5 m) and/or the impermeable clay layer (Class S lots), will have a point of discharge to the road drainage network;
- Lots ≤ 300m^2 will have a point of discharge to the road drainage network;
- Drainage treatment train of roadside swale, central median swales and raingardens with capacity to treat 15 mm of rainfall;
- Extensive use of roadside swales and central median swales to limit the use of pipes drains as far as practical. Swale concepts are provided in Appendix H. Appendix H shows the indicative location and preliminary cross sections for the swales. The final location and detail will be detailed in future UWMP's. Swale design will take into account a 1.2 m hardscaped maintenance strip requested by the City.
- Kerb breaks and flush kerbing to be utilised around POS and swales to encourage overland flow;
- Where required, pipe drains sized to convey runoff from the 5yr ARI storm event;
- The 2 yr ARI critical storm event contained within the existing channel of Kadina Brook;
- Invert of raingardens to have a minimum 0.5m separation to the estimated post-development CGL. CGL will be estimated as part of the UWMP concept design.

- Significant trees as identified under the Commonwealth EPBC Act to be retained within POS areas. Landscape design of raingardens in POS should be worked around significant trees.
- Landscaped Public Open Space areas are to be at least 80% native plants;

4.4.2 Surface Water Modelling

The stormwater management system has been modelled using XP-Storm and based on the methodology in Australian Rainfall & Runoff (AR&R) (Institution of Engineers Australia, 1987). The rainfall temporal pattern was assumed to be spatially uniform across the catchment. Storms modelled range from 1 hour to 72 hours duration.

The model extent is the entire Kadina Brook catchment down to the Helena Valley Rd Crossing. The Pre-development model, as discussed in Section 3.6.1 and Appendix D, was updated to represent the post-development catchments.

Approximately 50% of lots will be classified 'Class A' and the remainder 'Class S'. Given the underlying soil profile, soakwells will be limited to 'Class A' lots. Runoff coefficients applied for various land uses are presented in Table 7 with catchment land use presented in Table 8. Continuing loss calculations are presented in Appendix I.

TABLE 7: LOSS MODEL PARAMETERS

Drainage Area	Initial Loss (mm)	Continuing Loss (mm/hr)	Runoff Coefficient (%)
Class A Lot (Cottage)	15	1.8	-
Class A Lot (Traditional)	15	1.9	-
Class A Lot (Lifestyle)	15	-	15
Class S Lot (Cottage)	-	-	85
Class S Lot (Traditional)	-	-	80
Class S Lot (Lifestyle)	-	-	70
Road	-	-	80
POS	-	-	10

TABLE 8: POST-DEVELOPMENT CATCHMENT LAND USE

Land Use (ha)	N1	N2	N3	N4	S1	S2	S3	Total (ha)
Class A Lot (Cottage)	-	0.58	0.87	0.44	1.40	0.88	0.06	4.22
Class A Lot (Traditional)	6.39	4.72	-	1.86	2.65	3.11	-	17.39
Class A Lot (Lifestyle)	-	-	-	-	-	0.83	-	0.83
Class S Lot (Cottage)	-	2.68	0.90	1.56	-	0.24	0.47	5.85
Class S Lot (Traditional)	-	2.01	3.05	3.76	1.05	4.52	3.45	17.84
Class S Lot (Lifestyle)	-	-	-	1.69	-	2.75	-	4.44
Road	3.35	5.05	2.38	3.31	3.39	5.15	1.86	24.22
POS	0.55	1.99	1.11	1.20	1.07	1.57	1.41	9.15
Total Area (ha)	**10.29**	**17.03**	**8.31**	**14.26**	**9.56**	**19.05**	**7.25**	**85.75**

XP-STORM modelling results are presented in Tables 9 and 10 and shown on Figure 9 for the 1yr 1hr and 100yr ARI critical storm events.

TABLE 9: POST-DEVELOPMENT 1YR ARI 1HR DETENTION STORAGES

	N1	N2	N3	N4	S1	S2	S3
Storage Data							
Storage Invert (mAHD)	22.00	26.00	26.00	29.00	37.00	50.00	50.00
Subsoil Invert (mAHD)	21.50	25.50	25.50	28.50	36.50	49.50	49.50
Small Event							
Impervious Catchment Area (ha)	3.07	8.93	4.87	8.43	5.37	10.77	5.57
Storm Rainfall (mm)	15	15	15	15	15	15	15
Runoff Volume (m^3)	460	1340	730	1265	805	1615	835
Water level rise (m)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Top Water Level (mAHD)	22.50	26.50	26.50	29.50	37.50	50.50	50.50
TWL Surface Area (m^2)	1920[1]	5675[1]	1905[1]	3215[1]	2455[1]	3760[1]	3765[1]
Stored Volume(m^3)[2]	415[1]	1275[1]	620[1]	1200[1]	765[1]	1555[1]	785[1]
Peak Outflow (m^3/s)	0.012	0.006	0.006	0.005	0.018	0.006	0.006
Stored Volume/ Runoff Volume (%)	90	95	85	95	95	96	94

[1] Takes into account POS basin, swale adjacent to POS and road swales

[2] See Figure 9

TABLE 10: POST-DEVELOPMENT 5 AND 100YR ARI DETENTION STORAGES

	N3[2]	S2[3]
Storage Data		
Storage Invert (mAHD)	24.95	49.50
Outlet Invert [1] (mAHD)	24.95	49.50
Outlet Diameter [1] (mm)	375	3 x 300
100yr ARI		
Impervious Catchment Area (ha)	4.86	10.91
Critical Storm Duration (hrs)	6	6
Storm Rainfall (mm)	83	83
Runoff Volume (m^3)	4034	9055
Water level rise (m)	1.05	1.05
Top Water Level (mAHD)	26.00	50.55
TWL Surface Area (m^2)	7055	7740
Stored Volume(m^3)[4]	6085	5655
Peak Outflow (m^3/s)	0.305	0.580
Stored Volume/ Runoff Volume (%)	151	62
5yr ARI		
Impervious Catchment Area (ha)	4.37	9.70
Critical Storm Duration (hrs)	48	48
Storm Rainfall (mm)	102	102
Runoff Volume (m^3)	4465	9895
Water level rise (m)	0.65	0.65
Top Water Level (mAHD)	25.60	50.15
TWL Surface Area (m^2)	6415	7190
Stored Volume(m^3)[4]	2985	2260
Peak Outflow (m^3/s)	0.203	0.430
Stored Volume/ Runoff Volume (%)	67	23

[1] Basin outlet diameter and invert may be modified at detailed design stage, providing peak outflow is maintained at pre-development levels.

[2] Storage accounts for inflow from Catchment N2

[3] Storage accounts for inflow from Catchment S3

[4] See Figure 9

i) 5yr and 100yr storage results are inclusive of both the minor and major detention storages.

ii) All storages assume 1:6 side slopes

iii) Storage inverts are based on approximate topography rather than clearance from groundwater mapping (AAMGL) or soil profile.

The final configuration (i.e. side slopes) and exact location of the storage areas are dependent on final earthworks, drainage and road design levels for the Study Area. Drainage details will be refined further at the sub-division stage and reported in the relevant Urban Water Management Plan (UWMP).

4.4.3 Kadina Brook Crossings

Cedar Woods has prepared a Conservation Management Plan for the Parks and Recreation Reserve which identifies a number of crossing's to be constructed over Kadina Brook to allow pedestrian and vehicle access to the reserve. The crossings have support from DPAW. An extract from the Conservation Management Plan is provided below:

Stormwater detention areas for both urban cells will be provided with overflow connections to Kadina Brook. The subsequent Urban Water Management Plan will outline measures to manage the impacts of stormwater overflow into the Conservation Area.

Where appropriate the crossings will be used to restrict flows in Kadina brook to reduce peak flows downstream. Figure 10 provides locations and 100yr ARI peak top water levels behind the proposed crossings.

4.4.4 Helena Valley Rd Crossing Serviceability

Three scenarios were assessed by JDA using the post-development XP-Storm model of Kadina Brook (Section 4.4.3) to ensure the serviceability of Helena Valley Rd is maintained following development. Table 11 presents peak flow rates along Kadina Brook for the three scenarios. The serviceability of Helena Valley Rd is compromised by the subdivision of Lot 9500 Helena Valley Rd downstream of the Study Area. The three scenarios are as follows:

Scenario 1 is pre-development of the Study Area and lot 9500 land use. Results indicate Helena Valley Road is serviceable during the 100yr ARI critical rainfall event in this scenario.

Scenario 2 considers the subdivision approval for Lot 9500 Helena Valley Rd assuming existing land use for lot 911. The subdivision approval for Lot 9500 provides a 30 m conservation buffer adjacent to Kadina Brook and removal of 2 x 900 mm diameter pipe culverts upstream of Helena Valley Rd on the old road alignment. The modelling results show the proposed development reduces the floodway width and reduces available storage behind the Helena Valley Rd culverts, increasing the peak flow and causing water to overtop Helena Valley Road. Scenario 2 was also assessed with the addition of an extra 1200 mm culvert. Helena Valley Rd still overtops with the additional pipe.

Scenario 3 includes the Lot 9500 subdivision and development of the Study Area, including flow control from additional Kadina Brook crossings. The results indicate with the extra flow control along Kadina brook an additional 1200 mm diameter pipe culvert beneath Helena Valley Rd is sufficient to maintain the 100yr ARI serviceability of the crossing.

Scenario 4 includes the development of the Study Area only, including flow control from additional Kadina Brook crossings. The results indicate with the extra flow control along Kadina Brook the Helena Valley Rd crossings serviceability is maintained.

For scenario 2 and 3, if Lot 9500 development does proceed an upgrade to the Helena Valley Rd crossing should be assessed in more detail.

TABLE 11: KADINA BROOK PEAK FLOW RATES AT HELENA VALLEY RD CROSSING

Location	1yr 1hr (m^3/s)	5yr (m^3/s)	100yr (m^3/s)
Scenario 1 - Pre-Development			
Helena Valley Rd	1.82	3.23	4.48
Scenario 2 - Post-Development Lot 9500			
Helena Valley Rd	2.04	4.10	8.80
Scenario 3 - Post-Development Lot 9500 and Study Area			
Helena Valley Rd	1.93	3.83	7.59
Scenario 4 - Post-Development Study Area only			
Helena Valley Rd	2.16	4.31	5.78

4.5 Groundwater Management

Groundwater Management for the Study Area has been prepared in line with design criteria presented in the DWMS (RPS, 2012) and the Stormwater Management Manual for Western Australia (DoW, 2007). Design criteria include:

- Management of groundwater levels to protect infrastructure and assets.
- Maintaining groundwater regimes at pre-development conditions for the protection of groundwater-dependent ecosystems
- Protection of groundwater resources.
- Adoption of nutrient load reduction design objectives for discharges to groundwater.

As stated in Section 3.8.1, AAMGL is approximately 0.30 mBNS to 12 mBNS and a perched water table is likely to develop above the low permeability layer which is shallow in some areas.

The UWMP will assess a post-development groundwater level. Subsoils will be installed where required to ensure sufficient clearance to lot finished levels and operation of soakwells creating a controlled groundwater level (CGL).

Finished levels will become available at detailed design stage. Figure 11 shows indicative areas which may require subsoil drainage based on:

a) Depth from natural surface to AAMGL, and

b) Depth from natural surface to the low permeability layer

Figure 10 indicates that depths to the low permeability layer will determine requirements for subsoil drainage. The majority of the north Study Area is less than 2.0m from the low permeability layer while portions of the south Study Area are also less than 2.0m from the low permeability layer and thus may require subsoil drainage subject to finished levels.

The drainage management criteria for determination of lot finished levels shall be a minimum 1 m above estimated CGL. Estimated CGL will take into account subsoil drainage and estimated level of groundwater mounding between subsoil pipes.

Subsoils will be located in the area previously contaminated by abattoir effluent disposal. The drainage will not intercept the regional groundwater table, but is intended to control rainfall recharge that may perch on the shallow clay layers. Both the stormwater and subsoil systems will be connected to biofilter swales and/or basins prior to discharge into Kadina Brook. The proposed design poses no risk of mobilising deep groundwater to Kadina Brook.

4.6 Water Quality Management

4.6.1 Nutrient Source Controls

The effective implementation of the structural and non-structural controls as part of the urban development will enhance water quality from the Study Area as a result of the land use change, consistent with State Planning Policy 2.10: Swan Canning River System (WAPC, 2006).

Non-structural source controls to reduce nutrient export from the Study Area will focus on reducing the need for nutrient inputs into the landscape. The following strategies are proposed;

- Local native plants to make up a minimum 80% of the planted areas and streetscape treatments. Any non-local species will be selected for drought tolerance and low fertiliser requirements.

- Street sweeping and manhole eductions. The UWMP will outline the schedule and cleaning requirements for street sweeping and manhole eductions, which will be co-ordinated with the City of Swan.

Structural source controls are proposed to compliment the non-structural source controls and provide a complete treatment train for stormwater movement through the Study Area. The following structural controls are considered appropriate for the Study Area;

- The use of bio-retention storages and swales to treat road runoff. A minimum treatment capacity of approximately 2% of the connected impervious area should be provided.
- A trashrack installed downstream of each vegetated treatment basin, at the upstream end of the basin overflow.

The minimum specifications for all bio-retention systems (swales and storages) are presented in Table 12.

TABLE 12: MINIMUM SPECIFICATIONS FOR BIO-RETENTION SYSTEMS

Item	Specification
Amended soil media (DoW, 2011)	• Minimum 500 mm thick. • Hydraulic Conductivity, k_{sat} = 3 m/day. • PRI ≥ 5. • Light compaction only. • Infiltration testing of material prior to installation and again once construction is complete. On-going testing as per the monitoring program.
Plant selection, planting density and distribution	• Species and densities to be in accordance with the Vegetation Guidelines for Stormwater Biofilters in the South-West of Western Australia (Oversby et al., 2014).

The bio-retention systems should be sized to function correctly with a saturated hydraulic conductivity, k_{sat}, of 3 m/day. Recent research conducted by the Facility for Advancing Water Biofiltration (FAWB, 2008) indicates that the desired k_{sat} is in the range of 2.5 to 7 m/day, to fulfil the drainage requirements as well as retain sufficient moisture to support the vegetation. The FAWB (2008) research also specifies that for vegetated systems some clogging will occur in the first few years until the vegetation is established. Once the plants are established, the roots and associated biological activity maintain the conductivity of the soil media over time.

It should be recognised that data currently guiding the design of bio-retention systems is only recent and largely based on laboratory testing. The specifications provided in this document should be considered as the best available information at the time. Some flexibility in the specifications will be required as the knowledge base increases.

4.6.2 Land Use Change Nutrient Impacts

JDA NiDSS model (Nutrient Input Decision Support System) has been used to help quantify the nutrient inputs for the pre-development and post-development scenarios. The NiDSS model analyses inputs for Total Phosphorus and Total Nitrogen only.

The NiDSS analysis shows that the changes in land use from rural (pasture) to a built urban environment, without WSUD measures, will result in an increase in the nutrient load on the catchment. This increase needs to be reduced using WSUD principles. With the implementation of the proposed structural and non-structural controls, a reduction of 47.4% for Phosphorus and 35.1% for Nitrogen is achieved compared to urban development without WSUD. These estimates correspond to a reduced Phosphorus input of 5 kg/ha/yr and a reduced Nitrogen input of 48 kg/ha/yr.

Modelling results are provided in Appendix J.

5. IMPLEMENTATION

5.1 Urban Water Management Plan (Subdivision)

Processes defined in Better Urban Water Management (WAPC, 2008) require an Urban Water Management Plan (UWMP) at subdivision stage. With an approved LWMS, a UWMP is required as a condition of subdivision and prior to any subdivision activities.

Further work that is identified for inclusion in the UWMP:

- Design of treatment structures, vegetated swales and dry/ephemeral storages as outlined in the Stormwater Management Manual (DoW, 2007);
- Refinement of the final configuration (storage side slopes etc) and exact location of the flood detention storage areas dependent on final earthworks, drainage and road design levels for the Study Area;
- Confirmation of groundwater design levels; and
- Confirmation of subsoil location and levels.

5.2 Construction Management

5.2.1 Dewatering

Dewatering may be required for some elements of subdivision construction. Given the depth of construction, dewatering will only be in the Superficial Aquifer.

Prior to the commencement of any dewatering, the construction contractor will apply for and obtain from DoW a “Licence to Take Water”. All dewatering will be carried out in accordance with the conditions of this licence. Where possible, construction will be timed to minimise impacts on groundwater and any dewatering requirement.

Due to elevated levels of nutrients in the groundwater, dewatering will be managed on-site or discharged through the sewer to prevent untreated discharge to drains or surface water bodies.

5.2.2 Acid Sulphate Soils

Management of Acid Sulphate Soils (ASS) will be addressed as a separate process to the urban water management document approvals process (LWMS/UWMP).

ASS will be investigated and managed in accordance with the applicable Department of Environment Regulation (DER) Acid Sulphate Soil Guideline Series and requirements of dewatering licences as they arise.

5.3 Stormwater System Operation and Management

The operation and maintenance of the drainage system will initially be the responsibility of the developer, ultimately reverting to the local authority, City of Swan.

The surface and subsoil drainage system will require regular maintenance to ensure its efficient operation. It is considered the following operating and maintenance practices will be required periodically:

- Removal of debris to prevent blockages.
- Street sweeping to reduce particulate build up on road surfaces and gutters.
- Maintenance of vegetation in Bio-retention Systems/ Storages as outlined in the UWMP.

- Cleaning of sediment build up and litter layer on the bottom of Storages as specified in the UWMP.
- Undertake education campaigns regarding source control practices to minimise pollution runoff into stormwater drainage system.
- Checking and maintenance of subsoil drainage function.

5.4 Monitoring Programme and Contingency Planning

The monitoring program has been designed to allow a quantitative assessment of hydrological impacts of the proposed development.

The post-development monitoring program is designed to operate over a 5 year period. The program will be periodically reviewed to ensure suitability and practicality. The program may need to be modified as data is collected to increase or decrease the monitoring effort in a particular area or alter the scope of the programme itself.

The post-development monitoring locations proposed are:

- Monitor groundwater levels and quality for 3 pre-development groundwater sites (B2, B4 and B10) for comparison to pre-development data (Figure 7).
- Measure peak flows and quality along Kadina Brook at the inflow to the south Study Area and outflow from the north Study Areas.

A summary of the proposed monitoring program and reporting schedule is shown in Table 13, with the frequency of water quality target review and the contingency action plan detailed in Table 14.

All sampling is to be conducted according to Australian Standards and all water quality sample testing will be conducted by a NATA approved laboratory.

5.4.1 Reporting Mechanisms

The preparation of annual monitoring reports is to be co-ordinated by the developer and submitted to the Department of Water/City of Swan for review. The report will compare the monitoring results with the design criteria and performance objectives to determine what, if any, further actions may be necessary to consistent with contingency planning measures detailed in Table 14.

The proposed reporting schedule is detailed in Table 13.

TABLE 13: MONITORING SCHEDULE AND REPORTING

Monitoring Type	Location	Method	Frequency, Timing & Responsibility	Parameter	Reporting	Responsibility
Groundwater Level	3 monitoring sites (B2, B4 and B10).	Electrical depth probe or similar.	Quarterly for 5 years by Developer (Jan, April, July, Sept).	Water Level (mAHD)	Annual reports to be provided by the developer for a period of 5 years. Reports will be submitted to DoW/CoS within 3 months of completion of the reporting period.	Developer
Surface Water Quantity	2 monitoring sites (south and north Study Area).	Continuous logger.	Downloaded 3 times per year for 5 years.	Stage (Flow inferred)		
Groundwater Quality	3 monitoring sites (B2, B4 and B10).	Pumped bore samples.	Quarterly for 5 years by Developer (typically Jan, April, July, Sept).	In-situ: pH, EC, temp Lab: TN, TKN, NO_X, Ammonia, TP, FRP, selected metals		
Surface Water Quality	2 monitoring sites (south and north Study Area).	Collected grab samples or rising stage sampler.	3 times per year while flowing for 5 years.	In-situ: pH, EC, temp Lab: TN, TKN, NO_X, Ammonia, TP, FRP, selected metals, TSS		

TABLE 14: CONTINGENCY PLANNING

Monitoring Type	Criteria for Assessment	Criteria Assessment Frequency	Contingency Action
Groundwater Level	Groundwater levels not to exceed the estimated phreatic line by more than 300mm.	After monitoring occasion	1. Review design and operation of subsoil and stormwater drainage system. 2. Perform maintenance as required.
Surface Water Quantity	Flow discharging from Study Area to be within peak flows established in the LWMS.	Annual review of water quantity targets	1. Review design and operation of detention storage areas. 2. Perform maintenance as required.
Groundwater Quality	Nutrient concentrations in shallow bores should not exceed 20% of the maximum recorded pre-development level.	Annual review of water quality targets	1. Identify and remove any point sources. 2. Consider reinforcement of Community Education/Awareness program. 3. Review operational and maintenance (e.g. fertilising, cleaning) practices. 4. Consider alterations to POS areas including landscape regimes and soil amendment. 5. Consider modifications to the stormwater system. 6. Consider initiation of community based projects.
Surface Water Quality	Assess performance of vegetated detention storages in nutrient reduction. (Water quality discharging from the Study Area aims should not exceed 20% of the maximum recorded pre-development level.).		

5.5 Responsibilities and Funding

The key roles and responsibilities for the implementation of this LWMS are presented in Table 15 below, with details on the maintenance of the surface water treatment structures outlined in Section 5.3.

TABLE 15: SUMMARY OF RESPONSIBILITIES OF FUNDING

Management Issue	Responsibility and Funding	
	Developer	City of Swan
Negotiations with groundwater licence holders for transfer of water allocation	✓	
Construction of the planted swales	✓	
Construction of detention storages	✓	
Construction of irrigation system	✓	
Construction of street drainage	✓	
Street drainage defects liability period • 12 months (period between a successful Practical Completion Inspection and a defects inspection with written confirmation of City acceptance): • Ongoing (from notification of City acceptance):	✓	✓
Planted swale defects liability period • 12 months (period between a successful Practical Completion Inspection and a defects inspection with written confirmation of City acceptance): • Ongoing (from notification of City acceptance):	✓	✓
Detention storage defects liability period • 12 months (period between a successful Practical Completion Inspection and a defects inspection with written confirmation of City acceptance): • Ongoing (from notification of City acceptance):	✓	✓
Management of Stormwater Storage Landscaping • 2 years (period between a successful Practical Completion Inspection and a successful handover meeting with written confirmation of City acceptance): • Ongoing (from notification of City acceptance):	✓	✓
Irrigation system management • 2 years (period between a successful Practical Completion Inspection and a successful handover meeting with written confirmation of City acceptance): • Ongoing (from notification of City acceptance):	✓	✓
Post-development monitoring • Monitoring over a 5 year period, commencing immediately after the Practical Completion of the development:		✓
Street Sweeping • Period up to the successful Practical Completion of civil works. • Ongoing (from notification of City acceptance):	✓	✓

5.5.1 Recommendations

JDA has contacted Shire of Mundaring regarding the design capacity of the Helena Valley Rd crossing. The Shire has advised JDA that they have limited information available on the design capacity of the culverts. JDA recommends City of Swan advise Shire of Mundaring that if Lot 9500 subdivision proceeds a detailed assessment of the Helena Valley Rd culverts level of service is undertaken.

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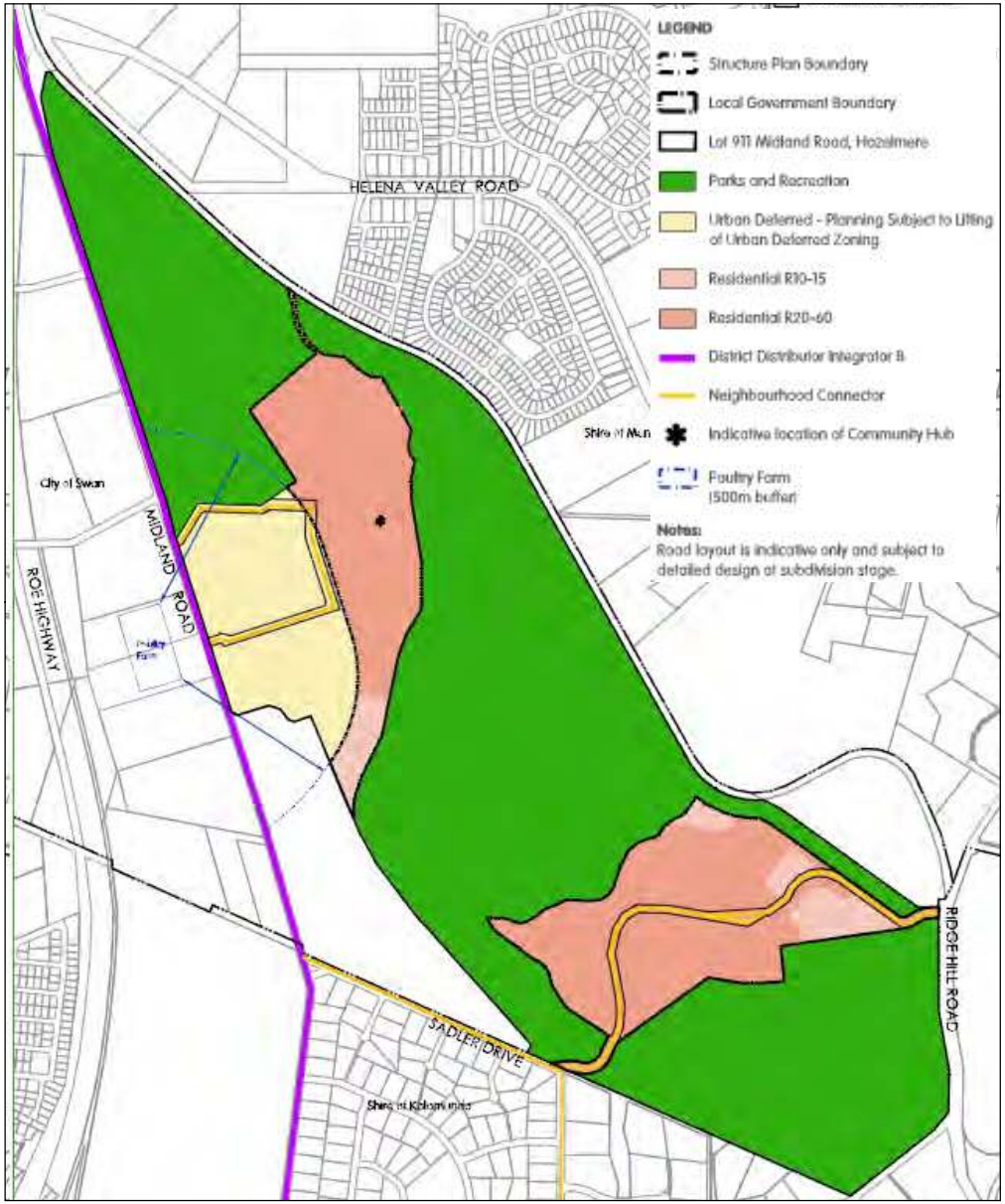
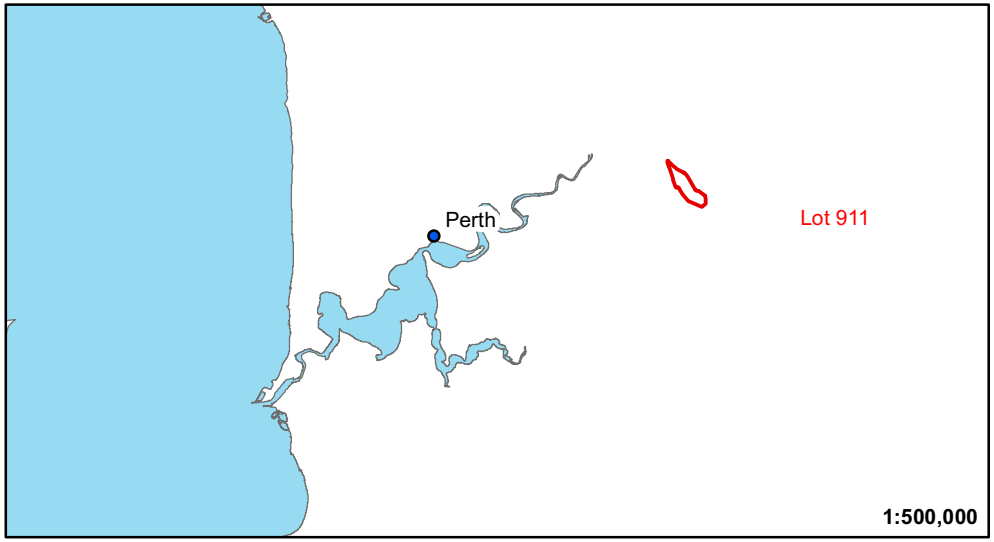
FIGURES





Data Source: Landgate (2012), Nearmap (2014), Roberts Day (2015)

Job No. J5569

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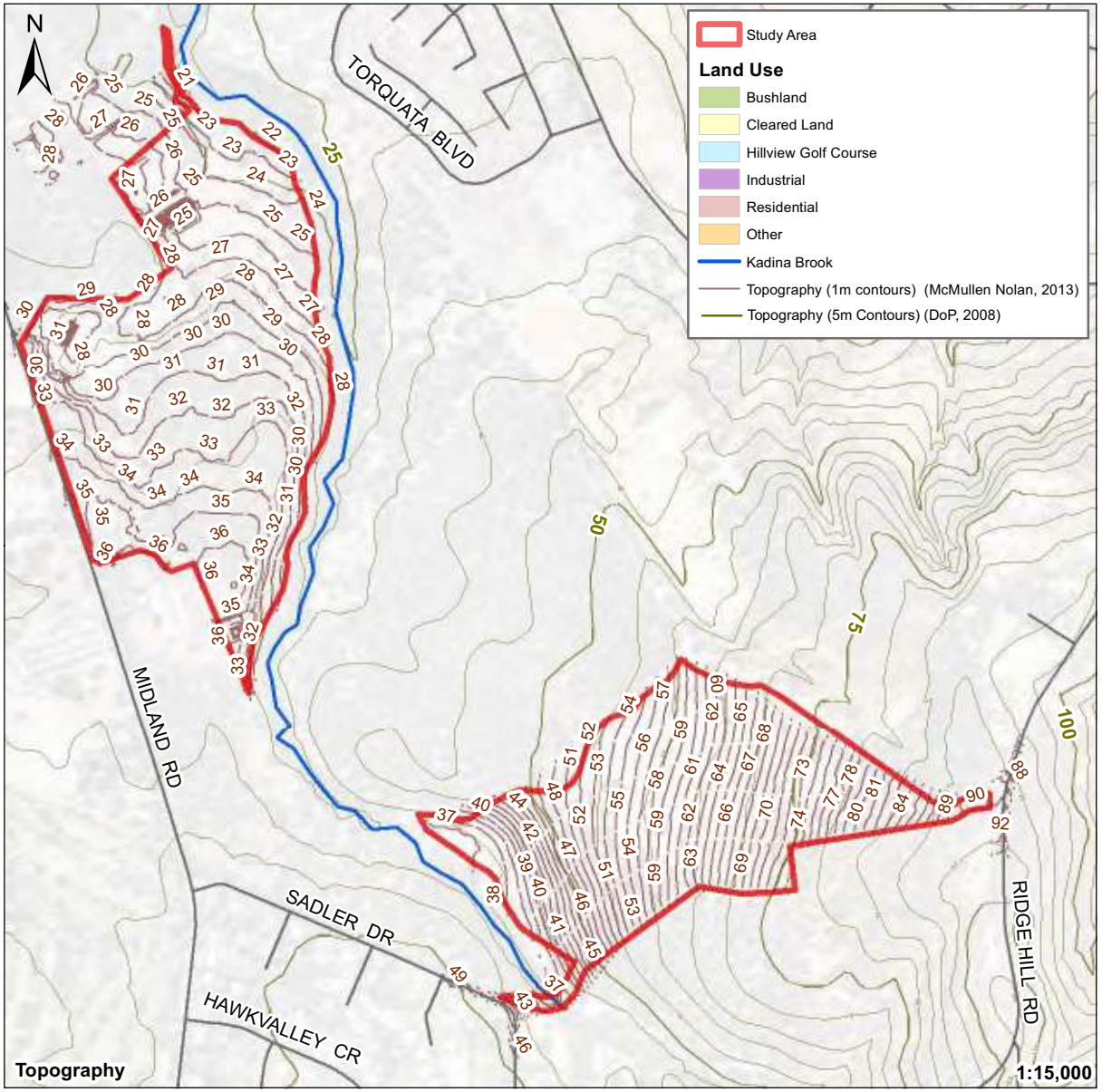
Cedar Woods Properties Limited
Lot 911 Midland Road, Hazelmere - LWMS
Figure 1: Indicative Cell Structure Plan



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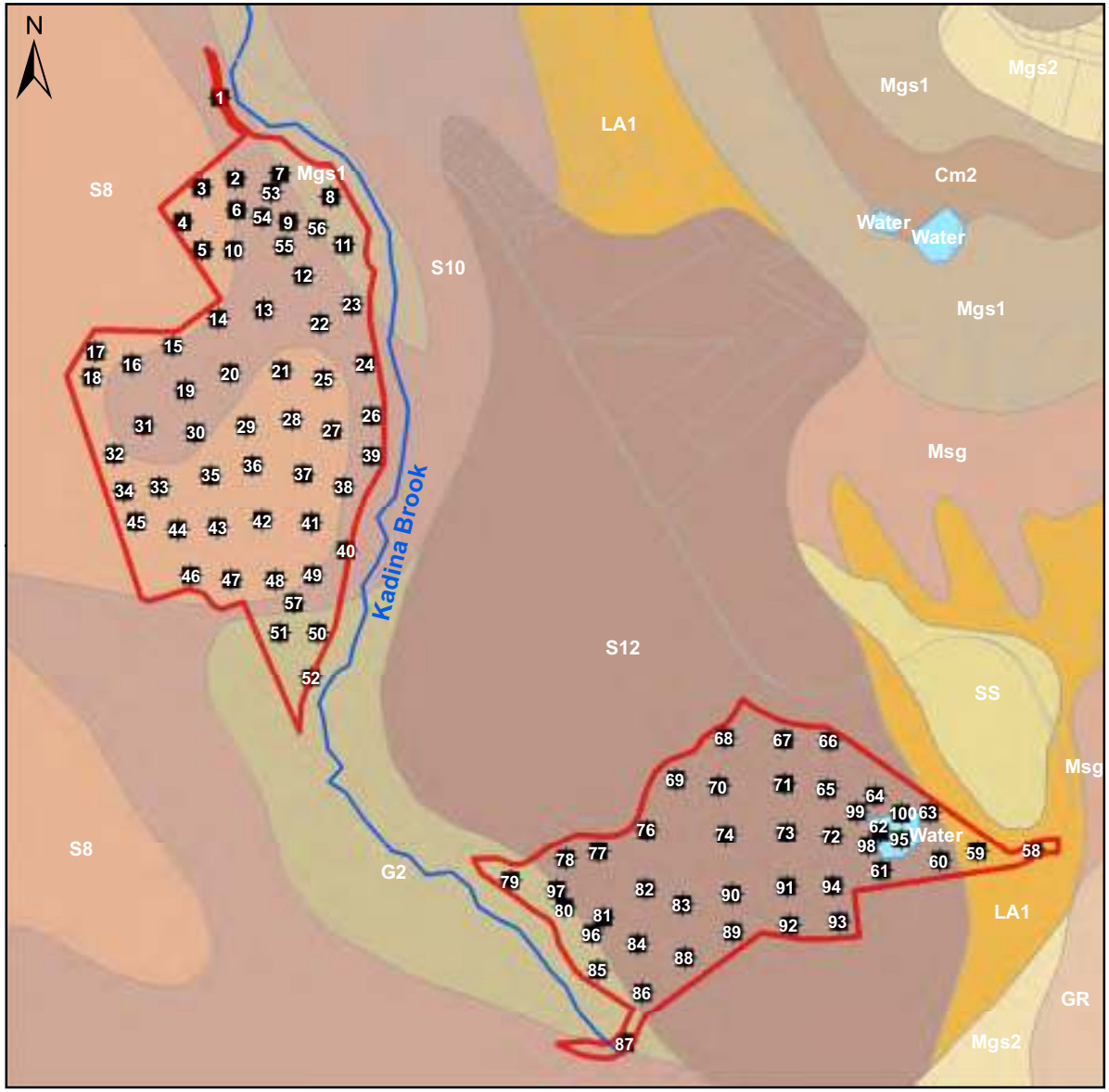
Lot 911 Midland Road, Hazelmere - LWMS

Figure 2: Existing Land Use and Topography



Study Area
Kadina Brook
Test Pits (Golder, 2014)

Surface Geology
Cm2
G2
GR
LA1
Mgs1
Mgs2
Msg
S10
S12
S8
SS
Water

Surface Geology

Cm2: CLAY - dark strong brown, hard when dry, soft when moist, variable silt content, no sand, of alluvial origin.

G2: GRAVEL

GR: GRANITE

LA1: LATERITE

Mgs1: PEBBLY SILT - strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered grainite pebble, some fine to medium-grained quartz sand, of alluvial origin.

Mgs2: GRAVELLY SILT - strong brown, tough with common pebbly horizons with little matrix containing quartzite, quartz, granite, laterite, of colluvial origin.

Msg: SANDY SILT - strong brown, firm, friable, dispersive in part, occasional pebbly horizons with little matrix containing quartzite, quartz, granite, laterite, of colluvial origin.

S8: SAND - Very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin.

S10: SAND - As S8 over sandy clay to clayey sand of the Guildford Formation, of eolian origin.

S12: SAND - Structureless, yellow, fine-grained, subangular and medium to coarse-grained subrounded to rounded quartz, feldspar and heavy minerals common, minor silt and clay, of colluvial origin.

SS: SANDSTONE

Data Source: Gozzard (1986)

Job No. J5569

Scale:1:15,000

0 200 400 600 800 Metres

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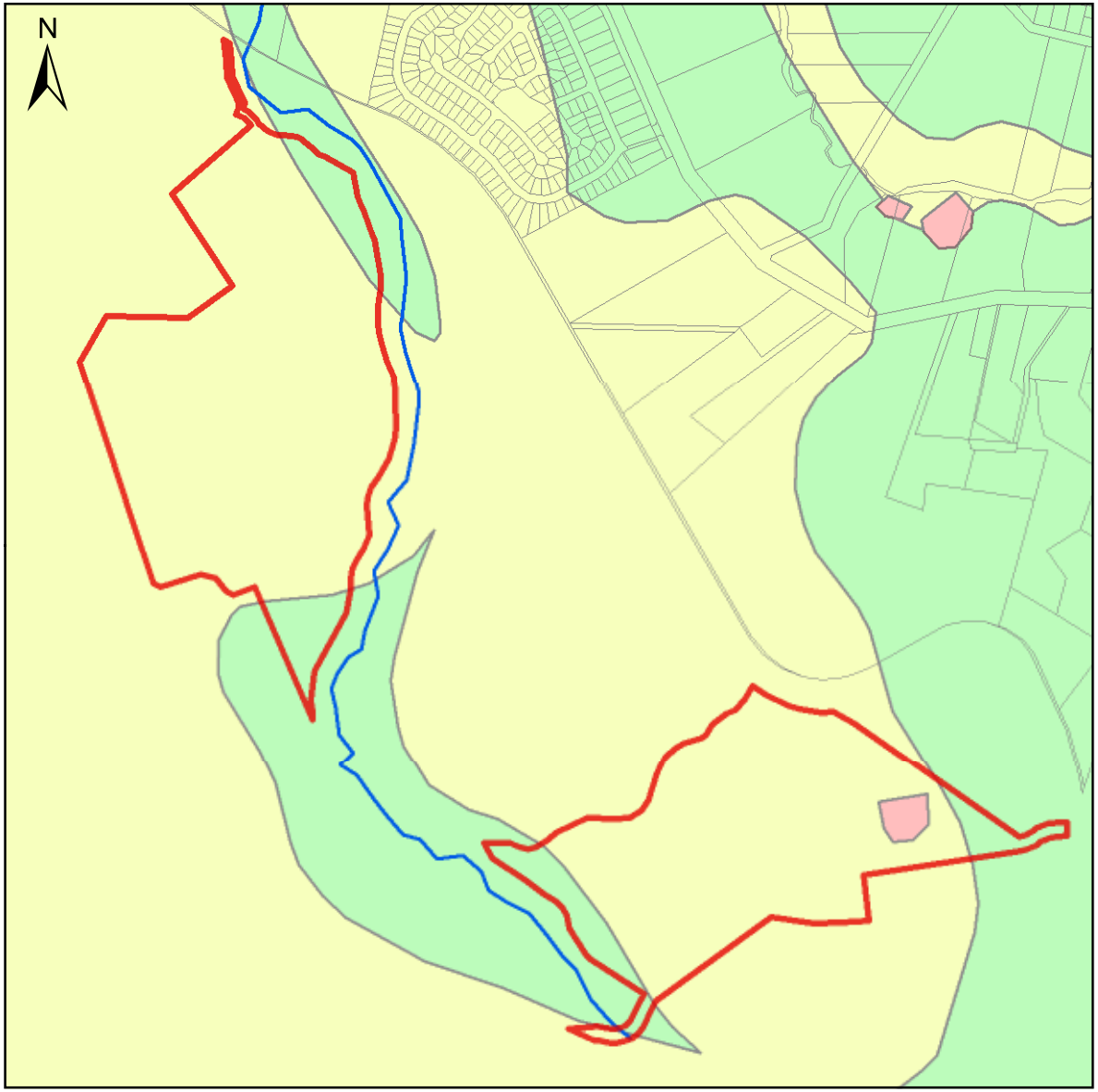
Cedar Woods Properties Limited
Lot 911 Midland Road, Hazelmere - LWMS

Figure 3: Surface Geology



Study Area
Kadina Brook
ASS Risk Mapping (DoW, 2010)
High to moderate risk
Moderate to low risk
No known risk

ACID SULPHATE SOILS - RISK DEFINITIONS:

High to moderate risk of ASS occurring within 3m of natural soil surface:
ASS in these environments can be widespread or sporadic. They may be very close to the surface or buried by many metres of alluvium or windblown sand. Base sediments of estuaries, rivers, creeks and lakes are also considered areas of high risk of ASS occurrence.

Moderate to low risk of ASS occurring within 3m of natural soil surface:
Where environments have not generally been suitable for ASS formation or ASS are highly localised or sporadic, they have been classed as having a moderate to low risk of occurrence. Where ASS is
present, it may be close to the surface or buried by many metres of alluvium or windblown sand. Most of these landforms are not expected to contain ASS.

No known risk of ASS occurring within 3m of natural soil surface (or deeper):
ASS are not known or expected to occur in these environments

JDA

Job No. J5569
Scale: 1:15,000
0 200 400 600 800 Metres

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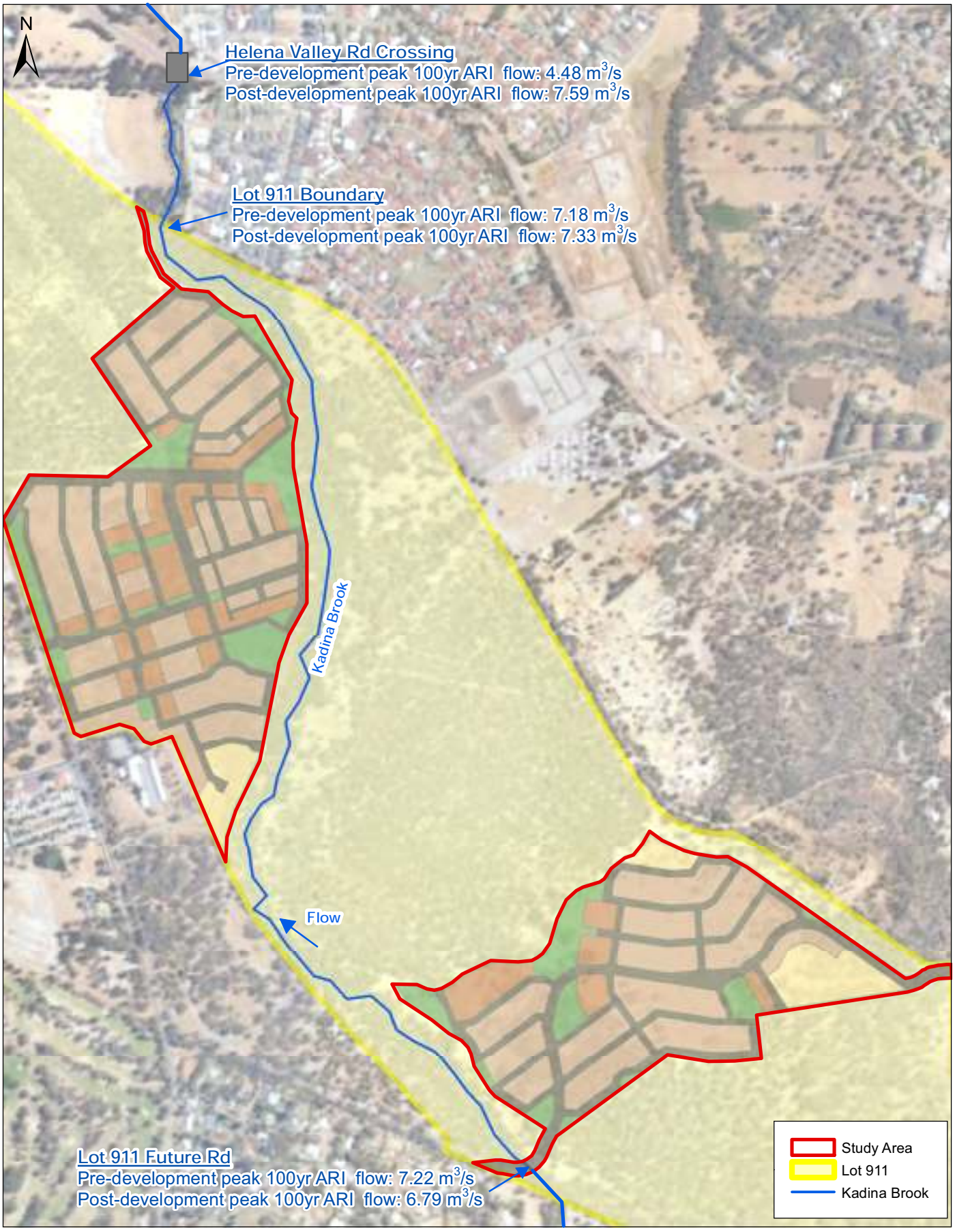
Cedar Woods Properties Limited
Lot 911 Midland Road, Hazelmere - LWMS
Figure 4: Acid Sulfate Soil Risk Mapping



Data Source: Nearmap (2014)

0 200 400 600 800 Metres

Job No. J5569 Scale: 1:11,500 Coordinate System: GDA 94, Zone 50 © COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2015	Cedar Woods Properties Limited Lot 911 Midland Rd, Hazelmere Figure 6: Kadina Brook Pre and Post-Development 100yr ARI Flow

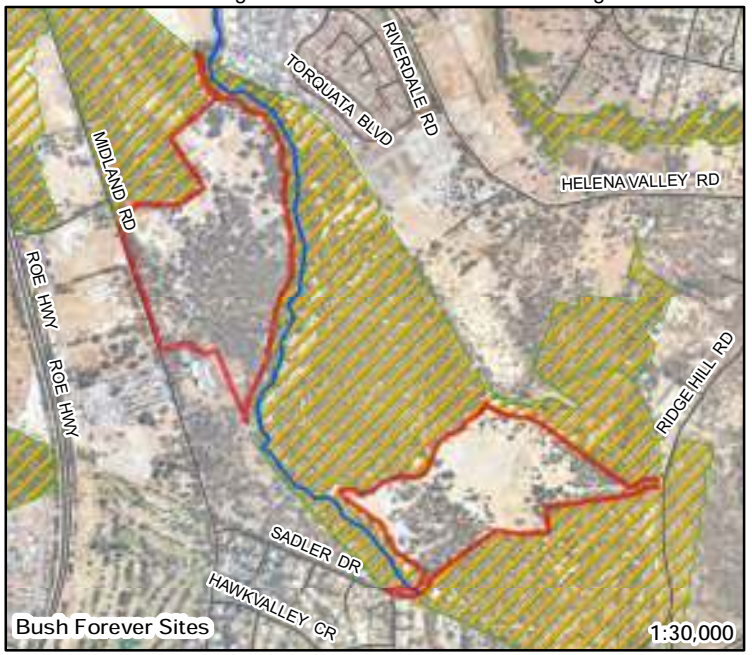
Study Area
Kadina Brook
Geomorphic Wetlands (DEC, 2012)
Conservation Category Wetland (CCW)
Resource Enhancement Wetland (REW)
Multiple Use Dampland
Bush Forever Sites

WETLAND DEFINITIONS:

Conservation Wetland:
Wetlands that support a high level of ecological attributes and functions.

Resource Enhancement Wetland:
Wetlands which may have been partially modified but still support substantial ecological attributes and functions.

Multiple Use Dampland:
Wetlands with few ecological attributes and functions remaining.



Data Source: Nearmap (2014)

JDA

Job No. J5569
Scale: 1:25,000

0 500 1,000 1,500 2,000 Metres

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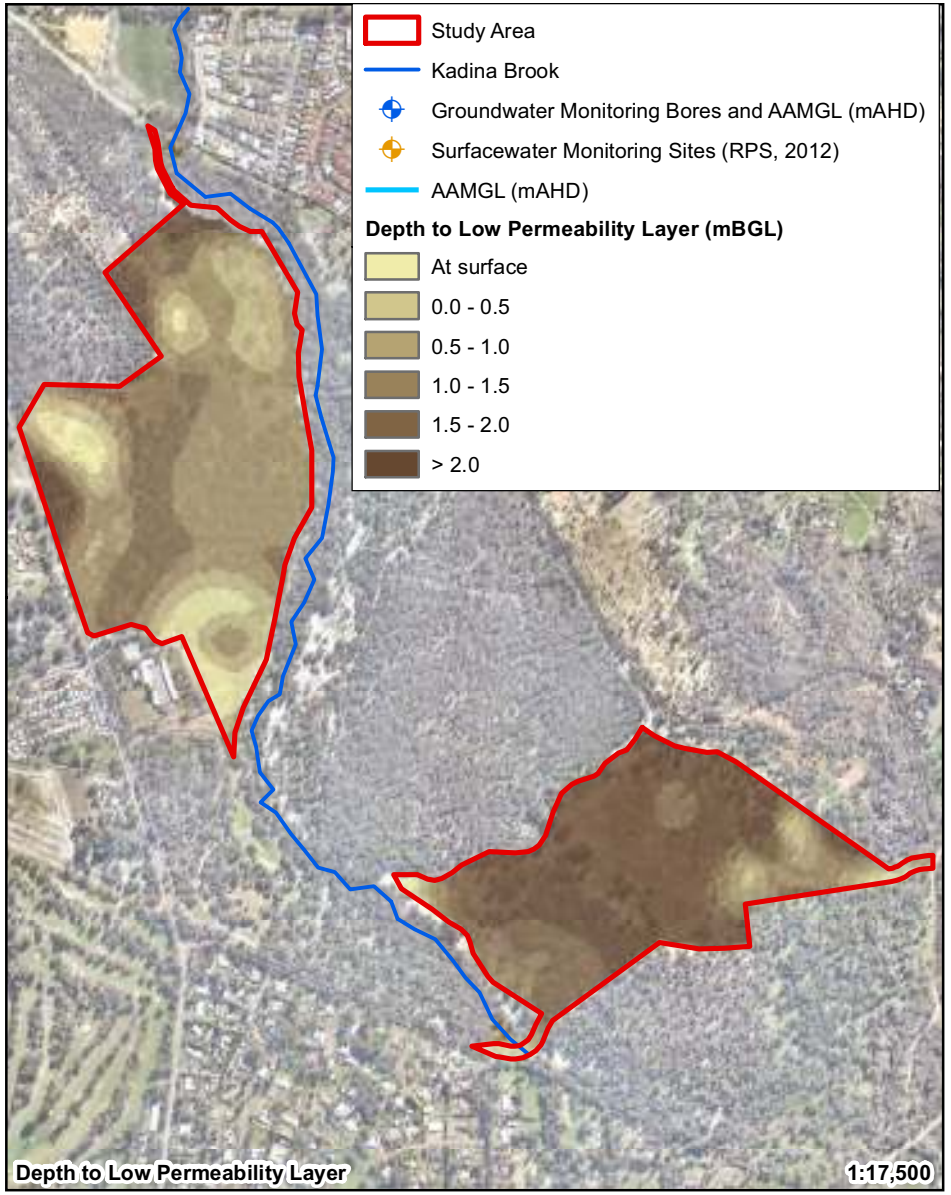
Lot 911 Midland Road, Hazelmere - LWMS
Figure 7: Wetland Mapping



Data Source: Nearmap (2014)

Job No. J5569
Scale: 1:18,500

0 200 400 600 800
Metres

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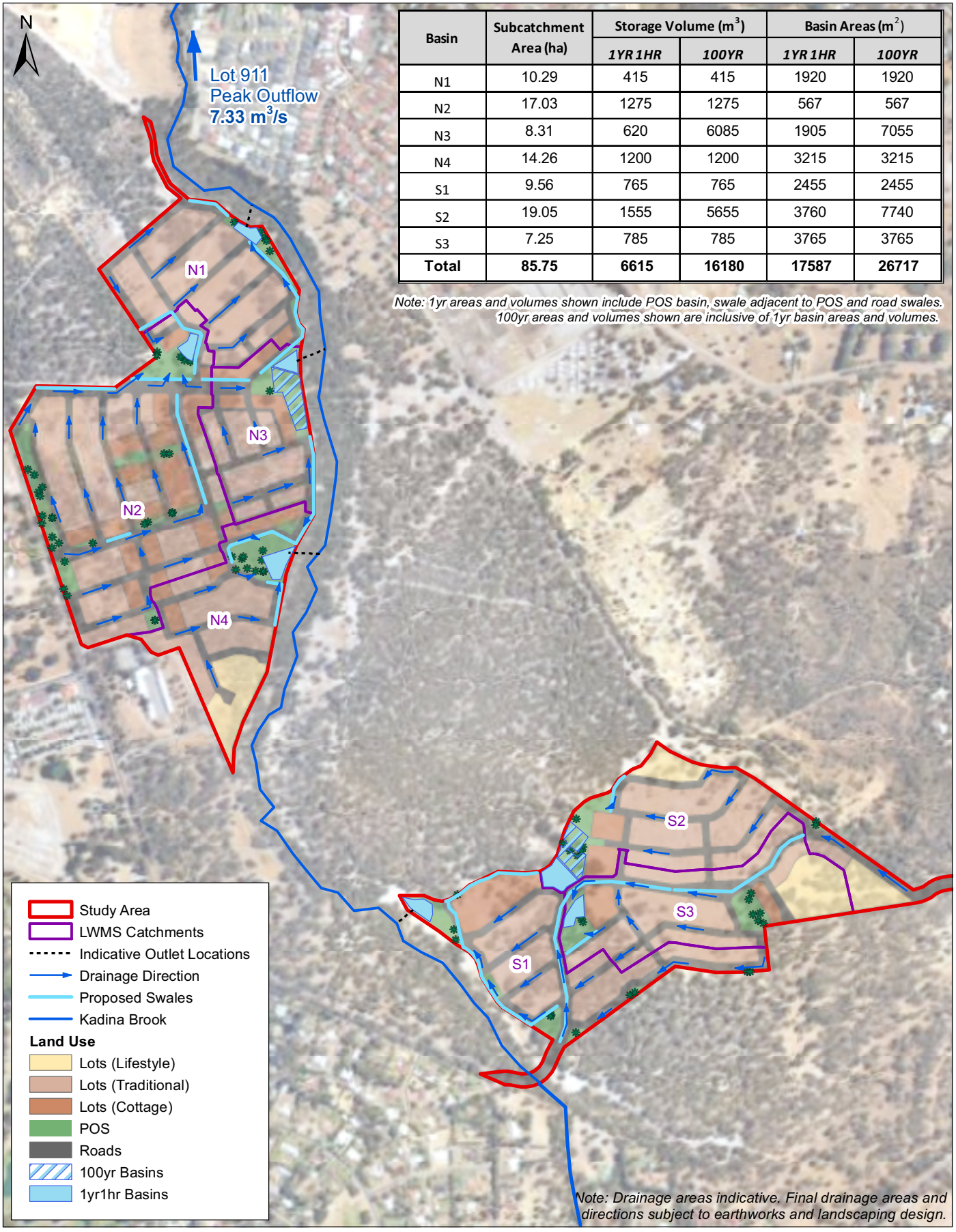
Figure 8: Groundwater Levels



Basin	Subcatchment Area (ha)	Storage Volume (m^3)		Basin Areas (m^2)	
		1YR 1HR	*100YR*	*1YR 1HR*	*100YR*
N1	10.29	415	415	1920	1920
N2	17.03	1275	1275	567	567
N3	8.31	620	6085	1905	7055
N4	14.26	1200	1200	3215	3215
S1	9.56	765	765	2455	2455
S2	19.05	1555	5655	3760	7740
S3	7.25	785	785	3765	3765
Total	**85.75**	**6615**	**16180**	**17587**	**26717**

Note: 1yr areas and volumes shown include POS basin, swale adjacent to POS and road swales. 100yr areas and volumes shown are inclusive of 1yr basin areas and volumes.

Note: Drainage areas indicative. Final drainage areas and directions subject to earthworks and landscaping design.

Data Source: Nearmap (2014)

0 200 400 600 800 Metres

Job No. J5569
Scale: 1:11,500
Coordinate System: GDA 94, Zone 50
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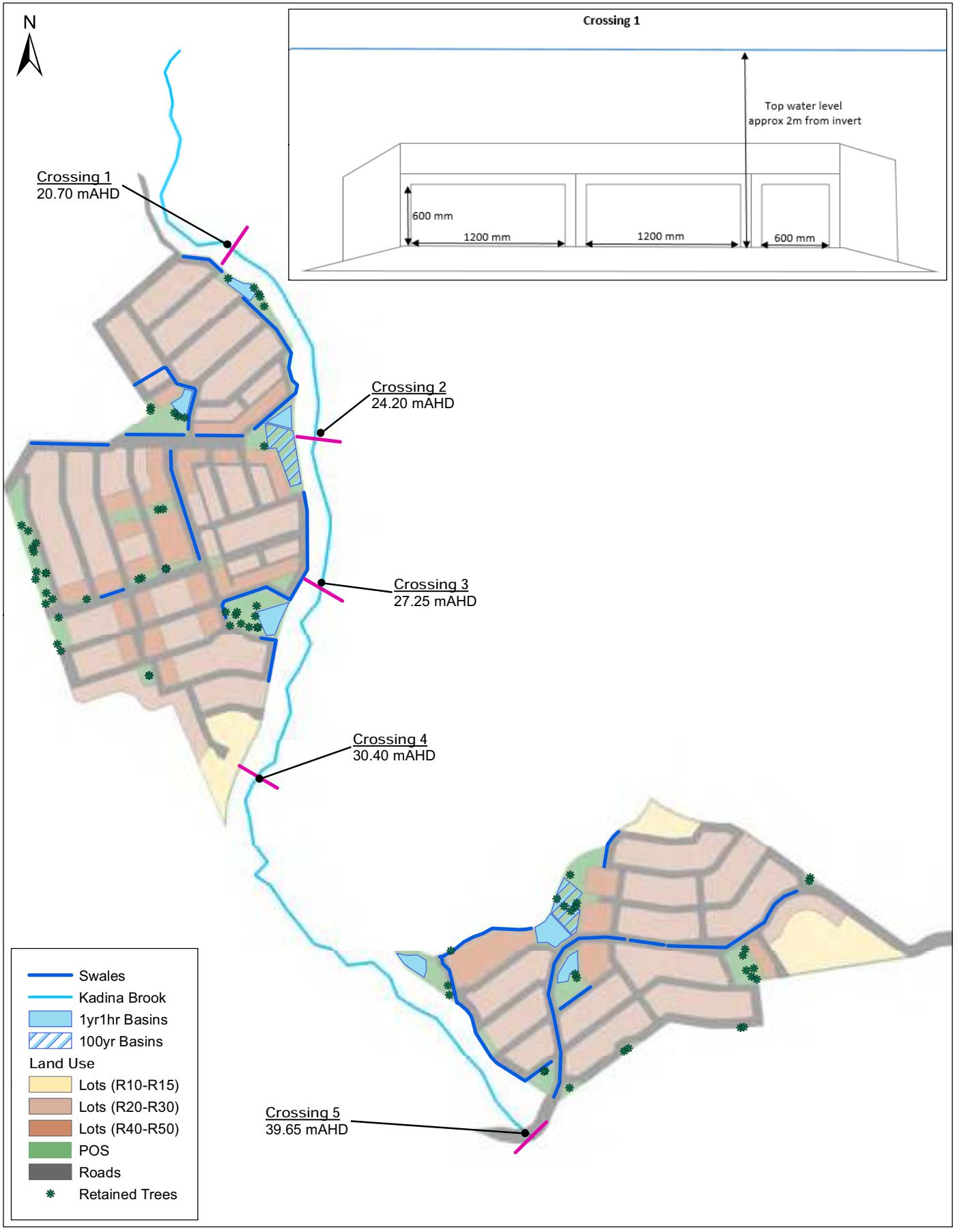
Lot 911 Midland Rd, Hazelmere

Figure 9: Stormwater Management Plan



Data Source: Land Use: CWP BUS UD1 030M Revised LSP.

0 200 400 600 Metres

Job No. J5569
Scale: 1:11,500
Coordinate System: GDA 94, Zone 50
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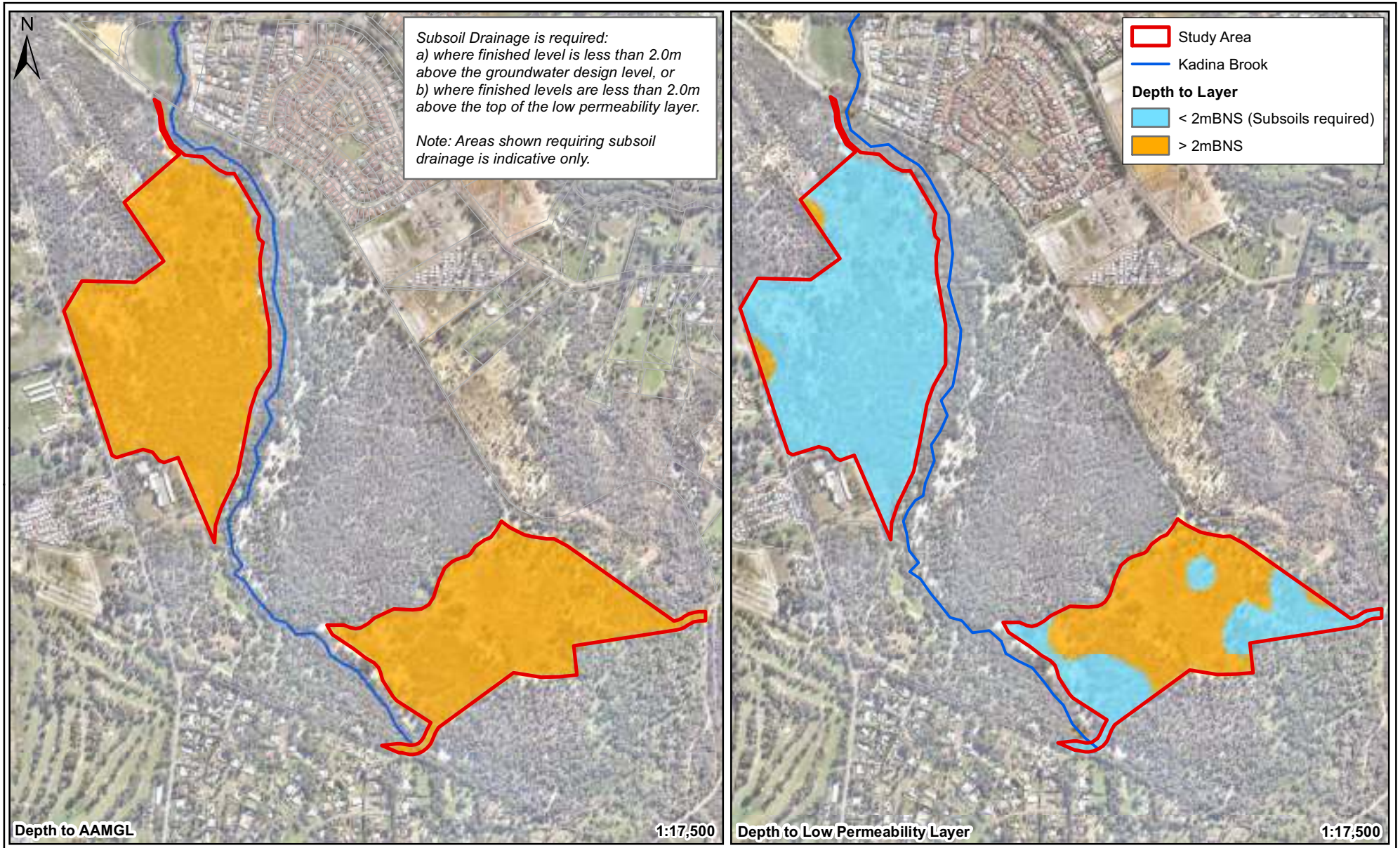
Figure 10: Kadina Brook Crossings 100yr ARI Top Water Levels



Data Source: Nearmap (2014)

JDA

Job No. J5569
Scale: 1:17,500

0 200 400 600 800 Metres

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Figure 11: Indicative Subsoil Drainage Areas

APPENDIX A

Local Water Management Strategy Checklist for Developers

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.

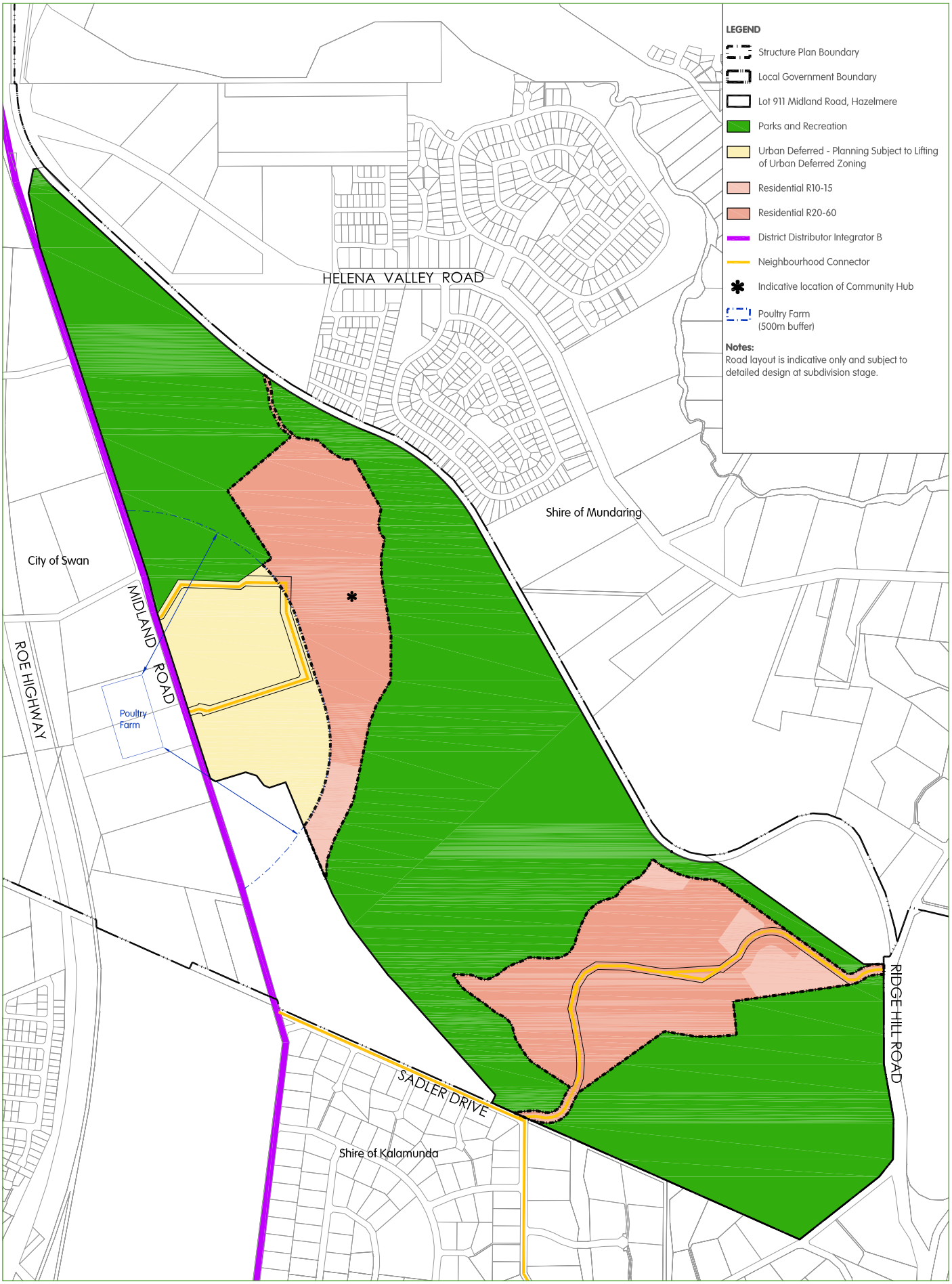
Local water management strategy item	Deliverable	☑	Comments
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements & requirements for BMPs and critical control points	X	
Introduction			
Total water cycle management – principles & objectives Planning background Previous studies		X	
Proposed development			
Structure plan, zoning and land use. Key landscape features Previous land use	Site context plan Structure plan	X X	
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas	Landscape Plan	X	
Design criteria			
Agreed design objectives and source of objective		X	
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		X	
Site Conditions - existing topography/ contours, aerial photo underlay, major physical features	Site condition plan	X	
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	X	
Environmental - areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	X	
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	X	
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	X	
Water use sustainability initiatives			
Water efficiency measures – private and public open spaces including method of enforcement		X	
Water supply (fit-for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		X	
Wastewater management		X	
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	X X	
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	X	

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	X X	
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	X	
Actions to address acid sulfate soils or contamination		X	
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.		X	
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		X	
Implementation			
Developer commitments		X	
Roles, responsibilities, funding for implementation		X	
Review		X	

APPENDIX B

Local Structure Plan

Plan 1: Local Structure Plan



APPENDIX C

Geotechnical Report
(Golders, Associates, 2014) - Provided on CD

APPENDIX D

Kadina Brook and Poison Gully Flood Modelling Report

Cedar Woods

Kadina Brook and Poison Gully

Flood Modelling Report

September 2014

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ATTACHMENT

1. FLOOD ESTIMATION

1.1 Poison Gully Flow Data Analysis

There is no historical stream flow data for Kadina Brook. Streamflow data was analysed for Poison Gully (Littlefield Road gauging station (No.616015) maintained by the Water Corporation), a similar-sized catchment located immediately south-west of the Kadina Brook catchment. Data was provided for the years 1983 to 2009 by Water Corporation (2015).

Rainfall data is from the BOM Perth Airport rain gauge (No. 009021). Log-Pearson flood frequency analysis of annual streamflow data over 26 years (from 1983 to 2009) indicates the highest recorded flood on 8 February 1992 was equivalent to a 30 yr ARI storm event, see Figure 1.

1.2 Runoff Coefficients

In order to compare Poison Gully with Kadina Brook the following analysis was made of land use and soil types. A comparison of areas corresponding to the land use and soil types are summarised in Table 1 for both catchments (see Figures 2, 3 and 4). For the purposes of this modelling the entire Kadina Brook catchment down to the Helena Valley Rd crossing was incorporated.

TABLE 1: KADINA BROOK AND POISON GULLY COMPARISON OF CATCHMENT LAND USE AND SOIL TYPE AREA

Area (ha)	Sand	Clayey Sand	Total	%
Kadina Brook				
Undeveloped	428	49	477	68
Developed	133	89	222	32
Total	**561**	**138**	**699**	**100**
Poison Gully				
Undeveloped	158	35	193	29
Developed	321	161	482	71
Total	**479**	**196**	**675**	**100**

Note:
Undeveloped areas refer to POS/Rural areas (Water Corporation, 1998)
Developed areas refer to Residential areas (Water Corporation, 1998)

Runoff coefficients were calibrated to a catchment model of Poison Gully based on the 8 February 1992 flood and are presented in Table 2. These values are in good agreement with values presented by Water Corporation (1998).

The existing pre-development Kadina Brook catchment to Helena Valley Rd was modelled in XP-Storm. Sub-catchments and land uses were estimated from topography and aerial photography. Runoff coefficients were adopted from the Urban Main Drainage Manual (Water Corporation, 1998). As a result, land uses were simplified to reflect undeveloped (including public open space (POS) and rural areas) or developed (mostly residential areas) areas while soil types were generalised as sand or clayey sand.

TABLE 2: COMPARISON OF RUNOFF COEFFICIENTS

Runoff Coefficients	Sand	Clayey Sand
Urban Main Drainage Manual (Water Corporation, 1998)		
Undeveloped	0.10	0.15
Developed	0.20	0.25
Calibrated to Poison Gully		
Undeveloped	0.10	0.15
Developed	0.17	0.23

1.3 Kadina Brook Flood Estimation

Calibrated runoff coefficients were used to establish a model for Kadina Brook model (Figure 5). Modelling results for the Kadina Brook catchment in the 100 yr and 10 yr ARI, as well as the 8 February 1992 flood are shown in Table 3 for comparison.

TABLE 3: COMPARISON OF KADINA BROOK TO HELENA VALLEY RD PEAK TOTAL CATCHMENT OUTFLOWS

Runoff Coefficients	Kadina Brook Peak Outflow (m^3/s)		
	100yr ARI	8 Feb 1992 Flood	10yr ARI
Urban Main Drainage Manual (Water Corporation, 1998)	7.18	5.71	4.25
Calibrated to Poison Gully	6.60	5.43	3.85

Peak flow estimates based on calibrated runoff coefficients are within 10% of those based on the Urban Main Drainage Manual runoff coefficients. This can be generally attributed to the variability in land use and soil types between the Poison Gully and Kadina Brook catchment. The results indicate that peak flow estimates based on the Urban Main Drainage Manual runoff coefficients are reasonable, and in the absence of historical stream flow data, can be adopted as the pre-development peak flows.

The adopted pre-development 100yr ARI peak flow for Kadina Brook is 7.18 m^3/s at the Lot 911 boundary (Figure 5).

Modelling assumptions for Kadina Brook and Poison Gully are provided in Attachment 1.

2. KADINA BROOK HYDRAULIC MODEL

2.1 Hydraulic Model

The hydraulic model of Kadina Brook was created from surveyed cross-sections (surveyed approximately 50m either side of Kadina Brook centreline) and long-sections (Figures 5 and 6). The model included surveyed culverts and a natural storage immediately upstream of Helena Valley Rd.

Modelling assumptions are provided in Attachment 1.

2.2 Results

Based on the adopted 100yr ARI pre-development flow estimate of 7.18 m^3/s for Kadina Brook to Helena Valley Rd estimates of the depth, freeboard, velocity and width are shown at certain cross-sections along Kadina Brook, presented in Table 4 below.

TABLE 4: KADINA BROOK PRE-DEVELOPMENT 100YR ARI FLOOD RESULTS

	Cross-Section 1	Cross-Section 2	Cross-Section 3	Cross-Section 4
Invert (mAHD)	17.90	21.70	27.30	33.65
Top Water Level (TWL) (100yr ARI) (mAHD)	18.55	22.55	28.05	34.80
Depth (m)	0.65	0.85	0.75	1.15
Elevation at 50m Buffer[1] (m)	21.00	24.00	31.00	37.00
Freeboard[2] (m)	2.45	1.45	2.95	2.20
Width at TWL (m)	30	22	18	12
Velocity (m/s)	0.90	0.80	1.00	0.95
Flow (100yr ARI) (m^3/s)	7.9	7.6	7.5	7.2

[1] Elevation at edge of Study Area

[2] Clearance from elevation at 50m buffer to top water level

Values shown reflect information at the particular cross-section shown.

Table 4 shows 100yr ARI Kadina Brook water depths from 0.65m to 1.15m, velocities from 0.8 m/s to 1.0 m/s and top water level widths of 12m to 30m. The 100yr ARI flood width remains well within the 50m buffer provided from the Kadina Brook centreline to the Study Area.

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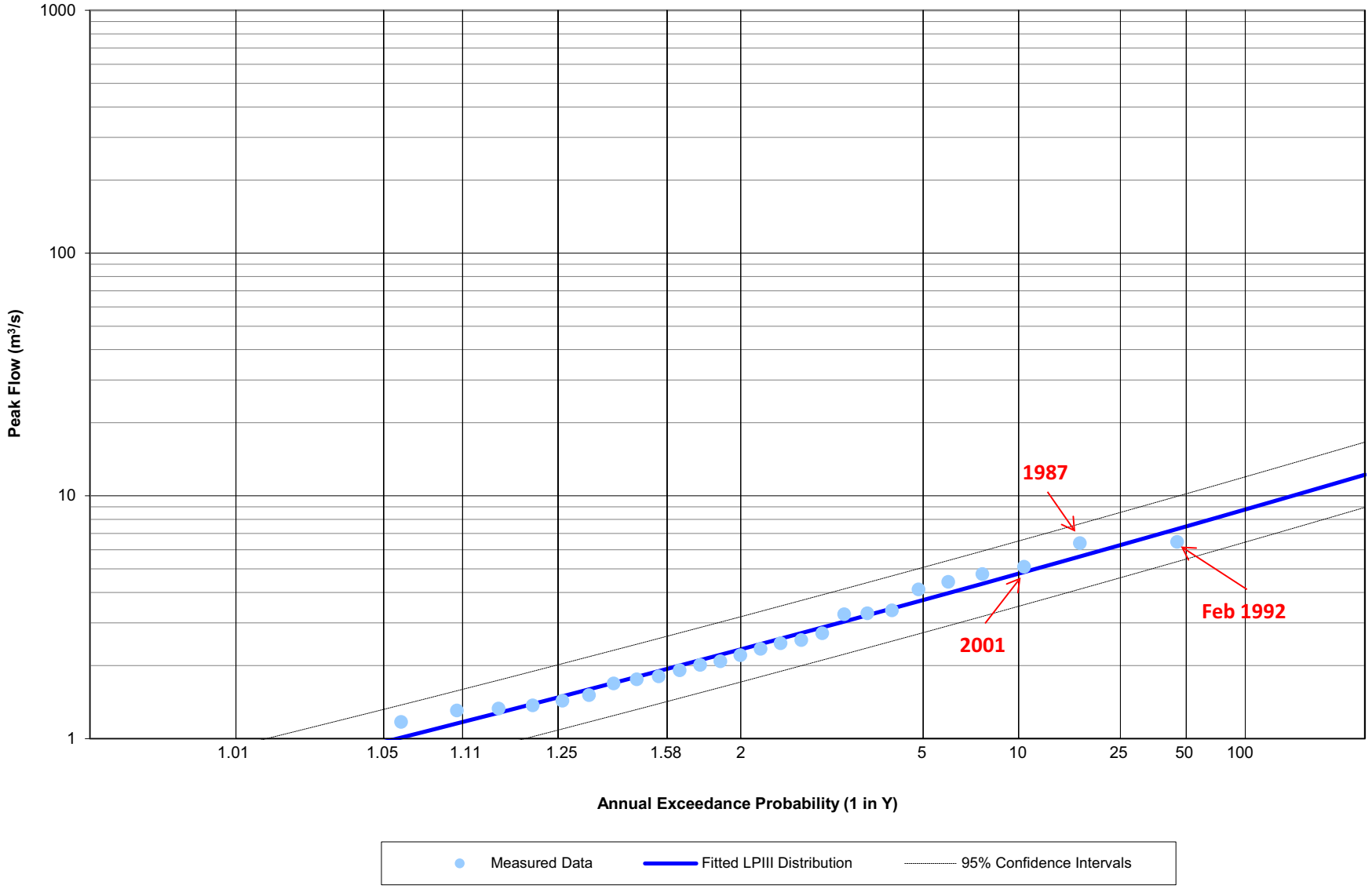

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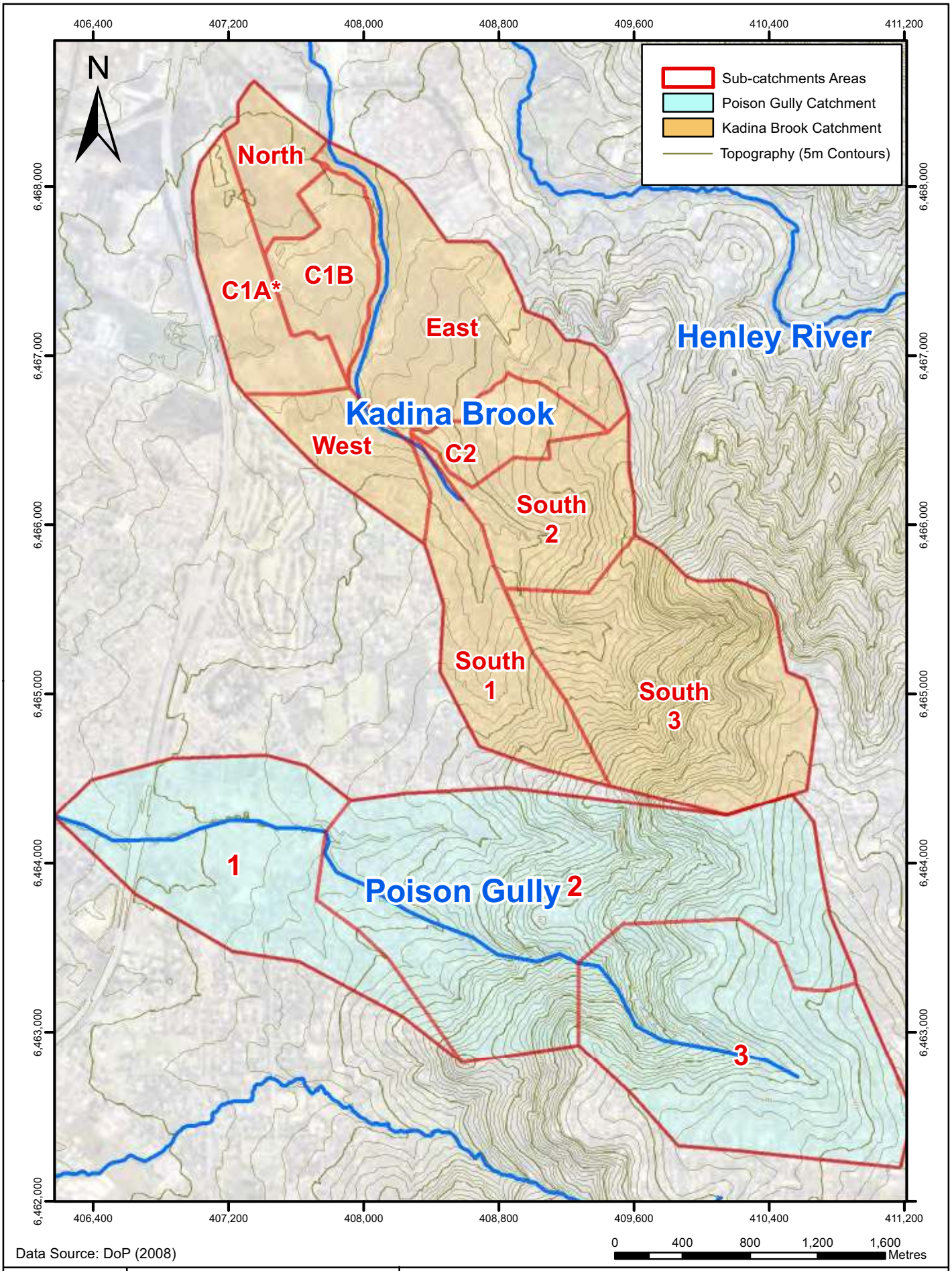
Kadina Brook and Poison Gully Flood Modelling Report

Figure 1: Annual Series Flood Frequency for Poison Gully (1983 to 2009)



Data Source: DoP (2008)

JDA

Job No. J5569
Scale 1:30,000 @A4
Coordinate System: GDA 94, Zone 50
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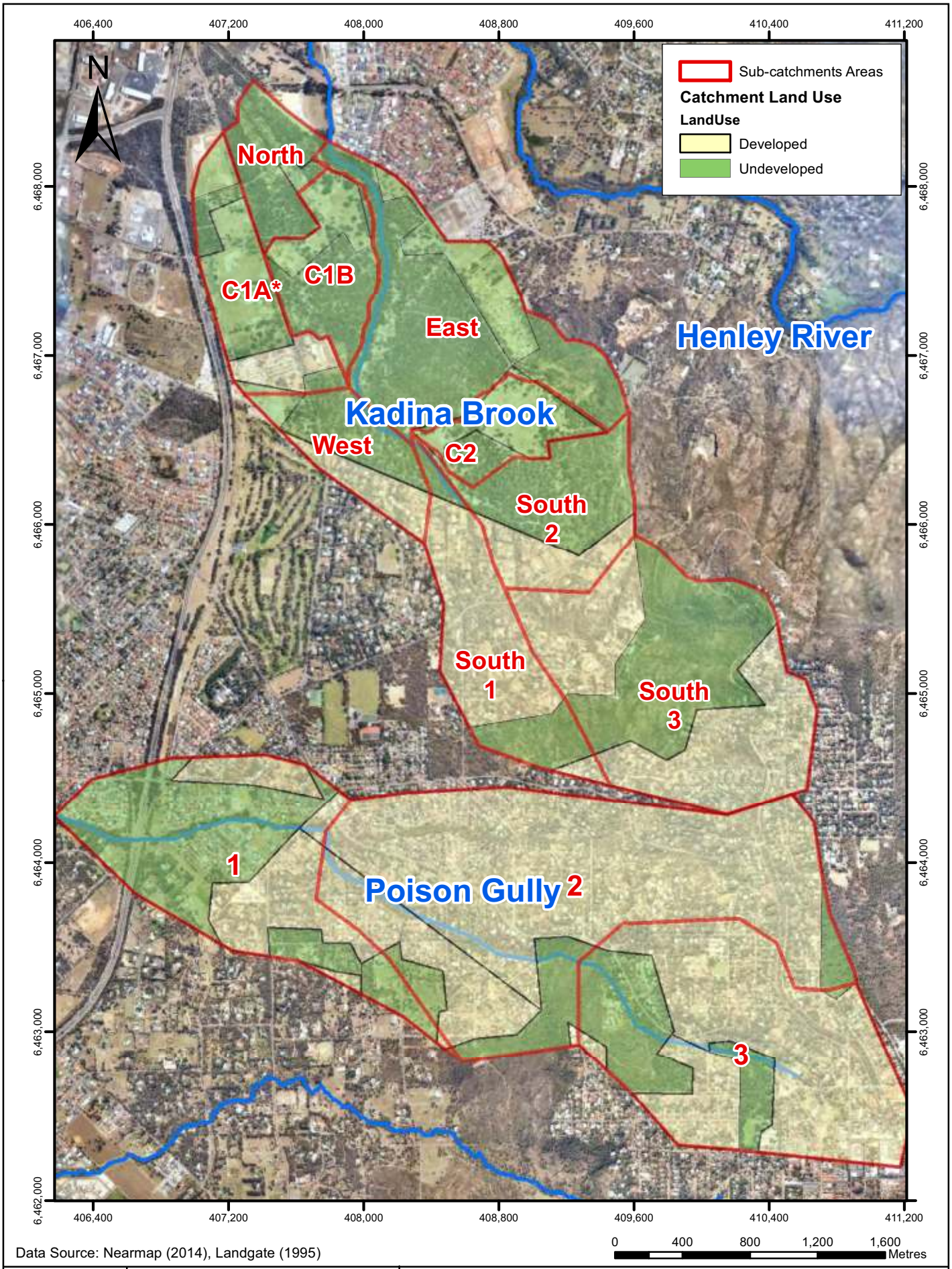
Figure 2: Catchment Areas and Topography



Data Source: Nearmap (2014), Landgate (1995)

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Job No. J5569
Scale 1:30,000 @A4
Coordinate System: GDA 94, Zone 50
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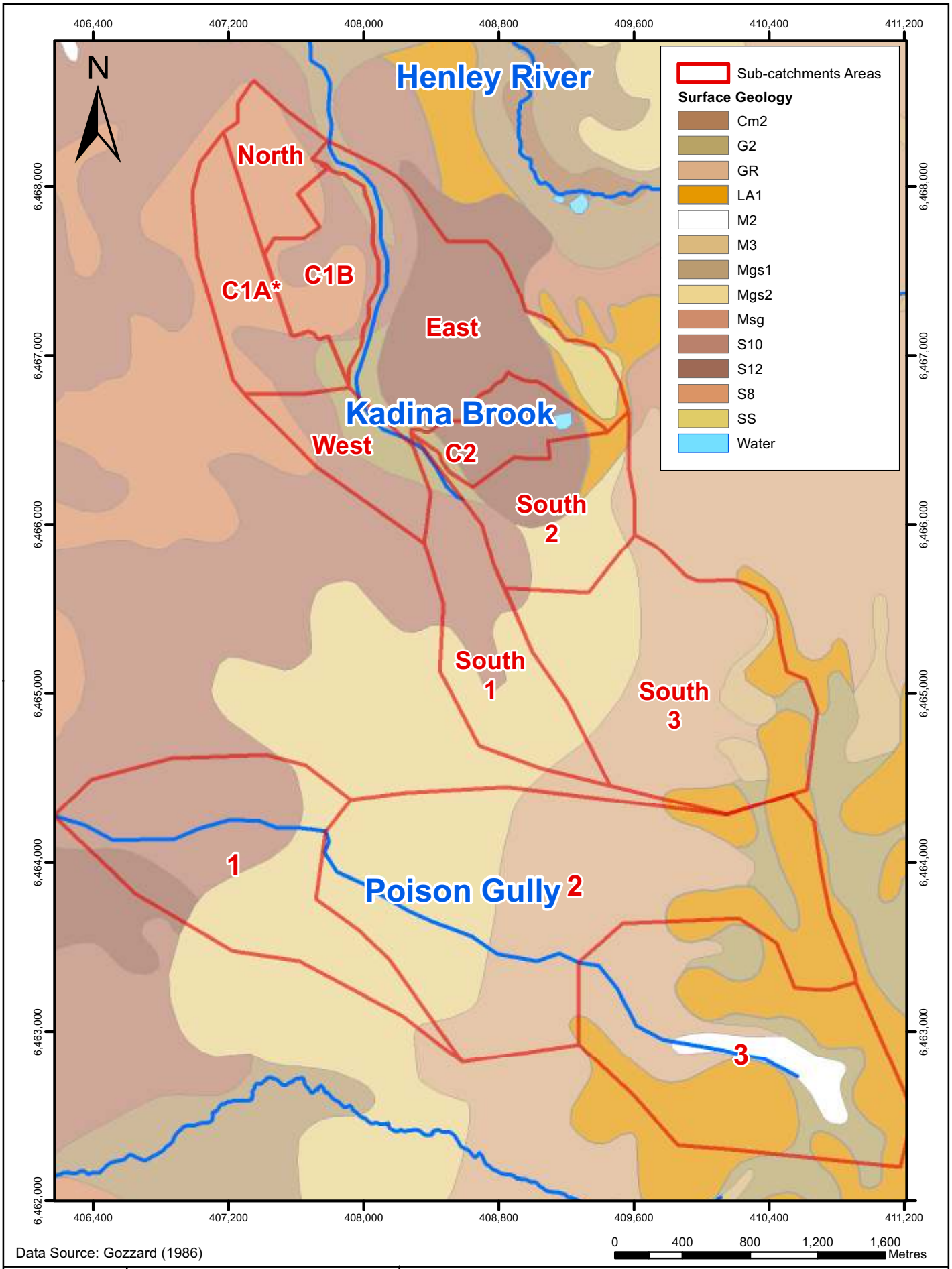
Figure 3: Pre-development Catchment Land Use



Data Source: Gozzard (1986)

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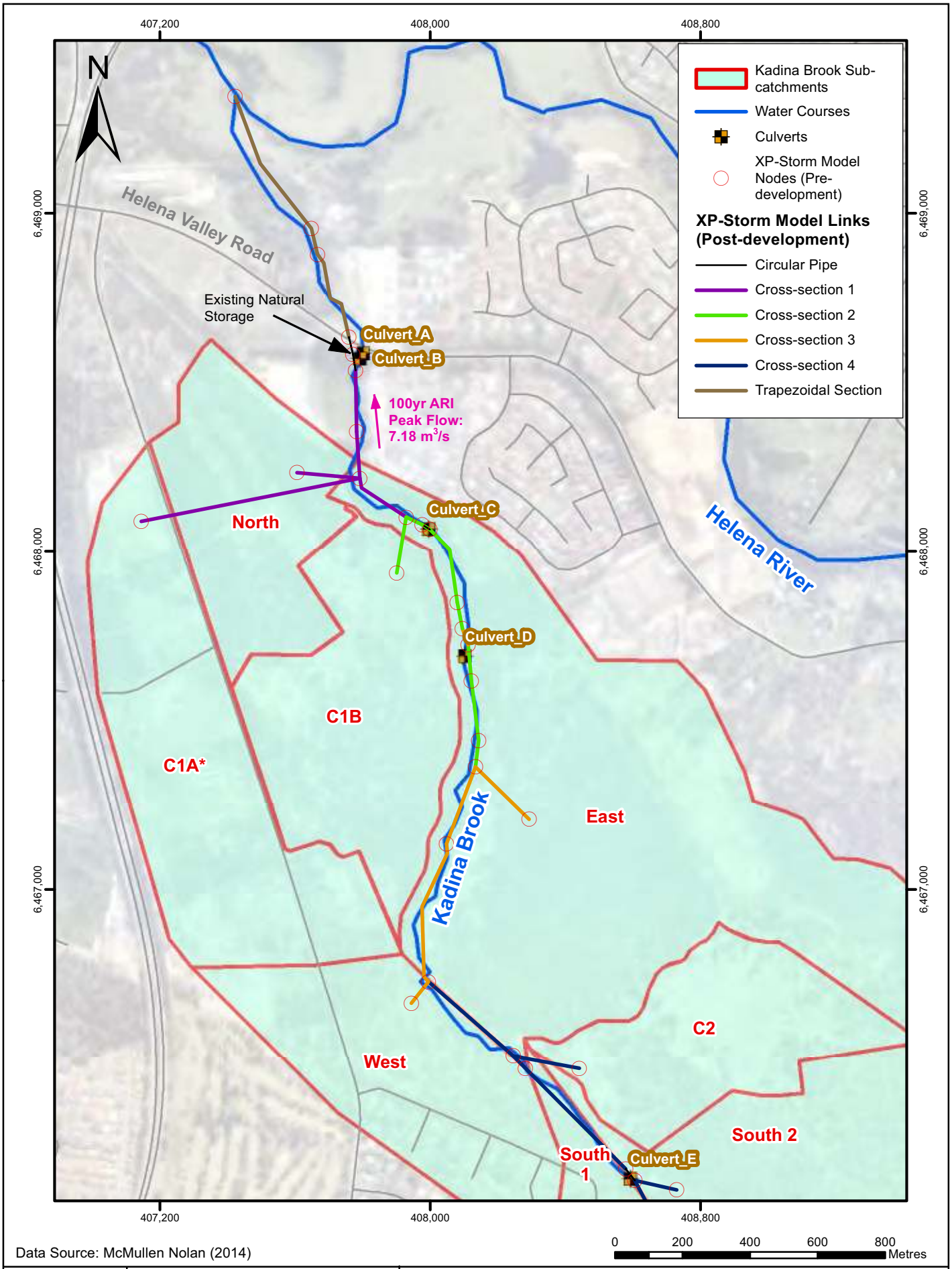
Figure 4: Catchment Soil Types



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Coordinate System: GDA 94, Zone 50
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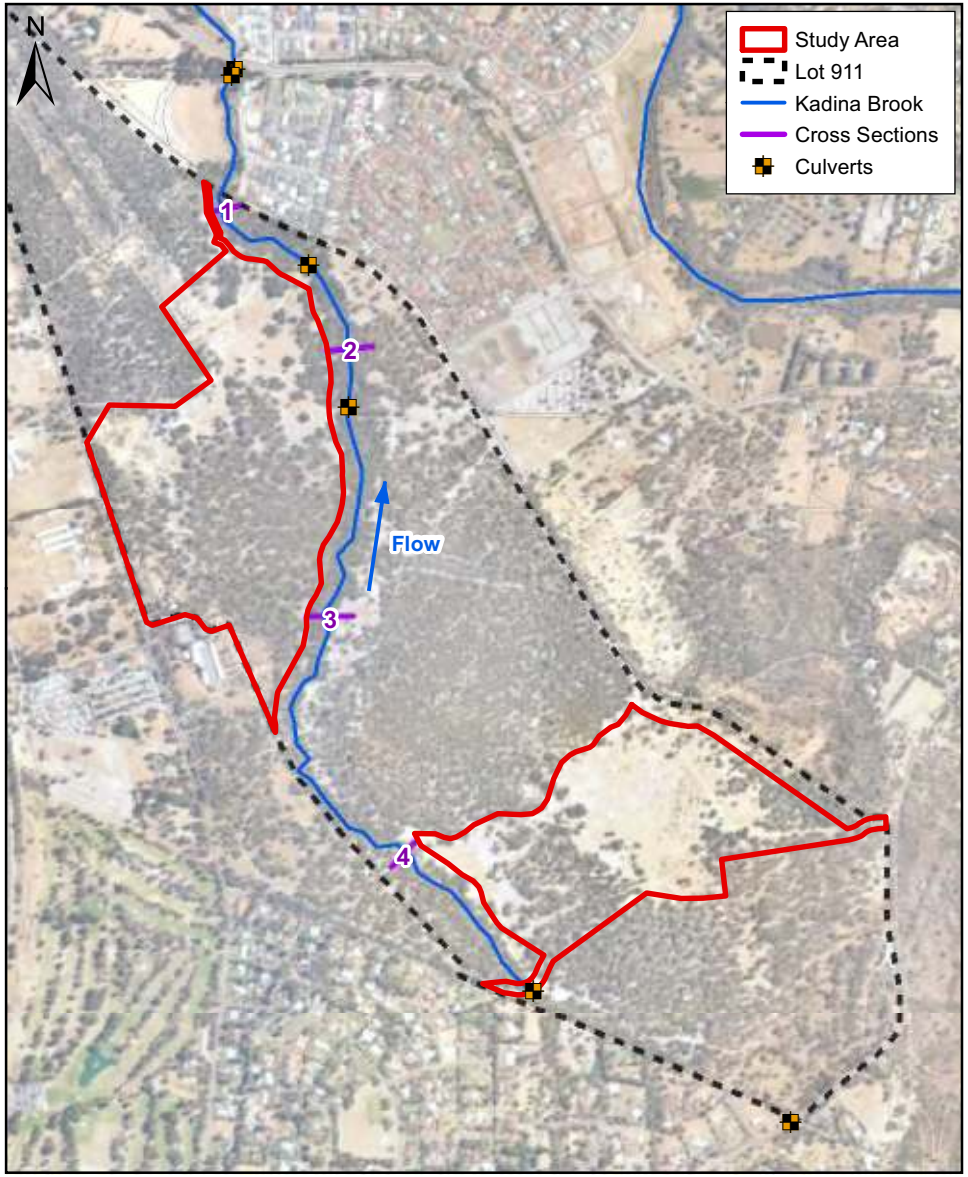
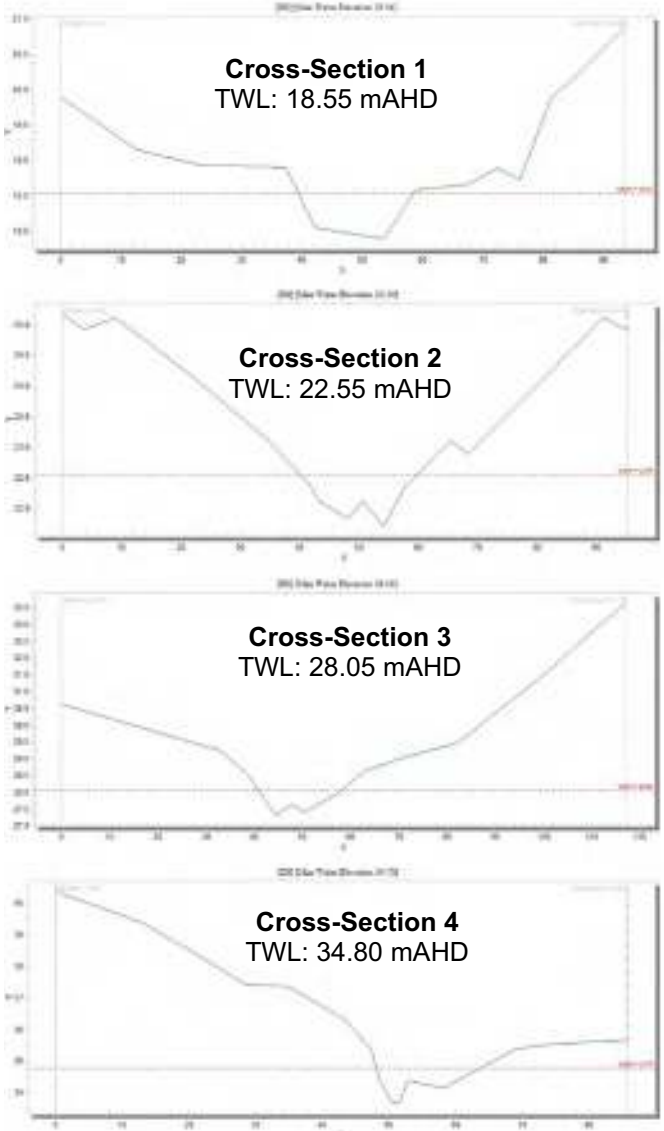
Figure 5: Kadina Brook Catchment Model (Pre-Development)



Data Source: Nearmap (2014), XP-Storm (2014)



Note: Cross-section details are provided in Table 6, Appendix C.
All cross-sections looking downstream.
Water levels in cross-section detail indicate water in the channel only.

JDA

Job No. J5569
Scale: 1:20,000

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Figure 6: Kadina Brook Cross-sections and 100yr ARI Top Water Levels

ATTACHMENT 1

Kadina Brook and Poison Gully
Modelling Assumptions

CONTENTS

LIST OF TABLES

1. PRE-DEVELOPMENT MODELLING PARAMETERS

1.1 Rainfall and Stream Flow Data

Kadina Brook	Poison Gully
Rainfall • Historical Storm (8 to 9 Feb 1992): Based on Perth Airport gauging station (No. 009021) (BoM, 2014). Hourly data from 11:00am 8 February to 4:00am 9 February 1992. • IFD: Based on Perth Airport location. *Stream Flow* • Not available for this catchment.	*Rainfall* • Historical Storm (8 to 9 Feb 1992): Based on Perth Airport gauging station (No. 009021) (BoM, 2014). Hourly data from 11:00am 8 February to 4:00am 9 February 1992. *Stream Flow* • Poison Gully historical stream flow data from Water Corporation gauging site (No. 616015). Hourly data from 11:00am 8 February to 4:00am 9 February 1992. Peak flow rate = 6.46 m^3/s for this storm event. This is also the historical peak flow for the site from 1983 to 2009.

1.2 Runoff Assumptions

Kadina Brook	Poison Gully
Runoff Catchment • Sub-catchment Areas: Based on 2014 aerial (Nearmap, 2014). See Table 1 and Figure C1. • Sub-catchment Slope: Estimated from 1m and 5m topographic contours (McMullen Nolan, 2013 and DoP, 2008). See Table 1 and Figure C1. • Runoff Routing method used: Laurenson's Method ($S=B.Q^{n+1}$) • Zero Detention (%): 0 • Evaporation: none *Runoff Coefficients* • Drainage catchment areas are simplified into 2 land uses (ie. Undeveloped or Developed) and 2 Soil Types categories (ie. Sand or Clay-Sand). See Table 3,	*Runoff Catchment* • Sub-catchment Areas: Based on 1995 aerial (Landgate, 2014). See Table 2 and Figure C1. • Sub-catchment Slope: Estimated from 5m topographic contours (DoP, 2008).See Table 2 and Figure C1. • Runoff Routing method used: Laurenson's Method ($S=B.Q^{n+1}$) • Zero Detention (%): 0 • Evaporation: none *Runoff Coefficients* • Drainage catchment areas are simplified into 2 land uses (ie. Undeveloped or Developed) and 2 Soil Types categories (ie. Sand or Clay-Sand). See Table 3, Figure C2 and Figure C3.

Figure C2 and Figure C3.

- Runoff coefficients are taken from the Urban Main Drainage Manual (Water Corporation, 1998). See Table 4.
- A second set of runoff coefficients are based on the Urban Main Drainage Manual values and calibrated to the Poison Gully catchment by adjusting the runoff coefficients representing 'Developed' (residential) areas. See Table 4.
- Note: Areas of sub-catchments C1A, C1 and C2 vary from DWMS estimates due to catchment refinement. Reassessment also concluded that C1A would not flow through C1B as indicated in the DWMS (RPS, 2012). Topography suggests runoff from this sub-catchment flows into Kadina Brook downstream of the Study Area.

- Runoff coefficients are taken from the Urban Main Drainage Manual (Water Corporation, 1998). See Table 4.
- A second set of runoff coefficients are based on the Urban Main Drainage Manual values and calibrated to the Poison Gully catchment by adjusting the runoff coefficients representing 'Developed' (residential) areas. See Table 4.

TABLE 1: KADINA BROOK PRE-DEVELOPMENT RUNOFF CATCHMENT DETAILS

Kadina Brook Catchment					
Sub-Catchment Name	**Total Area (ha)**	**Slope**	**Runoff Coefficient Area (ha)**	**Simplified Land Use**	**Simplified Soil Types**
C1A[1]	60.79	0.007	47.59	Rural	Sand
		0.007	13.2	Residential	Sand
C1B[2]	48.79	0.014	46.5	Rural	Sand
		0.014	2.26	Rural	Clay-Sand
C2[2]	35.0	0.048	35.0	Rural	Sand
East	131.49	0.035	124.49	Rural	Sand
		0.035	7	Rural	Clay-Sand
North	35.4	0.012	35.3	Rural	Sand
		0.012	0.12	Rural	Clay-Sand
South_1	82.6	0.055	5.6	Rural	Sand
		0.055	14.83	Rural	Clay-Sand
		0.055	35.36	Residential	Sand
		0.055	26.81	Residential	Clay-Sand
South_2	73.1	0.07	37.2	Rural	Sand
		0.07	12.51	Rural	Clay-Sand
		0.07	9.52	Residential	Sand
		0.07	13.92	Residential	Clay-Sand
South_3	187.5	0.09	68.08	Rural	Sand
		0.09	12.22	Rural	Clay-Sand
		0.09	58.98	Residential	Sand
		0.09	48.18	Residential	Clay-Sand
West	44.47	0.023	28.45	Rural	Sand
		0.023	16.02	Residential	Sand

[1] Area varies slightly from sub-catchment as reported in RPS (2012). This variation is due to revision of sub-catchment boundaries based on topography.
[2] Area varies slightly from sub-catchment as reported in RPS (2012). This variation is due to revision of the Study Area.

TABLE 2: POISON GULLY PRE-DEVELOPMENT RUNOFF CATCHMENT DETAILS

Poison Gully Catchment					
Sub-Catchment Name	**Total Area (ha)**	**Slope**	**Runoff Coefficient Area (ha)**	**Simplified Land Use**	**Simplified Soil Types**
1	160.3	0.04	80.9	Rural	Sand
		0.04	25.1	Rural	Clay-Sand
		0.04	12.1	Residential	Sand
		0.04	42.2	Residential	Clay-Sand
2	309.5	0.069	28.7	Rural	Sand
		0.069	7.0	Rural	Clay-Sand
		0.069	171.2	Residential	Sand
		0.069	102.7	Residential	Clay-Sand
3	205.1	0.066	48.8	Rural	Sand
		0.05	2.5	Rural	Clay-Sand
		0.12	137.3	Residential	Sand
		0.06	16.5	Residential	Clay-Sand

TABLE 3: COMPARISON OF CATCHMENT LAND USE AND SOIL TYPES AREA

Area (ha)	Sand	Clay-Sand
Kadina Brook		
Undeveloped (POS/Rural)	428	49
Developed (Residential)	133	89
Poison Gully		
Undeveloped (POS/Rural)	158	35
Developed (Residential)	321	161

TABLE 4: COMPARISON OF RUNOFF COEFFICIENTS

Runoff Coefficients	Sand	Clay-Sand
Urban Main Drainage Manual		
Undeveloped (POS/Rural)	0.10	0.15
Developed (Residential)	0.20	0.25
Calibrated to Poison Gully		
Undeveloped (POS/Rural)	0.10	0.15
Developed (Residential)	0.17	0.23

1.3 Simulation Parameters

Kadina Brook	Poison Gully
Time Control • Dry time step is 86400 seconds • Transition time step is 60 seconds • Wet time step is 60 seconds • Simulation period is 2 days	*Time Control* • Dry time step is 86400 seconds • Transition time step is 60 seconds • Wet time step is 60 seconds • Simulation period is 2 days

1.4 Hydraulics

Kadina Brook	Poison Gully
Culverts • Manning's n = 0.014 • Low Flow Roughness factor = 1 • Inlet Type = Not specified • Entrance and Exit Losses = 0.5 • Culverts allowed to be overtopped with road levels at various elevations above culvert. Overtopping elevations estimated	*Culverts* • No culverts. *Channels* • Modelled as Trapezoidal Channel: 3m wide, 1:3 slopes. • Long-section elevation and lengths estimated by topography (5m contours)

by site visit (23 April 2014). See Table 5 and Figure C.4.

Channels

- Modelled as Natural or Trapezoidal Channel.
- Trapezoidal channels (representing channel from Culvert A to Helena River): 1.5m width, 1:2 slopes.
- Cross-sections based on surveyed data at four different transects representative of the channel (McMullen Nolan, 2014). See Table 6 and Figure C.4.
- Long-section elevations and lengths based on surveyed data (McMullen Nolan, 2014).
- Manning's n = 0.035 (in all channels) (based on JDA site visit 23/4/2014).

Other Features

- Natural storage encountered between culverts A and B. Storage size estimated from site visit (23 April 2014). Modelled with depth = 3.5 m, 1:1 slopes and 15x15m square base.

(DoP, 2008)

- Manning's n = 0.035 (assumed similar to Kadina Brook).

TABLE 5: CULVERT DETAILS

Name	Diameter (mm)	No. of Conduits	Cover (m)
Culvert A	1200	2	0.5
Culvert B	900	2	1.5
Culvert C	450	2	0.1
Culvert D	900	2	0.1
Culvert E	750	1	2.0

TABLE 6: NATURAL CROSS-SECTION DETAIL (MCMULLEN NOLAN, 2014)

Cross-Section 1		Cross-Section 2		Cross-Section 3		Cross-Section 4	
Distance* (m)	Stage (mAHD)	Distance* (m)	Stage (mAHD)	Distance* (m)	Stage (mAHD)	Distance* (m)	Stage (mAHD)
0.0	22.0	0.0	29.1	0.0	34.0	0.0	42.0
12.5	21.3	3.5	28.8	32.9	32.6	13.1	41.0
23.6	21.0	9.0	29.0	38.8	31.9	21.3	40.0
27.9	21.0	22.4	28.0	44.5	30.7	28.3	39.1
37.3	21.0	34.8	27.0	47.8	31.0	34.9	39.0
42.2	20.2	41.7	26.3	50.3	30.8	43.2	38.0
53.4	20.0	43.4	26.0	57.6	31.4	47.3	37.0
55.9	20.3	48.1	25.7	62.7	32.0	48.6	36.0
58.7	20.7	50.7	26.0	70.6	32.4	50.3	35.4
67.6	20.8	54.2	25.6	82.0	32.8	51.4	35.3
72.4	21.0	57.7	26.3	92.2	34.0	52.0	35.6
76.0	20.8	65.4	27.0	101.1	35.0	52.8	36.0
81.3	22.0	68.3	26.8	108.8	36.0	58.1	35.8
85.8	22.3	81.0	28.0	117.1	37.0	68.9	37.0
93.6	23.0	91.1	29.0			74.4	37.2
		95.1	28.8			85.6	37.3

*Distance from left bank

1.5 Backwater

Kadina Brook	Poison Gully
Backwater • Outfall of 10.8 mAHD applied at ultimate downstream node to represent Helena River 100yr flood level (DoW, 2008). • Constriction at various culverts along Kadina Brook. Overtopping allows relief. (Table 5).	*Backwater* • Outfall of 10 mAHD applied at ultimate downstream node to represent water levels in Poison Gully at the time of the historical storm event.

APPENDIX E

Groundwater Bore Logs

Monitoring Well No: MW1

Project: Bushmead
Project No.: 0042826
Date: 22 March 2006
Location: Rifle Range
Hole Depth: 11 m
Hole Diameter: 420 mm

Initial Groundwater: 8 m
Eastings: 50407509
Northings: 6468076
Driller: Ecoprobe/Hollow Stem Auger

RL (mAHD): 27.577
Logged By: Marion Kehoe

USCS Class	Description	Graphic Log	Well Construction	Depth (m)	Sample	PID (ppm)	Remarks
	Ground Surface			0.0			
SP	**Sand** Cream brown, fine to medium grained, well sorted, dry, metal glass fragments				MW1_0.1	4.7	Bullet casings and broken glass
SP				1.0	MW1_0.8	152	Humid sample for PID test
	Sand Yellow brown, medium grained, well sorted, quartz, dry to moist			2.0			
SP	**Sand** Yellow, medium grained, well sorted, quartz, dry to moist			3.0			
SP	**Sand** Brown to yellow, medium grained, well sorted, quartz, dry			4.0	MW1_4.0	192	
SP	**Sand** Yellow, medium, grained,well sorted, quartz, dry to moist			5.0			
SW	**Gravelly sand** Red yellow, coarse grained red gravel with medium grained yellow sand matrix, moist			6.0	MW1_6.0	64.5	
SP							
SP	**Sand** Brown grey, medium grained,well sorted, quartz, dry			7.0	MW1_7.0	104	Humid sample for PID test
	Sand Grey, medium grained, well sorted, quartz, clay content 5%, moist			8.0			
CL	**Sandy clay** Grey, medium grained, well sorted, quartz, clay content 25 to 30%, compacted, moderate plasticity			9.0			
				10.0	MW1_10.0	72	
	Bottom of bore at 11m			11.0			

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Cloisters Square
WA 6850
Australia

Notes: All coordinates are presented in MGA94.

Checked by

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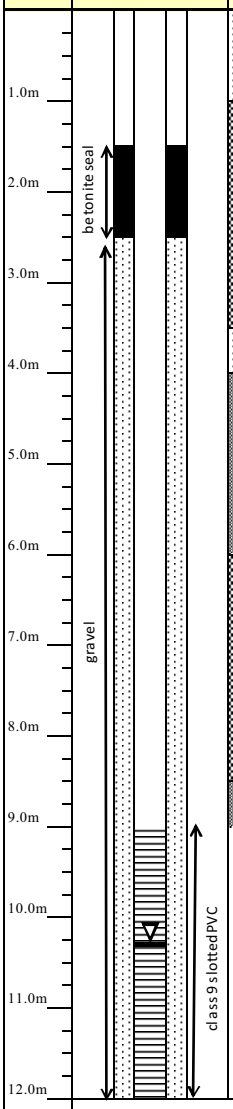
Fax: 9381 9279

LITHOLOGICAL LOG

Client: Cedar Woods		Job No:	J5569
Project: Hazelmere LWMS		Hole commenced:	6/03/2014
Bore location: 408026E 6467698N		Hole completed:	6/03/2014
Datum: 50 (GDA94)		Logged by:	RD
Bore Name: B1B		Total Depth:	12.0 mBTOC
Drill type: Air Rotary		R.L. TOC:	26.20 mAHD
Hole diameter: 75mm		Natural Surface:	26.25 mAHD



Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGICAL LOG						
			LITHOLOGY	COLOUR	GRAIN SIZE	SORTING	GRAIN SHAPE	MOISTURE	OTHER
0.0m – 1.0m			sand	pale red	fine to medium	moderately	sub-rounded	dry	
1.0m – 2.0m			clayey sand	red	fine to gravel	poor	sub-angular	dry	laterite gravel
2.0m – 3.0m			clayey sand	red	fine	well	sub-rounded	dry	
3.0m – 4.0m			clayey sand	red	fine to gravel	poor	sub-angular	dry	laterite gravel
4.0m – 5.0m			sand	pale orange	fine	well	sub-rounded	dry	
5.0m – 6.0m			sandy clay	cream red	fine	well	sub-rounded	dry	minor sub-angular quartz
6.0m – 7.0m			sandy clay	pale red	fine	well	sub-rounded	moist	
7.0m – 8.0m			clayey sand	grey, red mottles	fine	well	sub-rounded	dry	
8.0m – 9.0m			clayey sand	grey	fine	well	sub-rounded	moist	
9.0m – 12.0m			sandy clay	grey	fine	well	sub-rounded	moist	

no sample from 9 to 12 m due to collapse, assumed similar to 8.5 to 9.0m

EOH

Sand
Loamy sand
Sandy Loam
Sandy Clay
Sandy Clay Loam
Clay Loam
Clayey Sand
Clay

Grain Size	Sorting	Grain	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

BOREHOLE CONSTRUCTION LOG

PROJECT NUMBER: D10458				WEATHER: Fine	
BOREHOLE ID: B2				DRILLING METHOD: Solid Stemmed Auger	
SITE: Bushmead Riffle Range		LOCATION: Development Area		TOTAL DEPTH: 6.5 m	
EAST:	407970	NORTH:	6467137	TOP of COLLAR RL: mAHD	
DATE BEGUN:	15/10/2010	DATE COMPLETED:	15/10/2010	STATIC WATER LEVEL:	
SCIENTIST: JR				CASE DIAMETER: 50 mm	PVC CLASS: 18
DRILLING COMPANY: Strataprobe				LOCKABLE BORE: Yes	
DRILLER: Les/Rob				SHEET: 1 of 1	

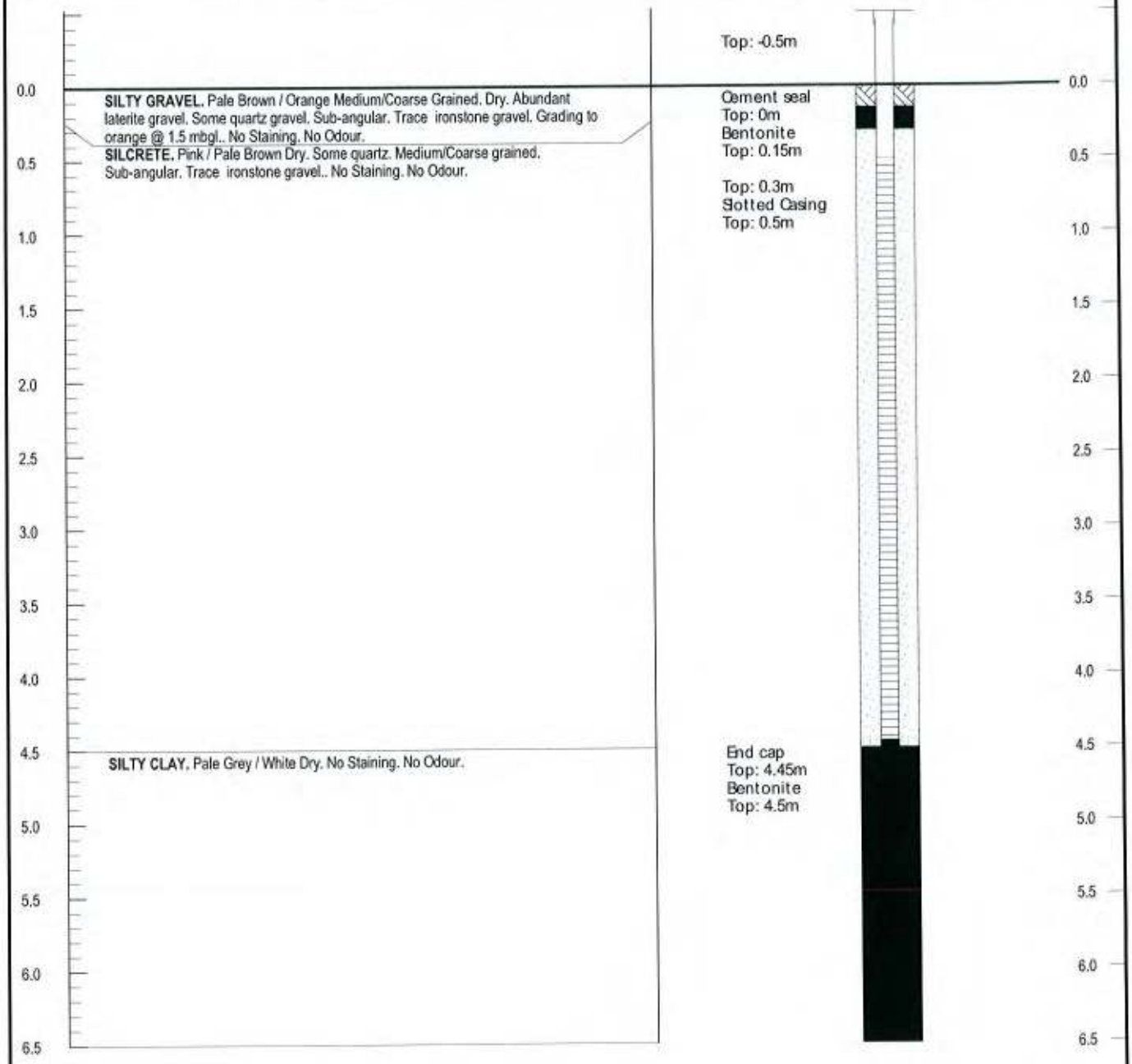
LITHOLOGY DESCRIPTION

SILTY GRAVEL. Pale Brown / Orange Medium/Coarse Grained. Dry. Abundant laterite gravel. Some quartz gravel. Sub-angular. Trace ironstone gravel. Grading to orange @ 1.5 mbgl.. No Staining. No Odour.

SILCRETE. Pink / Pale Brown Dry. Some quartz. Medium/Coarse grained. Sub-angular. Trace ironstone gravel.. No Staining. No Odour.

SILTY CLAY. Pale Grey / White Dry. No Staining. No Odour.

BORE INSTALLATION



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LITHOLOGICAL LOG

Client: Cedar Woods	Job No: J5569
Project: Hazelmere LWMS	Hole commenced: 6/03/2014
Bore location: 407969E 6467135N	Hole completed: 6/03/2014
Datum: 50 (GDA94)	Logged by: RD
Bore Name: B2(d)	Total Depth: 13.0 mBTOC
Drill type: Air Rotary	R.L. TOC: 32.67 mAHD
Hole diameter: 75mm	Natural Surface: 32.09 mAHD

BORE CONSTRUCTION

LITHOLOGICAL LOG

Depth (m)	LITHOLOGY	COLOUR	GRAIN SIZE	SORTING	GRAIN SHAPE	MOISTURE	OTHER
0.0–0.5	sand	orange	very coarse to gravel	moderately	sub-angular	dry	laterite
0.5–1.0	sand	orange	fine to gravel	poor	sub-angular	dry	laterite
1.0–2.0	sand	orange	fine to very coarse	poor	sub-angular	dry	laterite
2.0–2.5	sand	orange	fine to coarse	poor	sub-angular	dry	laterite
2.5–3.5	clayey sand	grey, red mottles	fine	well	sub-rounded	dry	
3.5–4.5	clayey sand	light grey	fine	well	sub-rounded	dry	
4.5–8.0	clayey sand	light grey	fine	well	sub-rounded	moist	
8.0–9.5	sandy clay	cream	medium	well	sub-rounded	moist	
9.5–10.0	sandy clay	cream	fine	well	sub-rounded	moist	
10.0–10.5	clayey sand	grey	fine	well	sub-rounded	moist	
10.5–13.0	sand	pale red	fine to medium	moderately	sub-rounded	moist	minimal clay content

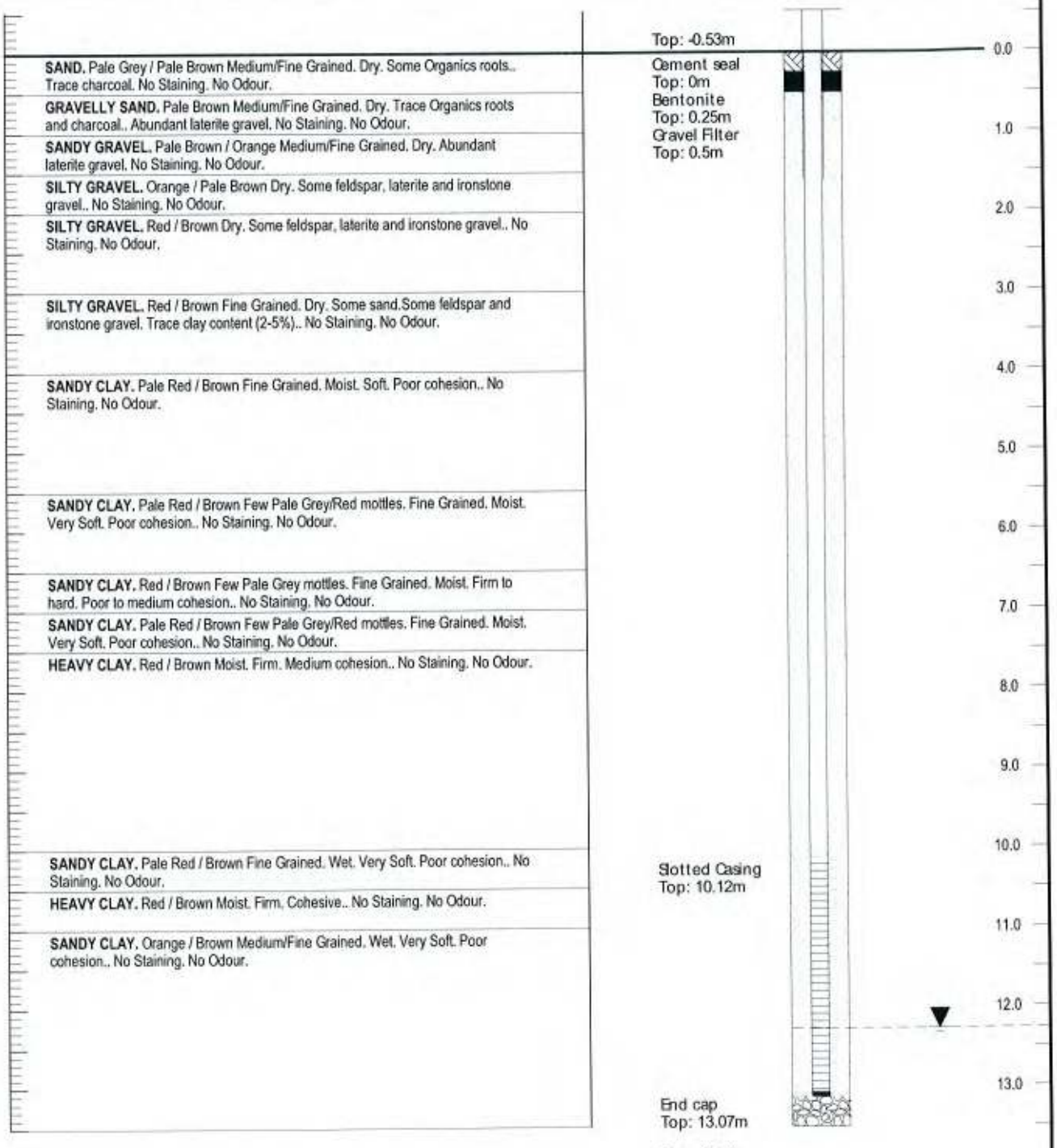
Legend (graphical log): Sand; Loamy sand; Sandy Loam; Sandy Clay; Sandy Clay Loam; Clay Loam; Clayey Sand; Clay

Grain Size	Sorting	Grain	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

BOREHOLE CONSTRUCTION LOG

PROJECT NUMBER: D10458				WEATHER: Fine	
BOREHOLE ID: B5				DRILLING METHOD: Solid Stemmed Auger	
SITE: Bushmead Riffle Range		LOCATION: Development Area		TOTAL DEPTH: 13.5 m	
EAST:	407536	NORTH:	6467391	TOP of COLLAR RL: mAHD	
DATE BEGUN:	28/10/2010	DATE COMPLETED:	28/10/2010	STATIC WATER LEVEL: 12.27 mbgl	
SCIENTIST: JR				CASE DIAMETER: 50 mm	PVC CLASS: 18
DRILLING COMPANY: Strataprobe				LOCKABLE BORE: Yes	
DRILLER: Les/Rob				SHEET: 1 of 1	

LITHOLOGY DESCRIPTION	BORE INSTALLATION
SAND. Pale Grey / Pale Brown Medium/Fine Grained. Dry. Some Organics roots.. Trace charcoal. No Staining. No Odour.	Top: -0.53m Cement seal Top: 0m Bentonite Top: 0.25m Gravel Filter Top: 0.5m
GRAVELLY SAND. Pale Brown Medium/Fine Grained. Dry. Trace Organics roots and charcoal.. Abundant laterite gravel. No Staining. No Odour.	
SANDY GRAVEL. Pale Brown / Orange Medium/Fine Grained. Dry. Abundant laterite gravel. No Staining. No Odour.	
SILTY GRAVEL. Orange / Pale Brown Dry. Some feldspar, laterite and ironstone gravel.. No Staining. No Odour.	
SILTY GRAVEL. Red / Brown Dry. Some feldspar, laterite and ironstone gravel.. No Staining. No Odour.	
SILTY GRAVEL. Red / Brown Fine Grained. Dry. Some sand.Some feldspar and ironstone gravel. Trace clay content (2-5%).. No Staining. No Odour.	
SANDY CLAY. Pale Red / Brown Fine Grained. Moist. Soft. Poor cohesion.. No Staining. No Odour.	
SANDY CLAY. Pale Red / Brown Few Pale Grey/Red mottles. Fine Grained. Moist. Very Soft. Poor cohesion.. No Staining. No Odour.	
SANDY CLAY. Red / Brown Few Pale Grey mottles. Fine Grained. Moist. Firm to hard. Poor to medium cohesion.. No Staining. No Odour.	
SANDY CLAY. Pale Red / Brown Few Pale Grey/Red mottles. Fine Grained. Moist. Very Soft. Poor cohesion.. No Staining. No Odour.	
HEAVY CLAY. Red / Brown Moist. Firm. Medium cohesion.. No Staining. No Odour.	
SANDY CLAY. Pale Red / Brown Fine Grained. Wet. Very Soft. Poor cohesion.. No Staining. No Odour.	Slotted Casing Top: 10.12m
HEAVY CLAY. Red / Brown Moist. Firm. Cohesive.. No Staining. No Odour.	
SANDY CLAY. Orange / Brown Medium/Fine Grained. Wet. Very Soft. Poor cohesion.. No Staining. No Odour.	
	End cap Top: 13.07m
	Top: 13.12m



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LITHOLOGICAL LOG

Client:	Cedar Woods	Job No:	J5569
Project:	Hazelmere LWMS	Hole commenced:	23/04/2014
Bore location:	407496E 6467659N	Hole completed:	23/04/2014
Datum:	50 (GDA 94)	Logged by:	JY/RD
Bore Name:	**B8(s)**	Total Depth:	1.6mBNS
Drill type:	Hand Auger	R.L. TOC:	29.13 mAHD
Hole diameter:	75mm	Natural Surface:	28.46 mAHD

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGICAL LOG						
			LITHOLOGY	COLOUR	GRAIN SIZE	SORTING	GRAIN SHAPE	MOISTURE	OTHER
0.5m			Sand	Dark Grey-Brown	fine to gravel	poor	sub-r	dry	laterite gravel
1.0m									
1.5m			Sandy Clay	yellow-orange	fine to gravel	poor	sub-r	dry	laterite gravel
			Clayey Sand	yellow-grey	f to g	poor	sub-r	dry	laterite gravel
2.0m									
2.5m									
3.0m									
3.5m									
4.0m									
4.5m									
5.0m									
5.5m									
6.0m									

Sand
Loamy sand
Sandy Loam
Loam
Sandy Clay Loam
Clay Loam
Sandy Clay
Clay

Grain Size	Sorting	Grain	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

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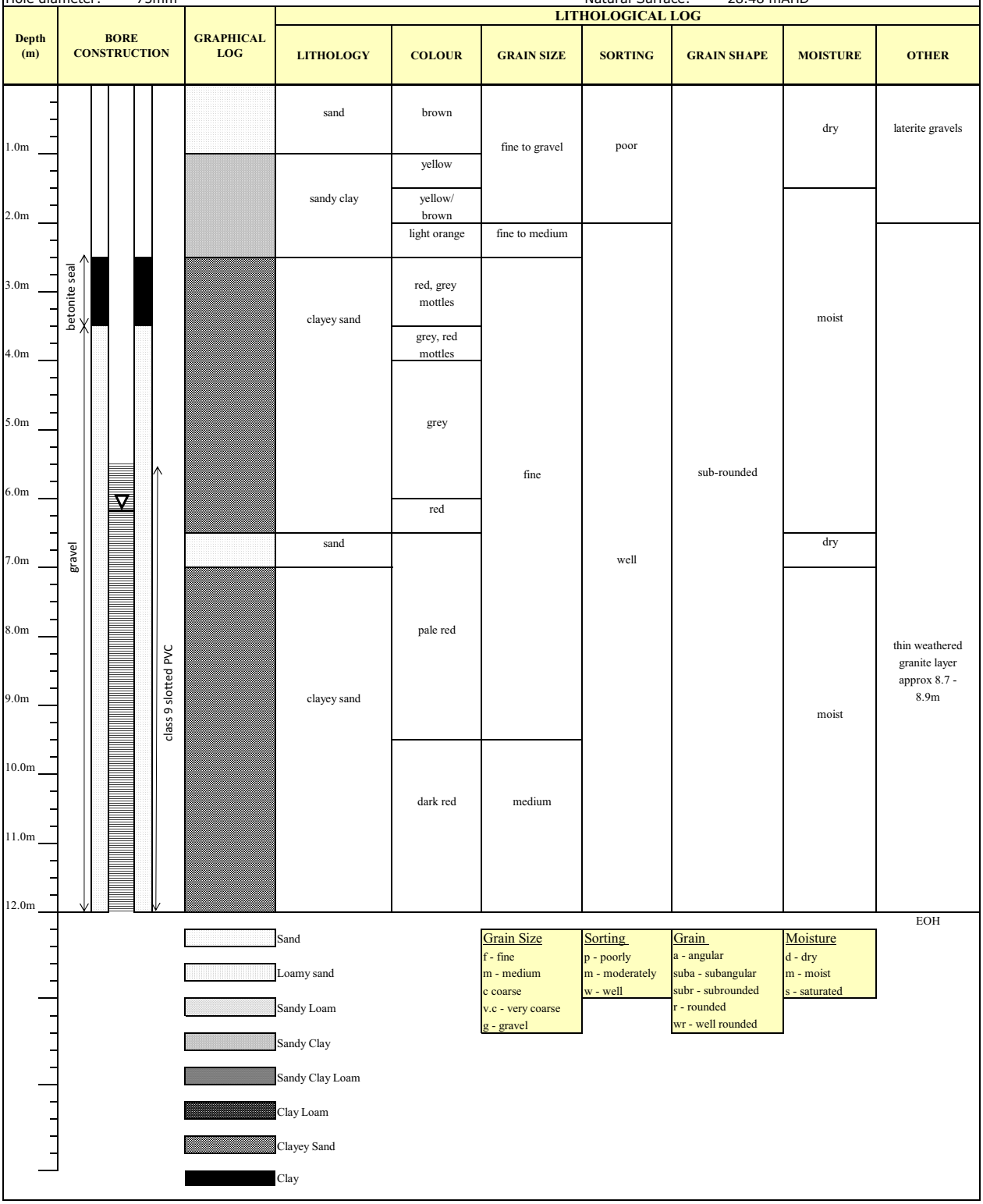
LITHOLOGICAL LOG

Client:	Cedar Woods	Job No:	J5569
Project:	Hazelmere LWMS	Hole commenced:	6/03/2014
Bore location:	407495E 6467658N	Hole completed:	6/03/2014
Datum:	50 (GDA94)	Logged by:	RD
Bore Name:	**B8(d)**	Total Depth:	11.5 mBTOC
Drill type:	Air Rotary	R.L. TOC:	29.10 mAHD
Hole diameter:	75mm	Natural Surface:	28.48 mAHD



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LITHOLOGICAL LOG

Client:	Cedar Woods	Job No:	J5569
Project:	Hazelmere LWMS	Hole commenced:	23/04/2014
Bore location:	407774E 6467792N	Hole completed:	23/04/2014
Datum:	50 (GDA 94)	Logged by:	JY/RD
Bore Name:	**B9(s)**	Total Depth:	1.2mBNS
Drill type:	Hand Auger	R.L. TOC:	26.99 mAHD
Hole diameter:	75mm	Natural Surface:	26.29 mAHD

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGICAL LOG						
			LITHOLOGY	COLOUR	GRAIN SIZE	SORTING	GRAIN SHAPE	MOISTURE	OTHER
0.5m			Sand	Grey	Fine	well	sub-r	dry	
1.0m				White to Pale Grey	Fine	well	sub-r	dry	
1.5m			Sandy Gravel	Red	Fine to Gravel	poor	sub-r	dry	laterite gravel
2.0m									
2.5m									
3.0m									
3.5m									
4.0m									
4.5m									
5.0m									
5.5m									
6.0m									

Sand
Loamy sand
Sandy Loam
Loam
Sandy Clay Loam
Clay Loam
Sandy Clay
Clay

Grain Size	Sorting	Grain	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

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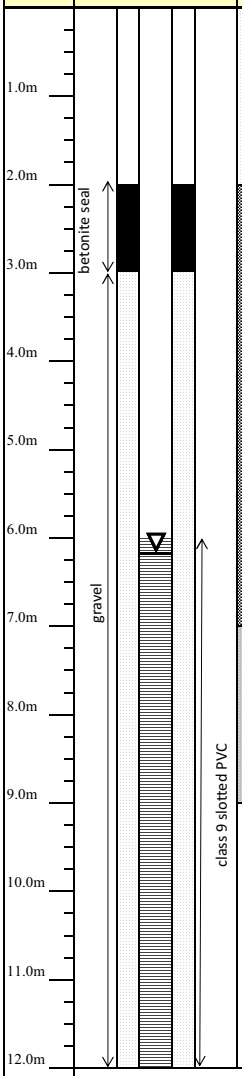
LITHOLOGICAL LOG

Client:	Cedar Woods	Job No:	J5569
Project:	Hazelmere LWMS	Hole commenced:	6/03/2014
Bore location:	407773E 6467791N	Hole completed:	6/03/2014
Datum:	50 (GDA94)	Logged by:	RD
Bore Name:	**B9(d)**	Total Depth:	12.0 mBTOC
Drill type:	Air Rotary	R.L. TOC:	26.91 mAHD
Hole diameter:	75mm	Natural Surface:	26.36 mAHD



LITHOLOGICAL LOG

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGY	COLOUR	GRAIN SIZE	SORTING	GRAIN SHAPE	MOISTURE	OTHER
0.0–1.0			sand	light grey	fine	well	sub-rounded	dry	
1.0–2.0			sand	orange	fine to very coarse	poor	sub-rounded	dry	
2.0–2.5			sand	red	fine to medium	well	sub-rounded	dry	
2.5–3.0			clayey sand	grey, red mottles	fine	well	sub-rounded	dry	very hard
3.0–6.0			clayey sand	light grey, minor red mottles	fine	well	sub-rounded	dry	very hard
6.0–7.0			clayey sand	grey	fine	well	sub-rounded	moist	very hard
7.0–8.0			sandy clay	grey minor red mottles	fine to coarse	moderately	sub-rounded	moist	very hard
8.0–9.0			sandy clay	pale red	fine to coarse	moderately	sub-rounded	dry	clay nodules from collapse?
9.0–12.0									

no sample from 9 to 12 m due to collapse, assumed similar to 8.5 to 9.0m

Sand
Loamy sand
Sandy Loam
Sandy Clay
Sandy Clay Loam
Clay Loam
Clayey Sand
Clay

Grain Size	Sorting	Grain	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

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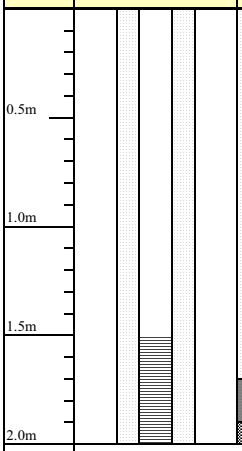
LITHOLOGICAL LOG

Client:	Cedar Woods	Job No:	J5569
Project:	Hazelmere LWMS	Hole commenced:	23/04/2014
Bore location:	407822E 6468069N	Hole completed:	23/04/2014
Datum:	50 (GDA 94)	Logged by:	JY/RD
Bore Name:	**B10(s)**	Total Depth:	2.0mBNS
Drill type:	Hand Auger	R.L. TOC:	22.99 mAHD
Hole diameter:	75mm	Natural Surface:	22.29 mAHD



Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGICAL LOG						
			LITHOLOGY	COLOUR	GRAIN SIZE	SORTING	GRAIN SHAPE	MOISTURE	OTHER
0.5m			Sand	Dark Grey-Brown	fine to gravel	well	sub-r	dry	
1.0m			Sand	yellow-orange to orange-brown	fine to gravel	medium to well	sub-r	dry	
1.5m									
2.0m			Clayey Sand	yellow-grey	f to g	poor	sub-r	dry	laterite gravel

Sand
Loamy sand
Sandy Loam
Loam
Sandy Clay Loam
Clay Loam
Sandy Clay
Clay

Grain Size	Sorting	Grain	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

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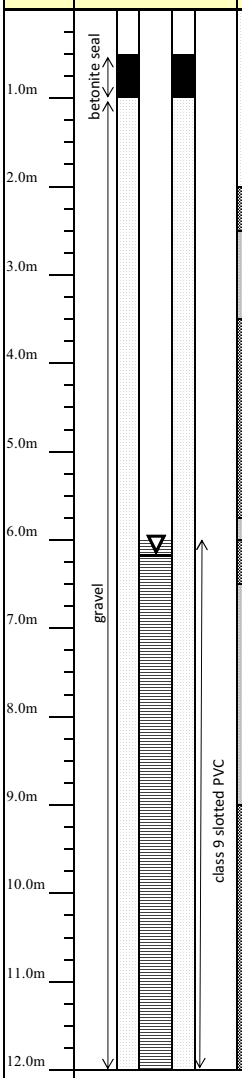
LITHOLOGICAL LOG

Client:	Cedar Woods	Job No:	J5569
Project:	Hazelmere LWMS	Hole commenced:	6/03/2014
Bore location:	407821E 6468068N	Hole completed:	6/03/2014
Datum:	50 (GDA94)	Logged by:	RD
Bore Name:	**B10(d)**	Total Depth:	12.0 mBTOC
Drill type:	Air Rotary	R.L. TOC:	22.89 mAHD
Hole diameter:	75mm	Natural Surface:	22.38 mAHD



Depth (m)	LITHOLOGY	COLOUR	GRAIN SIZE	SORTING	GRAIN SHAPE	MOISTURE	OTHER
0.0m – 1.0m	sand	light grey	fine to medium	poor	sub-rounded	dry	minor feldspar
		pale orange	fine to coarse				
		orage	fine to very coarse				
1.0m – 2.0m		light orange	medium to very coarse	moderately			
2.0m – 3.0m	clayey sand	orange	fine to medium				very dry
	sandy clay	pale red					
		red/ yellow					
3.0m – 4.0m	clayey sand	light grey	fine	well			very dry, very hard. Early stage granite?
4.0m – 5.0m							minor orange mottles
5.0m – 6.0m	sandy clay	brown	medium to coarse			moist	
	clayey sand	light grey	fine				
6.0m – 7.0m	sandy clay	light grey/ brown lenses	fine to medium				
7.0m – 8.0m						dry	
8.0m – 9.0m		grey					
9.0m – 10.0m	clayey sand		fine			moist	
10.0m – 11.0m							
11.0m – 12.0m							

Sand
Loamy sand
Sandy Loam
Sandy Clay
Sandy Clay Loam
Clay Loam
Clayey Sand
Clay

Grain Size	Sorting	Grain	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

Monitoring Well No: MW4

Project: Bushmead
Project No.: 0042826
Date: 21 March 2006
Location: Down gradient - Effluent Disposal
Hole Depth: 16.0 m
Hole Diameter: 420 mm

Initial Groundwater: 8.6 m
Eastings: 50407992
Northings: 6466736
Driller: Ecoprobe/Hollow Stem Auger

RL (mAHD): 32.073
Logged By: Marion Kehoe

USCS Class	Description	Graphic Log	Well Construction	Depth (m)	Sample	PID (ppm)	Remarks
	Ground Surface			0.0			
SP	**Sand** Brown orange, fine to medium grained sand, poorly sorted, quartz, organic matter (leaves and roots), dry			1.0	MW4_1.0	1.7	
SM SW	**Sand** Orange red, fine to medium grained, poorly sorted, quartz gravel with fine sandy matrix, dry			2.0	MW4_2.4	4.1	
SP	**Gravelly sand** Red brown, medium grained, poorly sorted, quartz gravel with fine sandy matrix, dry			3.0			
	Silty sand Brown red, fine grained, poorly sorted, minor quartz gravel, dry			4.0			Solid quartz and gravel fragments
SP	**Gravelly sand with clay** Orange brown, medium grained, poorly sorted, sandy matrix, clay content (10% to 15%), dry			5.0	MW4_4.6	22.5	
	Sand Grey, medium grained, well sorted, quartz, plastic, clay content (15% to 20%), dry			6.0			
SP	**Sand** Grey, medium grained, well sorted, clay content (15% to 20%), wet			7.0			
				8.0			
				9.0			
				10.0			
	End of Well at 10.6 m			11.0			
				12.0			
				13.0	MW4_13.0		
				14.0			
				15.0			
				16.0			Well was re-drilled over multiple days due to very hard geology and caving sands.
	End of Hole at 16 m **Hole collapsed 10.6 -16m**			17.0			

Environmental Resources Management
PO Box 7338
Cloisters Square
WA 6850
Australia

Notes: All coordinates are presented in MGA94.

Checked by

Monitoring Well No: MW2

Project: Bushmead
Project No.: 0042826
Date: 27 March 2006
Location: Rifle Range
Hole Depth: 10 m
Hole Diameter: 420 mm

Initial Groundwater: 6.45 m
Eastings: 50407593
Northings: 6468120
Driller: Ecoprobe/Hollow Stem Auger

RL (mAHD): 25.664
Logged By: Marion Kehoe

USCS Class	Description	Graphic Log	Well Construction	Depth (m)	Sample	PID (ppm)	Remarks
	Ground Surface			0.0			
SP	**Sand** Cream brown, fine to medium grained, well sorted, minor organic matter (roots) dry						
SP	**Sand** Yellow brown, fine to medium grained, well sorted, dry			1.0	MW2_1.0		
	Sand Brown grey, medium grained, well sorted, clay content 5%, moist			2.0			
				3.0			
SP				4.0			
				5.0	MW2_5.0		
SP	**Sand** Brown grey, medium grained, well sorted, clay content 5 to 10%, moist			6.0			
	Clayey sand Grey to light brown, medium grained, well sorted, weak plasticity, clay content 10 to 15%, very moist			7.0			
SC				8.0	MW2_8.0		
				9.0			
	Bottom of bore at 10 m			10.0			

Environmental Resources Management
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Cloisters Square
WA 6850
Australia

Notes: All coordinates are presented in MGA94.

Checked by

Monitoring Well No: MW2

Project: Bushmead
Project No.: 0042826
Date: 27 March 2006
Location: Rifle Range
Hole Depth: 10 m
Hole Diameter: 420 mm

Initial Groundwater: 6.45 m
Eastings: 50407593
Northings: 6468120
Driller: Ecoprobe/Hollow Stem Auger

RL (mAHD): 25.664
Logged By: Marion Kehoe

USCS Class	Description	Graphic Log	Well Construction	Depth (m)	Sample	PID (ppm)	Remarks
				11.0			
				12.0			
				13.0			
				14.0			
				15.0			
				16.0			
				17.0			
				18.0			
				19.0			
				20.0			
				21.0			

Environmental Resources Management
PO Box 7338
Cloisters Square
WA 6850
Australia

Notes: All coordinates are presented in MGA94.

Checked by

Monitoring Well No: MW3

Project: Bushmead
Project No.: 0042826
Date: 22 March 2006
Location: Rifle Range
Hole Depth: 6.3 m
Hole Diameter: 420 mm

Initial Groundwater: 3.8 m
Eastings: 50407745
Northings: 6467916
Driller: Ecoprobe/Hollow Stem Auger

RL (mAHD): 26.106
Logged By: Marion Kehoe

USCS Class	Description	Graphic Log	Well Construction	Depth (m)	Sample	PID (ppm)	Remarks
	Ground Surface			0.0			
GM	**Gravel Fill** Red gravel road base with silty matrix, dry						
	Sand Yellow, fine grained, well sorted, quartz				MW3_0.5	20.9	
SP	**Sand** Dark grey black, medium grained, quartz, dry			1.0			
	Sand Light grey, medium grained, quartz, well sorted, minor red brown molting, dry to moist						
GW	**Gravelly sand** Red brown, sandy matrix, coarse grained, poorly sorted, dry to moist			2.0	MW3_2.0	24.2	
	Clayey sand Grey, medium grained, well sorted, clayey sand matrix (20 to 25% clay content), plastic, quartz, moist, strong organic odour			3.0			
SC				4.0	MW3_4.0	11.3	
	End of sampling at 4.5 m			5.0			
				6.0			
	Bottom of bore at 6.3 m						

Environmental Resources Management
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Cloisters Square
WA 6850
Australia

Notes: All coordinates are presented in MGA94.

Checked by

Monitoring Well No: MW3

Project: Bushmead
Project No.: 0042826
Date: 22 March 2006
Location: Rifle Range
Hole Depth: 6.3 m
Hole Diameter: 420 mm

Initial Groundwater: 3.8 m
Eastings: 50407745
Northings: 6467916
Driller: Ecoprobe/Hollow Stem Auger

RL (mAHD): 26.106
Logged By: Marion Kehoe

USCS Class	Description	Graphic Log	Well Construction	Depth (m)	Sample	PID (ppm)	Remarks
				7.0			
				8.0			
				9.0			
				10.0			
				11.0			
				12.0			
				13.0			

Environmental Resources Management
PO Box 7338
Cloisters Square
WA 6850
Australia

Notes: All coordinates are presented in MGA94.

Checked by

APPENDIX F

Preliminary Landscape Water Requirements – 2 Year Establishment Requirments

Bushmead POS Landscape Water Requirements - 2 Year Establishment Requirement

		Irrigation Heavy Landscape Option		Xeriscaping Option		
	Total POS Area (m2)	**Irrigated Area (m2)**	**Water Requirement (kL pa) based on 6750 kL/Ha/Year**	**Irrigated Area (m2)**	**Water Requirement (kL pa) based on 6750 kL/Ha/Year**	Actual POS Area
POS 1	6,104	4,272.73	2,884.09	1,220.78	824.03	5,549
POS 2	9,658	6,760.60	4,563.41	1,931.60	1,303.83	8,780
POS 3	12,257	8,580.11	5,791.57	2,451.46	1,654.74	11,143
POS 4	9,316	6,521.13	4,401.76	1,863.18	1,257.65	8,469
POS 5	2,961	2,072.84	1,399.17	592.24	399.76	2,692
POS 6	13,200	9,240.00	6,237.00	2,640.00	1,782.00	12,000
POS 7	6,799	4,759.37	3,212.57	1,359.82	917.88	6,181
POS 8	15,653	10,957.10	7,396.04	3,130.60	2,113.16	14,230
POS 9	6,683	4,677.75	3,157.48	1,336.50	902.14	6,075
POS 10	3,028	2,119.81	1,430.87	605.66	408.82	2,753
POS 11	5,892	4,124.12	2,783.78	1,178.32	795.37	5,356
Total	**91,551**		**43,257.75**		**12,359.36**	

Note: Water Allocation based on D.O.W. 6750 kL/Ha/Year.
Actual POS areas have been increased by 10% to allow for surrounding road verges which will also require landscaping.
Irrigated areas include areas or turf, shrubs and trees only. Areas of hardscape and drainage basins are excluded.

APPENDIX G

Landscape Master Plan (EPCAD, 2014) – Provided on CD

APPENDIX H

Swale Concepts (WGE, 2015)

PLAN
SCALE 1:5000

REV.	DESCRIPTION	DRAWN	VER	APPROVED
A	ORIGINAL ISSUE	GAB		

WOOD & GRIEVE ENGINEERS
Wood & Grieve Engineers Ltd
A.C.N. 137 999 609
Ground Floor
226 Adelaide Tce, Perth
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Phone: +61 8 6222 7000
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Email wge@wge.com.au
Web www.wge.com.au
PERTH
MELBOURNE
SYDNEY
BRISBANE
GOLD COAST
ALBANY
BUSSELTON
SHENZHEN
DARWIN

CLIENT:
CEDAR WOODS PROPERTIES LIMITED

PROJECT:
BUSHMEAD

TITLE:
CROSS SECTIONS PLAN

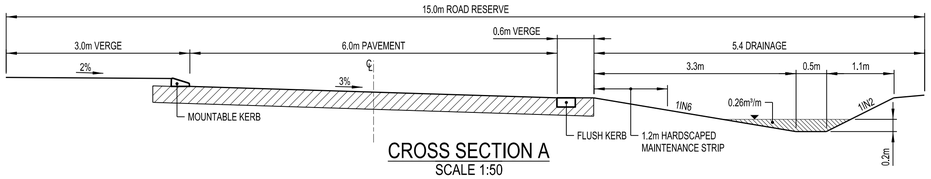
PRELIMINARY

SECTION: CIVIL SERVICES	VERIFIED :	SCALE : A1 @ 1:1000
DESIGNED : J. ZELONES	APPROVED FOR TENDER:	DATUM : A.H.D.
DRAWN : G. BATE	APPROVED FOR CONSTRUCTION :	WAPC : -

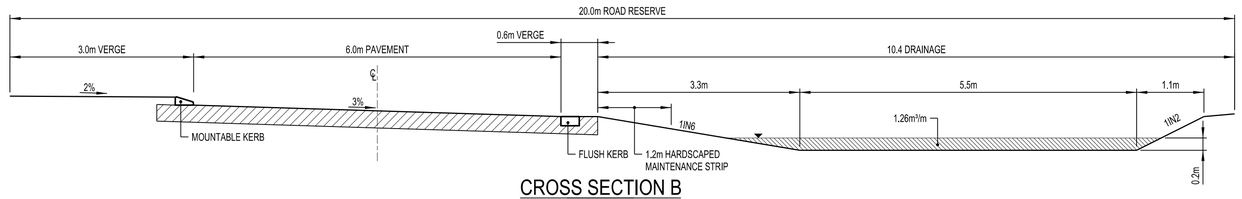
PROJECT No.	DRAWING No.	REVISION
18776-PER-C-MP	SK3	A

P:\18776-MP\Civil Drawings\Sketch\SK2\c swale xsections.dgn

A1 @ 1:1000
A3 @ 1:2000



CROSS SECTION A
SCALE 1:50



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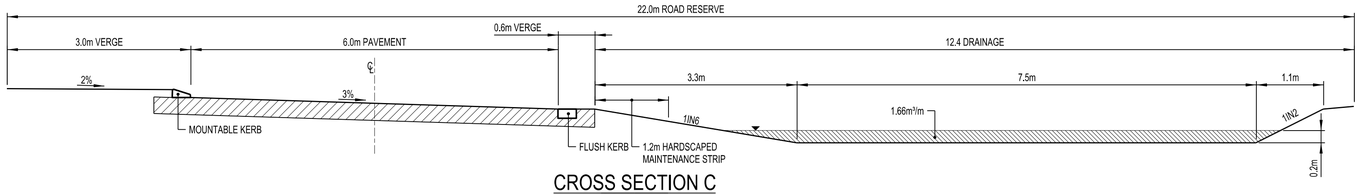
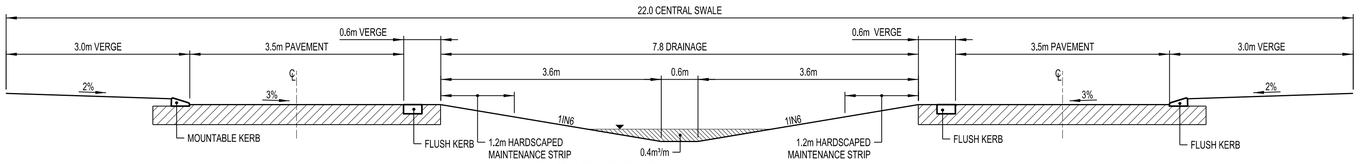
SCALE 1:50



CROSS SECTION C
SCALE 1:50

NOTES:
REFER TO DRAWING 18776-PER-C-MP/SK1 FOR CROSS-SECTION LOCATIONS



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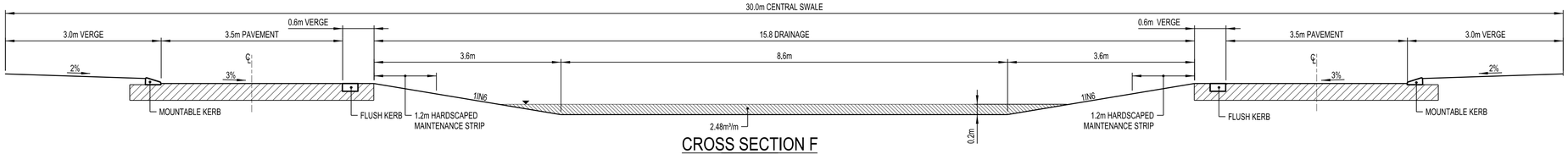
SCALE 1:50



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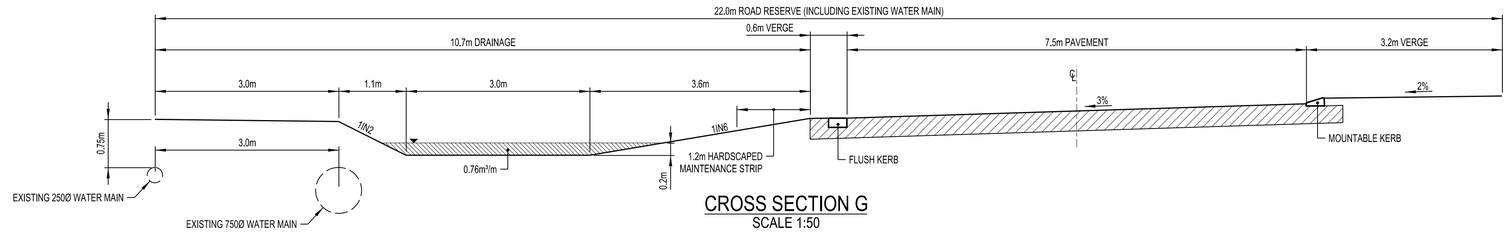

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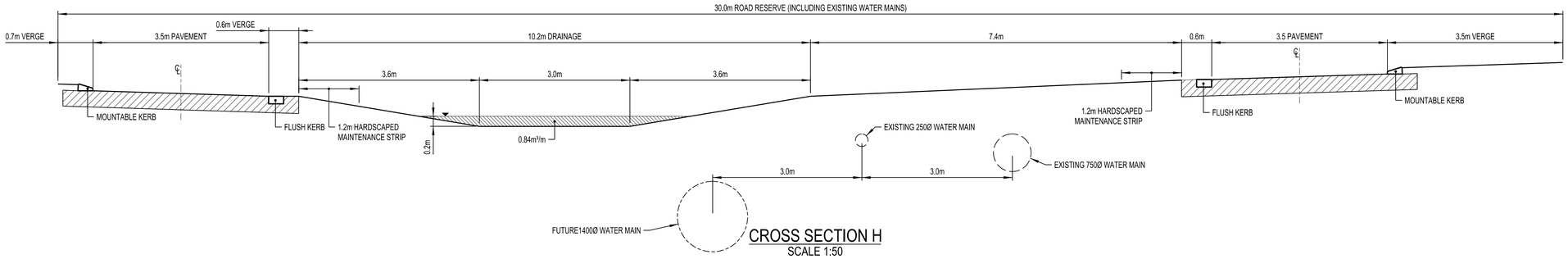
SCALE 1:50



CROSS SECTION H
SCALE 1:50

REV.	DESCRIPTION	DRAWN	VER	APPROVED
B	UPADTED PER CITY OF SWAN COMMENTS	GAB		
A	ORIGINAL ISSUE	GAB		

WOOD & GRIEVE ENGINEERS

Wood & Grieve Engineers Ltd
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Ground Floor
226 Adelaide Tce, Perth
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PERTH
MELBOURNE
SYDNEY
BRISBANE
GOLD COAST
ALBANY
BUSSELTON
SHENZHEN
DARWIN

CLIENT:
CEDAR WOODS PROPERTIES LIMITED

PROJECT:
BUSHMEAD

TITLE:
CROSS SECTIONS

PRELIMINARY

SECTION: CIVIL SERVICES	VERIFIED :	SCALE : A1 @ 1:1000
DESIGNED : J. ZELONES	APPROVED FOR TENDER:	DATUM : A.H.D.
DRAWN : G. BATE	APPROVED FOR CONSTRUCTION :	WAPC : -

PROJECT No.	DRAWING No.	REVISION
18776-PER-C-MP	SK4	B

P:\18776-MP\Civil Drawings\Sketch\SK2\c swale xsections.dgn

A1 @ 1:1000
A3 @ 1:2000

APPENDIX I

Continuing Loss Calculations

Class A Cottage Lot

Typical compact lot constructed in Piara Waters

User input

Lot design			
Lot area	m^2	300	
Roof area	m^2	195	Assumed maximum 65% lot area based on R-Codes
Outdoor living area	m^2	30	Assumed maximum 10% lot area based on R-Codes
Driveway area	m^2	30	Assumed maximum 10% lot area based on R-Codes
Total impervious	m^2	255	
Total impervious contributing	m^2	255	Soakwells are interconnected and overflow to street drainage
Rainfall loss from contributing impervious area			
Rainfall depth	mm	15	
	m	0.015	
Rainfall volume	m^3	3.83	Rainfall depth (m) times total impervious contributing area (m^2)
Soakwell volume	m^3	3.8	Combination of soakwells to achieve sufficient storage for rainfall volume
Soakwell surface area	m^2	4.31	Combined surface area of soakwells combination
Soil conductivity (K)	m/day	5	Based on typical imported fill
Soakwell clogging factor	%	0.5	
Design Soakwell Infiltration Rate (K)	m/day	2.50	
Continuing Loss	m/day	0.04	Soakwell area divided by total impervious contributing area multiplied by soil conductivity
	mm/hr	1.8	
Modelling assumptions			
Initial loss	mm	15	
Continuing loss	mm/hr	1.8	

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Class A Traditional Lot

Typical standard lot constructed in Piara Waters

User input

Lot design			
Lot area	m^2	400	
Roof area	m^2	240	Assumed maximum 60% lot area based on R-Codes
Outdoor living area	m^2	40	Assumed maximum 10% lot area based on R-Codes
Driveway area	m^2	40	Assumed maximum 10% lot area based on R-Codes
Total impervious	m^2	320	
Total impervious contributing	m^2	160	Front and Rear soakwells are not interconnected. Front of lot and driveway contributes. Rear of lot assumed not to contribute runoff to road.
Rainfall loss from contributing impervious area			
Rainfall depth	mm	15	
	m	0.015	
Rainfall volume	m^3	2.40	Rainfall depth (m) times total impervious contributing area (m^2)
Soakwell volume	m^3	2.42	Combination of front soakwells to achieve sufficient storage for rainfall volume
Soakwell surface area	m^2	2.9	Combined surface area of front soakwells combination
Soil conductivity (K)	m/day	5	Based on typical imported fill
Soakwell clogging factor	%	0.5	
Design Soakwell Infiltration Rate (K)	m/day	2.50	
Continuing Loss	m/day	0.05	Soakwell area divided by total impervious contributing area multiplied by soil conductivity
	mm/hr	1.9	
Modelling assumptions			
Initial loss	mm	15	
Continuing loss	mm/hr	1.9	

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APPENDIX J

NiDSS Nutrient Modelling Output Results

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists
Report Date : 18-Jun-14

Hazlemere LWMS	
Total Nutrient Input - No WSUD (kg/yr)	4,080
Reduction due to WSUD (kg/yr)	0
Percentage Overall Reduction	0.0%
Pecentage Development Reduction	0.0%
Cost of Selected Program ($/kg/yr)	$0

○ Total Phosphorus
◉ Total Nitrogen

Catchment Name Hazlemere LWMS
Option Description Pre-Development Scenario
Catchment Area 272 ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	0.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	0.0%	maintainance of verge by landowners
Road Reserves : Major	0.0%	maintainance of verge by local authority
POS : Active	0.0%	grassed areas
POS : Passive / Basins	75.0%	native vegetation
Rural : Pasture	25.0%	general pasture
Rural : Residential ~R2.5/R5	0.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	0.0%	town centre etc

Total Residential 0.0%
Total Area 100.0%

Nutrient Input Without WSUD

Residential	Garden	64.90	kg/net ha/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Lawn	92.40		0.00		0		0.0%
	Pet Waste	15.72		0.00		0		0.0%
	Car Wash	0.04		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
POS	Garden/Lawn	73.40	kg/ha POS/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Road	Major Roads	29.36	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
Reserve	Minor Roads	132.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Rural	Pasture	60.00	kg/ha Rural/yr	15.00	kg/gross ha/yr	4,080	kg/yr	100.0%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.00		0		0.0%
	Sub Total			15.00		4,080		100.0%
			Total	**15.00**	kg/gross ha/yr	**4,080**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%
Nutrient Input : Residential Area without WSUD	0.00	0	0.0%
Nutrient Input : Rural Area	15.00	4,080	100.0%

				Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**15.00**	**4,080**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists
Report Date : 18-Jun-14

Hazlemere LWMS	
Total Nutrient Input - No WSUD (kg/yr)	1,360
Reduction due to WSUD (kg/yr)	0
Percentage Overall Reduction	0.0%
Pecentage Development Reduction	0.0%
Cost of Selected Program ($/kg/yr)	$0

(•) Total Phosphorus
( ) Total Nitrogen

Catchment Name Hazlemere LWMS
Option Description Pre-Development Scenario
Catchment Area 272 ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	0.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	0.0%	maintainance of verge by landowners
Road Reserves : Major	0.0%	maintainance of verge by local authority
POS : Active	0.0%	grassed areas
POS : Passive / Basins	75.0%	native vegetation
Rural : Pasture	25.0%	general pasture
Rural : Residential ~R2.5/R5	0.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	0.0%	town centre etc

Total Residential 0.0%
Total Area 100.0%

Nutrient Input Without WSUD

Residential	Garden	21.65	kg/net ha/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Lawn	10.09		0.00		0		0.0%
	Pet Waste	2.81		0.00		0		0.0%
	Car Wash	0.13		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Pet Waste	4.47		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Road Reserve	Major Roads	1.04	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Minor Roads	20.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Rural	Pasture	20.00	kg/ha Rural/yr	5.00	kg/gross ha/yr	1,360	kg/yr	100.0%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.00		0		0.0%
	Sub Total			5.00		1,360		100.0%
	Total			**5.00**	kg/gross ha/yr	**1,360**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%
Nutrient Input : Residential Area without WSUD	0.00	0	0.0%
Nutrient Input : Rural Area	5.00	1,360	100.0%

				Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**5.00**	**1,360**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists
Report Date : 18-Jun-14

Hazlemere LWMS	
Total Nutrient Input - No WSUD (kg/yr)	**20,001**
Reduction due to WSUD (kg/yr)	**6,712**
Percentage Overall Reduction	**33.6%**
Pecentage Development Reduction	**35.1%**
Cost of Selected Program ($/kg/yr)	**$9**

○ Total Phosphorus
◉ Total Nitrogen

Catchment Name	Hazlemere LWMS	
Option Description	Pre-Development Scenario	
Catchment Area	272	ha

Land Use Breakdown

Residential : School	0.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	18.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	10.0%	maintainance of verge by landowners
Road Reserves : Major	0.0%	maintainance of verge by local authority
POS : Active	3.0%	grassed areas
POS : Passive / Basins	62.0%	native vegetation
Rural : Pasture	5.0%	general pasture
Rural : Residential ~R2.5/R5	2.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	0.0%	town centre etc

Total Residential	**18.0%**
Total Area	**100.0%**

Nutrient Input Without WSUD

Residential	Garden	82.60	kg/net ha/yr	14.87	kg/gross ha/yr	4,044	kg/yr	20.2%
	Lawn	115.50		20.79		5,655		28.3%
	Pet Waste	70.31		12.66		3,442		17.2%
	Car Wash	0.04		0.01		2		0.0%
	Sub Total			48.32		13,143		65.7%
POS	Garden/Lawn	73.40	kg/ha POS/yr	2.20	kg/gross ha/yr	599	kg/yr	3.0%
	Pet Waste	216.95		6.51		1,770		8.9%
	Sub Total			8.71		2,369		11.8%
Road	Major Roads	29.36	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
Reserve	Minor Roads	132.00		13.20		3,590		18.0%
	Sub Total			13.20		3,590		18.0%
Rural	Pasture	60.00	kg/ha Rural/yr	3.00	kg/gross ha/yr	816	kg/yr	4.1%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.30		83		0.4%
	Sub Total			3.30		899		4.5%
	Total			**73.53**	kg/gross ha/yr	**20,001**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden) ☑ Native Gardens (Lots - Lawn) ☑ Native Gardens (POS) ☑ Street Sweeping
☑ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 20%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	50%	7.43	2,022	10.1%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	50%	10.40	2,827	14.1%	$0	$0	$0.0
Native Gardens (POS)	50%	1.10	299	1.5%	$0	$0	$0.0
Community Education : Fertiliser	100%	4.67	1,269	6.3%	$0	$1,224	$1.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	100%	0.50	135	0.7%	$0	$11,220	$82.8
Totals		**24.09**	**6,554**	**32.8%**	**$0**	**$12,444**	**$1.9**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☑ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.58	158	0.8%	$475,565	$18,213	$295.5
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.58**	**158**	**0.8%**	**$475,565**	**$18,213**	**$295.5**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%
Nutrient Input : Residential Area without WSUD	70.23	19,103	95.5%
Nutrient Input : Rural Area	3.30	899	4.5%

				Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Removal via Source Control	24.09	6,554	32.8%	$0	$12,444	$1.9
Removal via In-Transit Control	0.58	158	0.8%	$475,565	$18,213	$295.5
Total Removal	24.68	6,712	33.6%	$475,565	$30,657	$8.8
Net Nutrient Input	**48.86**	**13,289**	**66.4%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists
Report Date : 18-Jun-14

Hazlemere LWMS	
Total Nutrient Input - No WSUD (kg/yr)	2,593
Reduction due to WSUD (kg/yr)	1,091
Percentage Overall Reduction	42.1%
Pecentage Development Reduction	47.4%
Cost of Selected Program ($/kg/yr)	$54

(●) Total Phosphorus
( ) Total Nitrogen

Catchment Name	Hazlemere LWMS	
Option Description	Post-Development Scenario	
Catchment Area	272	ha

Land Use Breakdown

Residential : School	0.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	18.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	10.0%	maintainance of verge by landowners
Road Reserves : Major	0.0%	maintainance of verge by local authority
POS : Active	3.0%	grassed areas
POS : Passive / Basins	62.0%	native vegetation
Rural : Pasture	5.0%	general pasture
Rural : Residential ~R2.5/R5	2.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	0.0%	town centre etc

Total Residential	18.0%
Total Area	100.0%

Nutrient Input Without WSUD

Residential	Garden	21.65	kg/net ha/yr	3.90	kg/gross ha/yr	1,060	kg/yr	40.9%
	Lawn	10.09		1.82		494		19.0%
	Pet Waste	2.81		0.51		138		5.3%
	Car Wash	0.13		0.02		6		0.2%
	Sub Total			6.24		1,698		65.5%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.08	kg/gross ha/yr	21	kg/yr	0.8%
	Pet Waste	4.47		0.13		36		1.4%
	Sub Total			0.21		58		2.2%
Road Reserve	Major Roads	1.04	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Minor Roads	20.00		2.00		544		21.0%
	Sub Total			2.00		544		21.0%
Rural	Pasture	20.00	kg/ha Rural/yr	1.00	kg/gross ha/yr	272	kg/yr	10.5%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.08		22		0.8%
	Sub Total			1.08		294		11.3%
	Total			**9.53**	kg/gross ha/yr	**2,593**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

- [x] Native Gardens (Lots - Garden)
- [x] Native Gardens (Lots - Lawn)
- [x] Native Gardens (POS)
- [x] Street Sweeping
- [x] Community Education : Fertiliser
- [ ] Community Education : Pet Waste
- [ ] Community Education : Car Wash

Education Effectiveness: 20%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	50%	1.95	530	20.4%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	50%	0.91	247	9.5%	$0	$0	$0.0
Native Gardens (POS)	50%	0.04	11	0.4%	$0	$0	$0.0
Community Education : Fertiliser	100%	0.81	221	8.5%	$0	$1,224	$5.5
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	100%	0.20	53	2.1%	$0	$11,220	$209.9
Totals		**3.90**	**1,062**	**40.9%**	**$0**	**$12,444**	**$11.7**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

- [x] Gross Pollutant Trap
- [ ] Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.11	29	1.1%	$475,565	$18,213	$1,596.4
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.11**	**29**	**1.1%**	**$475,565**	**$18,213**	**$1,596.4**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%
Nutrient Input : Residential Area without WSUD	8.45	2,300	88.7%
Nutrient Input : Rural Area	1.08	294	11.3%

	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr	kg/gross ha/yr	kg/yr	%
Removal via Source Control	$0	$12,444	$11.7	3.90	1,062	40.9%
Removal via In-Transit Control	$475,565	$18,213	$1,596.4	0.11	29	1.1%
Total Removal	$475,565	$30,657	$54.2	4.01	1,091	42.1%
Net Nutrient Input				**5.52**	**1,502**	**57.9%**

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