

**Appendix C: Detailed Flora and Vegetation Assessment. METRONET
Morley-Ellenbrook line (RPS 2019)**

DETAILED FLORA AND VEGETATION ASSESSMENT

METRONET Morley-Ellenbrook line



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REPORT

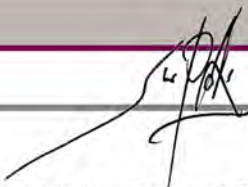
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SUMMARY

METRONET has undertaken a route options analysis to derive an indicative alignment for the Morley-Ellenbrook Line (MEL) transit option. The current option under consideration is a 21-kilometre (km) rail line running north from the existing Bayswater Station on the Midland line to the Ellenbrook town centre. This option spans two local government areas; the City of Swan and the City of Bayswater.

The survey area is located entirely within the City of Swan and encompasses a 1,194.87 hectare (ha) indicative development envelope, which includes provision for a transit corridor and construction and access areas and is located primarily in the Whiteman Park area.

RPS Australia West Pty Ltd (RPS) undertook a single visit detailed survey of 263.68 ha of remnant native vegetation within portions of the survey area as part of a broader survey in Spring 2017. During the 2017 survey, ten 10 metre (m) x 10m floristic quadrats were sampled within the current survey area.

RPS was subsequently engaged by METRONET to undertake additional surveys and sampling to supplement the 2017 survey results to ensure that the entire survey area had been adequately characterised and mapped, and flora and vegetation values identified and recorded. This report documents the combined results of the Spring 2017, Spring 2018 and Autumn 2019 surveys.

Survey objectives and scope of works

The objectives of this detailed flora and vegetation survey were to:

- Identify and characterise the flora and vegetation within the survey area, via provision of a comprehensive flora inventory and vegetation unit and condition mapping.
- Identify the presence and extent of conservation significant flora and ecological communities that are currently listed under the *Biodiversity Conservation Act 2016* (BC Act) and the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) within the survey area.
- Identify and describe the vegetation and significant flora species present or likely to be present within the survey area, including an analysis of the significance of flora and vegetation in local, regional and state contexts.
- Map the location of significant flora and significant vegetation within the survey area.

This detailed flora and vegetation survey included:

1. Detailed flora and vegetation survey of the intact remnant native vegetation within the survey area
2. Reconnaissance flora and vegetation survey of the remainder of the survey area
3. Targeted Threatened and Priority Flora surveys of known or potentially suitable habitat for each of the target species within the survey area at the appropriate time (the documented peak flowering time).

The survey was coordinated and conducted by RPS Botanist Caroline Gill under Licence to Collect Flora for Scientific or Other Prescribed Purposes No. SL012440. Caroline was accompanied in the field by experienced consultant botanists Catherine Tauss, Brian Morgan and Kelli McCreery. The survey methods and sampling quadrat sizes used were based on the requirements for Detailed Flora and Vegetation Surveys in the Swan Coastal Plain region as outlined in with *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (Environmental Protection Authority [EPA] 2016).

Detailed flora and vegetation survey findings

- A total of 321 vascular flora taxa (species, subspecies and varieties) were recorded for the current survey of which 246 (76.6%) were native species and 75 (23.4%) were naturalised alien (weed) species. The taxa recorded represent 63 families and 189 genera.

- Seventy-five naturalised alien (weed) species were recorded within the survey area. Annual and perennial Poaceae species (grasses) and Asteraceae species (daisies) accounted for 37% of the weed species recorded. The most widespread weeds included **Briza maxima*, **Bromus diandrus*, **Ehrharta calycina*, **Pennisetum clandestinum*, **Pentameris airoides* subsp. *airoides*, **Hypochaeris glabra* and **Ursinia anthemoides*. These naturalised bushland weeds were recorded at low densities throughout much of the vegetation within the survey area.
- No Threatened Flora (TF) species listed under the BC Act or the EPBC Act were recorded within the survey area.
- Two Priority Flora (PF) species listed by the Department of Biodiversity Conservation and Attractions (DBCA) were recorded within the survey area: *Cyathochaeta teretifolia* (P3); and *Anigozanthos humilis* subsp. *chrysanthus* (P4).
- The Western Australian Organism List database was searched to determine the legal status of each weed recorded, and any control requirements that may apply under the *Biosecurity and Agriculture Management Act 2007*. Of the 47 weed species recorded two species (*Zantedeschia aethiopica* [Arum Lily]; and *Moraea flaccida* [Cape Tulip]) were determined to be Declared Pests - s22(2)¹, requiring C3² management. None of the weeds recorded were listed as Weeds of National Significance.
- Eighteen vegetation units were described and mapped including upland, wetland and transitional vegetation types. Additionally, another six units were described which represented highly modified and degraded areas, generally cleared of native vegetation. There are 19 quadrats and 16 relevés within the survey area however the vegetation units were derived from the analysis of a total of 33 quadrats (14 of which were outside the survey area) and 20 relevés (four of which were outside the current survey area) as well as mapping notes recorded in the field during the surveys.
 - Modified/Cleared - These six mapping units include previously cleared farmland with remnant isolated native trees, the recent clearing for the NorthLink Perth to Darwin Highway and the new Lord Street, other infrastructure including car parks, buildings and quarries, pine plantations, areas of rehabilitation, and private lots with some remnant trees but no intact native vegetation.
 - Marri on Low Slopes and Flats - Three Marri (*Corymbia calophylla*) vegetation units were mapped for the survey area ranging from sparse woodland to closed forest. The units were differentiated based on their co-dominant species, i.e., *Banksia* spp., Jarrah (*Eucalyptus marginata*) generally on lower slopes, or *Melaleuca preissiana* and *Xanthorrhoea preissii* on the flats.
 - Low-lying Banksia Woodland - Two low-lying Banksia woodland vegetation units were mapped for the survey area. The units were differentiated based on their dominant and co-dominant tree and shrub species.
 - Banksia Woodland on Dune Slopes and Crests - Two 'upland' Banksia woodland vegetation units were mapped for the upper dune slopes and crests within the survey area. *Banksia attenuata* and *B. menziesii* were the dominant tree species in both units which were differentiated based on the presence of co-dominant tree species (e.g. *Eucalyptus tottiana*), and different dominant shrub species.
 - Melaleuca Wetland / Dampland - Seven Melaleuca wetland vegetation units were mapped for the survey area. This broad vegetation type occurred throughout the floodplains, palusplains, sumplands and damplands which are dominant features within the survey area. *Melaleuca*

¹ Declared Pest - s22(2) - Declared pests must satisfy any applicable import requirements when imported, and may be subject to an import permit if they are potential carriers of high-risk organisms. They may also be subject to control and keeping requirements once within Western Australia

² C3 - Organisms that should have some form of management applied that will alleviate the harmful impact of the organism, reduce the numbers or distribution of the organism or prevent or contain the spread of the organism

preissiana was the dominant tree species in this broad vegetation type with *M. raphiophylla* as a dominant or co-dominant in some of the vegetation units. Other co-dominant tree species included *Eucalyptus rudis* subsp. *rudis* and *Corymbia calophylla*. Dominant shrub species differed between the vegetation units.

- *Eucalyptus rudis* Wetland / Dampland / Creekline - Four *Eucalyptus rudis* subsp. *rudis* wetland vegetation units were mapped for the survey area. This vegetation occurred along the banks (floodplains) of Bennett Brook, extending onto the palusplains. *Melaleuca raphiophylla* occurred as a co-dominant tree species in three of the four vegetation units.
- Vegetation condition within the survey area ranged from Excellent to Completely Degraded. A large proportion of the survey area (88%) was in Degraded or worse condition. These areas comprised previously cleared farmland with remnant isolated trees, recent clearing for the NorthLink Perth to Darwin Highway and the new Lord Street upgrade, buildings, roads, tracks, bushland regeneration areas, pine plantation and developed private lots. The Degraded condition throughout much of the remnant trees over pasture vegetation units is due to historical grazing by livestock and kangaroos and weed infestation. Within the intact bushland portions, condition ranged from Good to Excellent but these areas were generally small, isolated, and surrounded by cleared paddocks in Completely Degraded condition. The vegetation in the best condition was recorded on the slopes and crests of dunes and comprised *Banksia* woodland with a dense or mid-dense shrub layer. Several small patches of wetland vegetation were mapped in Good, Very Good and Excellent condition in the eastern side of Whiteman Park.
- Based on the results of the desktop and field surveys, and the multivariate analysis of the data, and assessment of the survey outcomes the conservation significant values identified within the survey area include
 - No TF species listed under the BC Act or the EPBC Act were recorded
 - Confirmed presence of the EPBC-listed Threatened Ecological Community (TEC) *Banksia Woodlands of the Swan Coastal Plain Ecological Community* which is synonymous with the State-listed Priority 3 PEC *Banksia dominated woodlands of the Swan Coastal Plain IBRA region*
 - Potential presence of Priority 3 PEC SCP23b - *Swan Coastal Plain Banksia attenuata - Banksia menziesii* woodlands (FCT23b)
 - Confirmed presence of FCTS17 - *Eucalyptus rudis - Taxandria linearifolia* wetlands in Bassendean Dunes, considered 'rare' on the Swan Coastal Plain. This community type is not a listed PEC or TEC but is of recognised conservation significance on the Swan Coastal Plain
 - Confirmed presence of two PF species as currently listed by the DBCA: *Cyathochaeta teretifolia* (P3) and *Anigozanthos humilis* subsp. *chrysanthus* (P4). PF species are not protected under State or Commonwealth legislation
 - Confirmed presence of six flora taxa of "other" conservation significance, as defined by *Bush Forever: Volumes 1 & 2* (Western Australian Planning Commission 2000). These taxa include those that are confined to scarce or refugial habitats; form uncommon, regionally significant populations; have significant geographical ranges; and undescribed taxonomic entities.

1 INTRODUCTION

1.1 Project background

METRONET has undertaken a route options analysis to derive an indicative alignment for the Morley-Ellenbrook Line (MEL) transit option. The current option under consideration is a 21-kilometre (km) rail line running north from the existing Bayswater Station on the Midland line to the Ellenbrook town centre. This option spans two local government areas; the City of Swan and the City of Bayswater.

The survey area is located entirely within the City of Swan and encompasses a 1194.87 hectare (ha) indicative development envelope, which includes provision for a transit corridor and construction and access areas and is located primarily in the Whiteman Park area (Figure A).

RPS Australia West Pty Ltd (RPS) undertook a single visit detailed survey of 264 ha of remnant native vegetation within portions of the survey area as part of a broader survey in Spring 2017. During the 2017 survey, ten 10 metre (m) x 10m floristic quadrats were sampled within the current survey area.

RPS was subsequently engaged by METRONET to undertake additional surveys and sampling to supplement the 2017 survey results to ensure that the entire survey area had been adequately characterised and mapped, and flora and vegetation values identified and recorded. This report documents the combined results of the Spring 2017, Spring 2018 and Autumn 2019 surveys.

1.2 Survey objectives

The objectives of this detailed flora and vegetation survey were to:

- Identify and characterise the flora and vegetation within the survey area, via provision of a comprehensive flora inventory and vegetation unit and condition mapping.
- Identify the presence and extent of conservation significant flora and ecological communities that are currently listed under the *Biodiversity Conservation Act 2016* (BC Act) and the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) within the survey area.
- Identify and describe the vegetation and significant flora species present or likely to be present within the survey area that may be indirectly impacted by the proposal beyond the development envelope, including an analysis of the significance of flora and vegetation in local, regional and state contexts.
- Map the location and extent of significant flora and significant vegetation within the survey area.

1.3 Scope of works

The core scopes of work undertaken for the detailed flora and vegetation survey were:

1. Detailed flora and vegetation survey of the intact remnant native vegetation within the survey area
2. Reconnaissance flora and vegetation survey of the remainder of the survey area
3. Targeted Threatened and Priority Flora surveys of known or potentially suitable habitat for each of the target species within the survey area at the appropriate time (the documented peak flowering time).

1.3.1 Detailed flora and vegetation survey

The detailed flora and vegetation assessment for the survey area was undertaken over three surveys in October 2017, October 2018 and April 2019.

In summary the following was undertaken for the detailed assessment within the survey area:

- October 2017 - establishment and sampling of 19 floristic sites (10 quadrats and nine relevés)

- October 2018 - establishment and sampling of an additional 16 floristic sites (nine quadrats and seven relevés)
- April 2019 - a revisit of the 19 quadrats established in October 2017 and October 2018 to ensure that all quadrats have been sampled twice in accordance with the requirements of the *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016) guidance on flora and vegetation survey in Western Australia.

1.3.2 Reconnaissance flora and vegetation survey

A reconnaissance survey was undertaken over the parts of the survey area (approximately 884.5 ha) which do not represent 'intact remnant native vegetation', that is, areas which have been previously cleared and / or highly modified and / or are in poor condition (and therefore are not likely to support significant flora or vegetation).

The reconnaissance survey was undertaken between November and December 2018 over five days to verify the information gathered from the desktop study. It involved a site visit by experienced botanists to undertake low intensity sampling of the flora and vegetation, and to describe and map the vegetation units and condition present.

1.3.3 Targeted Threatened and Priority flora surveys

The targeted surveys involved systematic searches of all potentially suitable habitats for target species within the survey area. Significant flora taxa identified as having a moderate or high likelihood of occurring within the survey area (based on proximity of known records and / or presence of suitable habitat) were the focus of targeted searches at the appropriate time, that is, during their documented flowering time. These searches were undertaken during the detailed flora surveys in 2017 and 2018, and in the case of *Caladenia huegelii*, as part of a dedicated survey on 28 September 2018 during the species' documented peak flowering time.

1.4 Guiding principles and legislative framework

Commonwealth and State legislation pertaining to the conservation of native flora and vegetation include the EPBC Act, BC Act and *Environmental Protection Act 1986* (EP Act). The EP Act is the primary legislation that governs environmental impact assessment and protection in Western Australia. The aim of the EP Act is "to provide for an Environmental Protection Authority, for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with foregoing".

Section 4A of the EP Act states that the following principles, applicable to native flora and vegetation should be adhered to in order to protect the environment of Western Australia:

1. The Precautionary Principle – Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
2. The Principle of Intergenerational Equity – The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
3. The Principle of the Conservation of Biological Diversity and Ecological Integrity – Conservation of biological diversity and ecological integrity should be a fundamental consideration.

1.4.1 Conservation significant flora

Within Western Australia, Threatened Flora (TF) are listed as such if they are in danger of extinction, rare or otherwise in need of special protection. These taxa are legally protected under the BC Act. The removal of these taxa or impact to their surroundings is not permitted without prior ministerial approval. The Department of Biodiversity Conservation and Attractions (DBCA) maintains a list of Priority Flora (PF) species, which may

be rare or threatened but for which there are either insufficient survey data to determine accurately their status, or which are rare but not currently considered to be threatened. A PF taxon is assigned to one of five priority categories. TF and PF categories are defined in Appendix A, Table A-1.

Many taxa listed as TF under the BC Act have additional protection as they are also listed as TF under one of six threat categories (Extinct, Extinct in the wild, Critically Endangered, Endangered, Vulnerable or Conservation Dependent) under the EPBC Act. TF taxa are defined as Matters of National Environmental Significance (MNES) under the EPBC Act and penalties apply for any damage to individuals, populations or habitats of these flora. EPBC Act conservation category codes are defined in Appendix A, Table A-2.

1.4.2 Conservation significant vegetation

Under the BC Act and the EP Act, Threatened Ecological Communities (TECs) are classified by DBCA into the TEC categories (Appendix A, Table A-3). Other ecological communities are classified by DBCA in the category of Priority Ecological Communities (PECs) (Appendix A, Table A-4) pending further survey and/or definition. A subset of the DBCA-listed TECs are also listed and protected as MNES under the EPBC Act. EPBC Act threat categories for TECs are defined in Appendix A, Table A-5.

2 METHODS

2.1 Desktop assessment

RPS undertook a thorough desktop assessment of flora and vegetation within the survey area and the local area as part of the 2017 detailed survey within Whiteman Park (RPS 2018). Prior to commencement of the 2018 / 2019 field surveys this information was thoroughly reviewed. This involved a review of available literature including previous flora survey reports and spatial datasets; searches results of Commonwealth Government databases for TF and TECs protected under the EPBC Act; and DBCA databases and mapping for TF and PF. Additionally, the results and of the 2017 survey were reviewed.

2.1.1 Previous biological surveys

A review of flora and vegetation studies that have been undertaken in the vicinity of the survey area including:

- Detailed Flora and Vegetation Assessment – METRONET Ellenbrook Alignment (RPS 2018)
- Environmental Impact Assessment and Environmental Management Plan: Ellenbrook Bus Rapid Transit (Aurecon 2016)
- Level 2 Spring Flora and Vegetation Assessment: NorthLink WA Perth–Darwin National Highway (Coffey 2015)
- Swan Valley Bypass, Perth–Darwin National Highway: Level 2 Flora and Vegetation Survey (360 Environmental 2014a)
- Tonkin Grade Separations: Flora, Vegetation and Fauna Survey (360 Environmental 2014b)
- Perth–Darwin National Highway – Tonkin Highway Link Alignment Definition Study: Environmental Impact Assessment and Biological Survey (GHD 2013).

2.1.2 Regional data

A review of publicly available data and broad-scale vegetation mapping and remnant extent including:

- Vegetation Complex mapping (Hedde et al. 1980)
- Vegetation Association mapping (Beard 1981)
- Floristic Survey of the Swan Coastal Plain (Gibson et al. 1994)
- Bush Forever: Volumes 1 & 2 (Western Australian Planning Commission [WAPC] 2000).

2.1.3 State and Commonwealth Government databases

Interrogation of the following Commonwealth and state databases were undertaken within a 5 km radius of the survey area.

- Department of the Environment and Energy (DEE) Protected Matters Database for MMNES including
 - Wetlands of International Importance
 - Listed TECs
 - Listed TF Species
- Western Australian DBCA Threatened and Priority Flora Database, and the Western Australian Herbarium (WAH) Specimen Database
- Western Australian DBCA TEC / PEC database
- Western Australian Department of Primary Industries and Regional Development (DPIRD) Declared Plants list.

2.2 Field surveys

The field surveys included reconnaissance surveys involving the selective sampling of flora and vegetation via the recording of relevés and mapping notes; and detailed surveys where sampling of flora and vegetation was undertaken using floristic quadrats and relevés. A total of 19 quadrats and 16 relevés were sampled between October 2017 and April 2019 across the survey area. The October 2017 survey involved the establishment and sampling of ten quadrats and nine relevés. The October 2018 survey involved the establishment and sampling of an additional nine quadrats and 7 relevés. The April 2019 survey involved the resampling of the 19 quadrats established during the previous two surveys.

2.2.1 Reconnaissance flora and vegetation survey

The reconnaissance survey was undertaken over the parts of the survey area (approximately 884.5 ha) which have been previously cleared and / or highly modified and / or are in poor condition (and therefore were not likely to support significant flora or vegetation).

The reconnaissance survey was undertaken in accordance with EPA (2016) and involved selective sampling of flora and vegetation to produce maps of vegetation units and vegetation condition at an appropriate scale and based on aerial imagery interpretation, preliminary mapping and ground-truthing.

The reconnaissance field survey was undertaken by RPS botanist Carrie Gill, with the assistance of Cate Tauss and Julijanna Hantzis over several days in December 2018 and January 2019, and involved traversing the survey area by vehicle and on foot to:

- Verify the data from the desktop survey at a local scale.
- Characterise the vegetation throughout the survey area.
- Identify any constraints and potential impacts of development on local flora and vegetation values, or ecological importance.

The reconnaissance survey involved the sampling of the range of flora taxa and vegetation community types observed within the previously cleared / highly modified portions of the survey area via a total of seven relevés (unbounded flora survey sites comprising a similar area to a 10 m × 10 m quadrat which is the appropriate site size for the South-west region).

The following parameters were recorded for each relevé:

- Site code
- Location (GDA94 GPS coordinates)
- Digital photographs of the vegetation
- Landform and soil description
- Vegetation description - dominant growth form, height, cover and species for the three traditional strata (upper, mid and ground)
- Any other location information that might be useful in vegetation classification including slope, aspect, litter, fire history, vegetation/landform/soil correlations
- Assessment of vegetation and description of disturbances
- A comprehensive species list (annuals and perennials), including weeds and their percentage foliar cover.

2.2.2 Detailed flora and vegetation survey

The survey was coordinated and conducted by RPS Botanist Caroline Gill under Licence to Collect Flora for Scientific or Other Prescribed Purposes No. SL012440. Caroline was accompanied in the field by experienced consultant botanists Catherine Tauss, Kelli McCreery and Brian Morgan. The survey was

undertaken over two days between 19 and 20 October 2018. The survey methods and sampling quadrat sizes used were based on the requirements for Detailed Flora and Vegetation Surveys in the Swan Coastal Plain (SCP) region as outlined in EPA (2016).

RPS undertook the initial survey in October 2017 over a wider area which included several other rail alignment options. The 2017 survey involved the establishment and sampling of a total of ten 10 m x 10 m floristic quadrats within the current survey area and another 14 quadrats outside it. The methods and outcomes of this 2017 survey were documented in *Detailed Flora and Vegetation Assessment – METRONET Ellenbrook Alignment* (RPS 2018). The RPS (2018) survey report which included a desktop assessment; conservation significant flora and communities' database search results; and site data and spatial data of the vegetation unit and condition mapping were used to inform the 2018 /2019 surveys and this report.

The October 2018 and April 2019 surveys aimed to supplement the 2017 data, fill any information gaps and ensure that all flora and vegetation values within the survey area had been comprehensively surveyed, characterised and mapped. The October 2018 survey involved the establishment and sampling of an additional nine floristic quadrats within the survey area in order to adequately sample and describe the range of vegetation within the survey area. The April 2019 survey involved the resampling of all 19 quadrats established in 2017 and 2018 within the survey area.

The field survey focused on areas of remnant native vegetation within the survey area which are managed by local and state government agencies (i.e. no private landholdings were accessed or surveyed).

Mapped remnant vegetation comprises approximately 11% of the total survey area (Figure B). The remaining 89% of the survey area consists of highly modified landscapes; these areas were mapped according to their land use and broad condition. Intensive sampling of the vegetation at floristic sites was limited to areas of intact native vegetation on public lands.

The number of quadrats required to adequately sample the flora is dependent on the diversity of vegetation units present, heterogeneity within these vegetation units, the size of the vegetation units mapped and the size of the survey area. The detailed survey involved the establishment of 19 floristic quadrats (bounded 10 m x 10 m sites) and 16 relevés (unbounded sampling sites) throughout the different vegetation types within the survey area. It should be noted however that the vegetation units described and mapped for the survey area were derived from the analysis of a total of 33 quadrats (14 of which were outside the survey area) and 20 relevés (four of which were outside the survey area). Most of the intact native vegetation units were represented by between three and six floristic sites. Those units that were mapped for the cleared and highly modified areas (where vegetation was either absent or highly disturbed and degraded) were described from relevés and mapping notes because the vegetation was not in good enough condition to warrant establishing floristic quadrats.

The detailed survey involved:

- A targeted search for TF and PF, and Declared Plants as determined by the database search results, and the likelihood of any TECs occurring within the survey area
- Comprehensive quadrat-based flora recording and collection. Bounded 10 m x 10 m quadrats were established and sampled in intact, mature vegetation in areas of best condition to provide data for the floristic classification of the vegetation of the survey area
- Collection of information at each quadrat included
 - Site code
 - Location (GDA94 GPS coordinates)
 - Size, shape and orientation of quadrat
 - Photograph/s from north-west corner
 - Landform and soil description

- Dominant growth form, height, cover and species for the three traditional strata (upper, mid and ground)
- Any other location information that might be useful in vegetation classification including slope, aspect, litter, fire history, vegetation/landform/soil correlations
- Assessment of vegetation and description of disturbances
- A comprehensive species list (annuals and perennials), including weeds
- Opportunistic collections and relevés were also recorded to verify that the remnant vegetation has been well characterised and important values identified
- Compilation of a comprehensive vascular flora inventory of all flora species recorded within the survey area including weed species
- Vegetation condition mapping using the recommended EPA (2016) scale adapted from Keighery (1994) including the location of any Declared Plants listed under the *Biosecurity and Agriculture Management Act 2007* (BAM Act) and Weeds of National Significance (WONS) known to be invasive and threats to biodiversity
- Floristic classification of the vegetation in the survey area. The conservation value of the FCTs within the survey area was determined in order to assess the native vegetation values
- Vegetation unit description and mapping using the National Vegetation Information System (NVIS) (ESCAVI, 2003). Vegetation types were described to Association (Level V)
- Identification and mapping of areas of ecological importance (e.g. TF, TECs, conservation significant wetlands Bush Forever sites) within the survey area.

2.2.3 Targeted Threatened and Priority flora surveys

Targeted threatened and priority flora searches were conducted as part of the detailed survey and aimed to determine the size and extent of all significant flora populations or vegetation in the survey area and to place any impacts into context locally and regionally.

All potentially suitable habitats were systematically searched for target species and communities. Significant flora taxa identified as having a moderate or high likelihood of occurring within the survey area (based on proximity of known records and / or presence of suitable habitat) were the target of the searches.

RPS undertook a targeted search for *Caladenia huegelii* (grand spider orchid) as a separate targeted survey during the species' documented flowering period on 28 September 2018 (Appendix E).

2.3 Data analysis

2.3.1 Taxonomic determinations

Flora specimens were either identified in the field, or collected and identified using the keys, publications and databases of the WAH. Plant specimens were identified by specialist taxonomist Cate Tauss. Nomenclature was aligned with the current names in FloraBase (Western Australian Herbarium 2017).

2.3.2 Vegetation mapping

Vegetation community mapping was conducted using a combination of aerial photo-interpretation, regional and local vegetation mapping, on-ground confirmation, vegetation structure data, and multivariate analysis results. Vegetation types were described to Association (Level V) in accordance with the National Vegetation Information System (NVIS) (ESCAVI 2003) (Appendix A, Table A-6 and Table A-7).

Vegetation condition mapping was conducted using the recommended EPA (2016) scale adapted from Keighery (1994) and Trudgen (1988) (Appendix A, Table A-8).

2.3.3 Multivariate analysis of floristic data

Floristic Community Types (FCTs) are based on a survey of the vegetation of the SCP from Seabird to Dunsborough, completed by Gibson et al. (1994). The purpose of the survey was to determine the number and type of vegetation communities present across the southern SCP and to then assess how much of each remained and whether they are adequately represented and protected within reserves. The Gibson et al. (1994) survey involved the sampling of 508 10 m x 10 m floristic plots.

The current survey data was analysed against the combined SCP (Gibson et al. 1994) and Supplementary dataset (Keighery et al. 2012), which is derived from the results of several additional floristic studies completed between 1990 and 1996. These supplementary studies involved the sampling of an additional 590 floristic plots. These studies are summarised in Table 1.

Table 1 Floristic studies used in the preparation of the SCP and supplementary dataset

| Study | Reference | Coverage | No. of sampling sites | Years of survey |
|----------|-----------------------------------------------|-------------------------------------------------------------------|-----------------------|-----------------|
| SCP | Gibson et al. (1994) | Southern SCP | 508 | 1990-1993 |
| SYS6ENV | DEP (1996) – 1994 data | Southern SCP | 590 | 1993-1994 |
| SYS6ENV2 | DEP (1996) – 1994 data | Southern SCP | | 1995-1996 |
| GRIFFIN | Griffin (1993, 1994), Weston et al. (1993) | SCP north of Perth | | 1993 |
| GJKENV | Keighery (1996) | Tuart (<i>Eucalyptus gomphocephala</i>) woodlands on the SCP | | 1990-1994 |

The survey data was reconciled with the SCP and Supplementary datasets of Gibson et al. (1994) and Keighery et al. (2012) by standardising the names of taxa with those used in the earlier studies. This was necessary due to changes in nomenclature in the intervening period. Taxa that were only identified to genus level were excluded while some infraspecies that have been identified since these studies were reduced to species level.

Floristic quadrat data (presence / absence) was analysed using multivariate techniques (via PRIMERV6 software) to classify the vegetation types within the survey area. The survey data included weed species (as did the original studies) and was analysed against the combined SCP and Supplementary dataset to determine the Floristic Community Type and the conservation significance of the vegetation; specifically, the presence of any TECs or PECs within the survey area.

Data from each of the nine 2018, and ten 2017 floristic quadrats was combined with the 1098 site SCP and Supplementary dataset, separately in PRIMERV6, and a dendrogram classification (Hierarchical Cluster Analysis) conducted to identify statistically significant clusters. Analysing each test site separately with the SCP dataset is considered a more reliable means of deriving accurate FCT groups because the addition of a single test site (sample) causes minimal disruption to the dataset.

A resemblance matrix of the presence / absence data for the combined dataset was constructed using the Bray Curtis Similarity Coefficient and a Hierarchical Cluster Analysis was carried out on this matrix using the group average linkage method. The outputs from this analysis were illustrated as dendrograms.

Once an FCT had been assigned to each site, a comparison could be made against the DBCA's TEC / PEC database in order to assess the conservation significance of the vegetation.

2.4 Limitations

2.4.1 Survey limitations

Botanists who conduct flora and vegetation surveys for environmental impact assessment in Western Australia are obliged to report on the limitations and constraints in such studies. Some potential limitations / constraints on surveys may adversely impact on the scientific rigour, completeness or the validity of the survey results. EPA (2016) identifies standard limitations which can limit and constrain the validity of flora and vegetation surveys. These include:

- Availability of contextual information at a regional and local scale
- Competency and experience of the field team
- Proportion of flora recorded and/or collected, and problems with taxonomic determinations
- The effort and extent of the survey
- Access restrictions within the survey area
- Survey timing, rainfall, season of survey
- Disturbances that may have affected the results of survey such as fire, flood or clearing.

Two of these standard limitations applied, to some extent, to the survey as discussed below.

2.4.1.1 Access restrictions within the survey area

The field survey focused on the portions of the survey area which are managed by local and State government agencies. No private landholdings were accessed or surveyed so vegetation mapping for these areas has been extrapolated from aerial imagery and topographical maps.

2.4.1.2 Disturbances (clearing)

Much of the survey area covered highly modified landforms including linear infrastructure, urban development, previously cleared agricultural land and pine plantation. The remnant and / or degraded vegetation which occurred in these areas could not be intensively sampled because the floristics and structure of the vegetation were not representative of intact pre-disturbance vegetation. As such this proportion of the survey area was not mapped or described in terms of FCT group.

2.4.2 Floristic analysis limitations

It is generally accepted that the addition of new quadrats to the regional dataset to produce a combined classification, may disrupt the original classification of quadrats (Griffin and Trudgen 2004), the more data that is added, the higher the level of disruption. Analysing each test site separately with the regional dataset is considered a more reliable means of deriving accurate FCT groups because the addition of a single test site (sample) causes minimal disruption to the dataset.

The use of different statistical analysis software (PRIMERV6 rather than PATN, which was used in the original analysis) is recognised to cause differences in the hierarchical clustering of the data. This is because the two software programs use a different default beta value in the group-average linkage (UPGMA) clustering routine. Neil Gibson confirmed that it was likely that we would not be able to recreate the original analysis results exactly because PRIMER does not allow you to change the beta value in the UPGMA algorithm. The version of PATN used 20 years ago used a value of -0.1 as a default, this parameter is not accessible in PRIMER which uses a default of 0.0 (N. Gibson, pers. comm. 21 November 2016).

Finally, the success of the PRIMERV6 analysis to assign an FCT to survey quadrats can be limited to the extent that the type of vegetation in the study area was sampled in the SCP Supplementary surveys. It is generally acknowledged that the southern SCP regional surveys under-sampled the full range of vegetation across the bioregion and that there are likely to be as-yet-undefined FCTs as well as transitional vegetation types that do not align with any of the FCTs defined in the Gibson et al. (1994) or Keighery et al. (2012) analyses.

Other potential limitations / constraints which may adversely impact on the scientific rigour, completeness or the validity of the multivariate floristic analysis results include:

- Proportion of flora recorded and/or collected
- Problems with taxonomic determinations
- Survey timing
- Rainfall
- Season of survey
- Site inundation (in the case of wetlands).

3 EXISTING ENVIRONMENT

3.1 Existing and historical land use

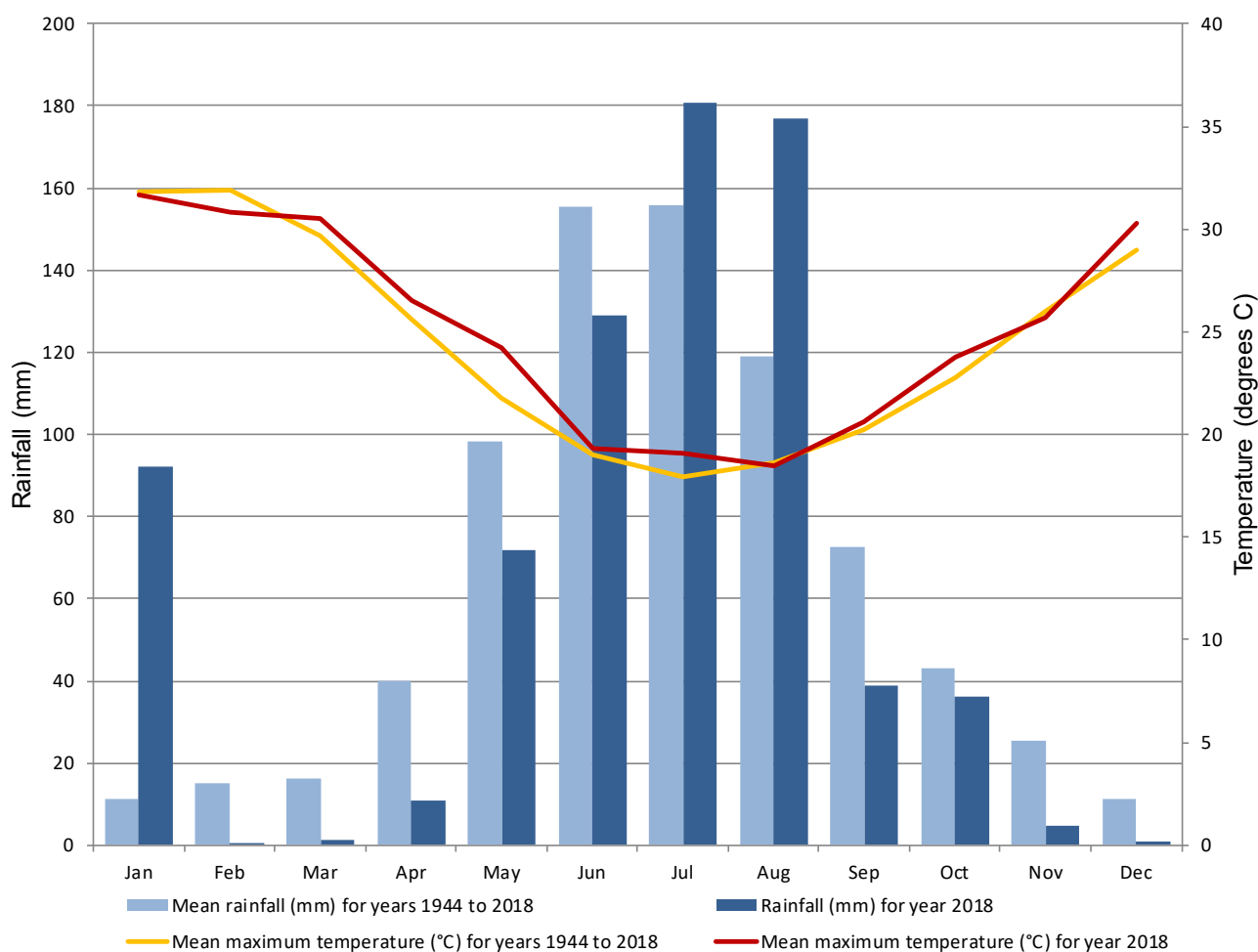
A range of land uses are represented within the survey area including linear infrastructure (roads and transmission lines), urban (residential and industrial) development, previously cleared agricultural land, nature reserves, Bush Forever sites and pine plantation (state forest). The survey area is located within the City of Swan's Local Government Area.

3.2 Climate

The climate of the SCP is generally described as Warm Mediterranean with winter precipitation of 600–1000 mm, and with 5–6 dry months per year (Beard 1990).

The Bureau of Meteorology (BoM) weather station closest to the survey area is the Perth Airport weather station no. 009021, located approximately 7 km to the south of the survey area.

Rainfall for the Perth region for 2018 was 743.8 millimetres (mm) which represents approximately 3% less than the 75-year average for the same period of 766.7 mm. However, approximately 30% more rain than the long-term average was received in July and August (BoM 2019) which resulted in an excellent survey season. Historical rainfall data collected from the Perth Airport weather station is presented in Graph 1 (BoM 2019).



Graph 1: Mean monthly rainfall (mm) and maximum temperature data (°C) for Perth Airport weather station (009021) for years 1944 to 2018, and rainfall and temperature data for 2018 (BoM 2019)

3.3 Interim Biogeographical Regionalisation of Australia

The Interim Biogeographic Regionalisation for Australia (IBRA) divides Australia into bioregions based on major biological and geographical/geological attributes (Thackway and Cresswell 1995). The IBRA currently recognises 89 bioregions and 419 biological subregions in Australia. The survey area lies within the Perth (SWA02) subregion of the SCP bioregion.

The Perth subregion is composed of colluvial and aeolian sands, alluvial river flats and coastal limestone and the vegetation is described by Mitchell et al. (2002) as Heath and/or Tuart woodlands on limestone, Banksia and Jarrah-Banksia woodlands on Quaternary marine dunes of various ages and Marri on colluvial and alluvials.

3.4 Geology, landform and soils

The SCP consists of five major geomorphological elements as defined by McArthur and Bettanay (1960). From west to east these are the Quindalup Dunes, Spearwood Dunes, Bassendean Dunes, Pinjarra Plain, and Ridge Hill Shelf. These systems lie roughly parallel to the coast and are distinguished by their geology, topography, vegetation and soils. The survey area lies within the Bassendean Dunes and the Pinjarra Plain landforms. The Bassendean Dune System is of generally low relief, often with broad swales or relatively flat sand sheets between the low dunes. Soils are predominantly deep grey leached quartz sands. The Pinjarra Plain is a piedmont and valley-flat alluvial plain consisting predominantly of clayey alluvium that has been transported by rivers and streams from the Darling and Dandaragan Plateaus.

Surface geology mapping for the Perth region (Department of Mines, Industry Regulation and Safety (DMIRS) 2019) indicates that the survey area is a mosaic of four geological features (Table 2). Surface geology mapping for the survey area is presented in Figure C.

Table 2: Surface geology within the survey area

| Code | Description |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mgs 1 | PEBBLY SILT - strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial origin |
| Cps | PEATY CLAY - dark grey and black with variable sand content of lacustrine origin |
| S10 | SAND - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin |
| S8 | SAND - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin |

(Data Source: DMIRS 2019)

3.5 Surface hydrology

The survey area lies within the Swan Avon – Lower Swan catchment and intersects two sub-catchments; the Bennett Brook catchment in the south, and the Ellenbrook catchment in the north (DPIRD 2019).

Interrogation of the linear hydrography database identified that the survey area intersects Bennett Brook (a significant stream and Conservation Category Wetland) (DPIRD 2019).

3.6 Groundwater hydrology

The survey area is located on the shallow, unconfined Superficial Aquifer, commonly known as the Gngangara Mound. The Superficial Aquifer, along with the shallow Mirrabooka Aquifer, the deep Leederville Aquifer and the deep Yarragadee Aquifer make up the Gngangara Groundwater System which extends north of the Swan River to Gingin in the north and from the coast east to the Darling Scarp and covers approximately 2,200 km² (DWER 2019). The Superficial Aquifer consists of several superficial formations including the Yoganup, Ascot Limestone, Bassendean Sand, and Tamala Limestone formations, which overlie Cretaceous, Jurassic and Triassic sediments.

3.7 Geomorphic wetlands

DBCA has developed a dataset which maps the location, boundaries and management category of wetlands on the SCP. Geomorphic wetlands have been categorised according to landform and water permanence (hydroperiod). A management category (Conservation, Resource Enhancement and Multiple Use in order of conservation priority) was assigned to each wetland to guide their management and protection.

The survey area intersects the mapped extents of 14 Conservation Category Wetlands (CCWs) and six Resource Enhancement Wetlands (REWs) (Figure D; Table 3). The definitions and management objectives for the three wetland management categories, and geomorphic wetland types are presented in Appendix A, Table A-9 and Table A-10.

Table 3: Geomorphic wetlands of the SCP intersecting the survey area

| Unique feature identifier (UFI) | Management category | Wetland type |
|---------------------------------|----------------------|---------------------------------|
| 8429 | Conservation | Sumpland |
| 8548 | Conservation | Sumpland |
| 8572 | Conservation | Palusplain |
| 8550 | Conservation | Dampland |
| 8670 | Conservation | Floodplain (West Bennett Brook) |
| 8680 | Conservation | Palusplain |
| 8722 | Conservation | Palusplain |
| 8724 | Conservation | Sumpland (Horse Swamp) |
| 8726 | Conservation | Lake (Mussel Pool) |
| 8728 | Conservation | Palusplain |
| 8797 | Conservation | Dampland |
| 15033 | Conservation | Floodplain |
| 15259 | Conservation | Floodplain |
| 15260 | Conservation | Palusplain |
| 8678 | Resource Enhancement | Sumpland |
| 8679 | Resource Enhancement | Dampland |
| 8806 | Resource Enhancement | Palusplain |
| 14447 | Resource Enhancement | Palusplain |
| 15752 | Resource Enhancement | Palusplain |
| 15757 | Resource Enhancement | Sumpland |

3.8 Bush Forever

Bush Forever identifies areas of regional conservation value on the SCP portion of the Perth Metropolitan Region (PMR) with an aim to protect a comprehensive representation of the biological diversity on the Metropolitan Coastal Plain (WAPC 2000). The survey area intersects one Bush Forever site (Table 4 and Figure E).

Table 4: Bush Forever site intersecting the survey area

| Site number | Site name | Significant features | Area of BF Site intersecting the survey area (ha) |
|-------------|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|
| 304 | Whiteman park, Whiteman/West Swan | Priority Flora; rich and diverse flora and fauna; largest known stands of <i>Cyathochaeta teretifolia</i> ; CCWs including Bennett Brook; regionally significant river; Forms part of a regional ecological linkage | 554.61 |

3.9 Perth regional ecological linkages

In the Perth region, regional and local ecological linkages have been identified following a methodology outlined in the *Local Government Biodiversity Planning Guidelines for the Perth Metropolitan Region* (Del Marco et al. 2004) which defines an ecological linkage as a series of non-contiguous natural areas that connect larger natural areas by forming stepping stones through the altered landscape that allows the movement over time of organisms (animals, seeds, pollen) between these larger areas and across the landscape.

The survey area forms part of a regionally significant ecological linkage, Greenways 32, 39, 21, 40, and 38 (Tingay and Associates 1998), which extends from Bennett Brook north through Whiteman Park to the northern-most part of the survey area in Ellenbrook (Figure F).

3.10 DBCA managed lands and reserves

One DBCA Managed Lands and Reserves intersects the survey area north of Gnangara Road (Table 5 and Figure G). No regional parks are located within the survey area. The nearest regional parks, Herdsman Lake Regional Park and Yellagonga Regional Park lie approximately 5 km and 9 km respectively, to the west of the survey area.

Table 5: DBCA managed lands and reserves intersecting the survey area

| Name | Category | Class | Purpose | Tenure | Vesting |
|-----------------------------------|--------------|-------|--------------|------------|-------------------------------|
| Gnangara-Moore River State Forest | State Forest | A | State Forest | Crown land | Conservation Commission of WA |

3.11 Regional reserves

The survey area intersects two portions of land reserved as Parks and Recreation under the Metropolitan Region Scheme (MRS); Whiteman Park and the A-Class Nature Reserve (Gnangara-Moore River State Forest) listed in Table 5. Parks and Recreation areas are managed to protect the integrity, function and environmental values of the bushland and landforms to the requirement of the WAPC on the advice of the EPA and are only to be used for conservation, landscape and complimentary purposes.

3.12 Environmentally sensitive areas (ESAs)

Environmentally Sensitive Areas (ESAs) are declared by the Minister for Environment under section 51B of the EP Act.

The following areas are declared to be ESAs:

- Declared World Heritage property as defined in section 13 of the EPBC Act
- Area that is included on the Register of the National Estate, because of its natural heritage value, under the *Australian Heritage Council Act 2003*
- Defined wetland and the area within 50 metres of the wetland. Defined wetlands include Ramsar wetlands, conservation category wetlands and nationally important wetlands
- Area covered by vegetation within 50 metres of rare flora, to the extent to which the vegetation is continuous with the vegetation in which the rare flora is located
- Area covered by a TEC
- Bush Forever site listed in "Bush Forever" Volumes 1 and 2 (WAPC 2000), except to the extent to which the site is approved to be developed by the Western Australia Planning Commission.

3.13 Regional vegetation

3.13.1 Beard vegetation mapping

The survey area is situated in South West Botanical Province and the Darling Botanical District (Beard 1990). This region typically consists of forest country with related woodlands and is divided into four botanical subdistricts. The survey area is located within the SCP Subregion in the Drummond Botanical Subdistrict, which according to Beard (1990) consists mainly of the following vegetation communities:

- Banksia Low Woodland on leached sands and Melaleuca Swamps in poorly drained areas
- Woodland of tuart (*Eucalyptus gomphocephala*); and jarrah (*Eucalyptus marginata*) and marri (*Corymbia calophylla*) on less leached soils.

Vegetation mapping of the Pinjarra region was completed by Beard (1979) at a scale of 1:250,000. Shepherd et al. (2002) reassessed Beard's existing mapping dividing some of the broader vegetation units up into smaller units.

The vegetation within the survey area is mapped as the following four broad-scale associations:

- Vegetation Association 1001 - Medium very sparse woodland; jarrah, with low woodland; banksia & casuarina
- Vegetation Associations 1018 - Mosaic: Medium forest; jarrah-marri / Low woodland; banksia / Low forest; teatree / Low woodland; *Casuarina obesa*
- Vegetation Association 1009 - Medium woodland; marri and river gum
- Vegetation Association 949 – Low woodland banksia.

The remnant extent and reservation status of these vegetation associations within Western Australia, SWA02 Perth IBRA Subregion, and City of Swan are presented in Table 6.

Three of these vegetation associations (1001, 1018 and 1009) have between 10% and 30% of their pre-European extent remaining within the Perth (SWA02) Subregion.

Table 6: Pre-European extent, current extent and reservation status of vegetation associations within the Western Australia, Perth IBRA subregion and City of Swan

| Vegetation association | Area | Pre-European extent (ha) | Present extent (ha) remaining | % of present extent remaining | % of present extent in secure tenure |
|------------------------|-------------------|--------------------------|-------------------------------|-------------------------------|--------------------------------------|
| 1001 | Western Australia | 57,410 | 12,661 | 22.05 | 2.80 |
| | SWA02 Bioregion | 57,410 | 12,661 | 22.05 | 2.80 |
| | City of Swan | 8,868 | 2,321 | 26.18 | 0.02 |
| 1018 | Western Australia | 14,059 | 2,445 | 17.39 | 0.72 |
| | SWA02 Bioregion | 13,946 | 2,418 | 17.34 | 0.73 |
| | City of Swan | 6,013 | 987 | 16.42 | 0.15 |
| 1009 | Western Australia | 18,225 | 3,004 | 16.48 | 0.02 |
| | SWA02 Bioregion | 18,183 | 2,982 | 16.40 | 0.02 |
| | City of Swan | 8,520 | 379 | 4.45 | 0.00 |
| 949 | Western Australia | 218,194 | 123,104 | 56.42 | 13.81 |
| | SWA02 Bioregion | 184,475 | 104,129 | 56.45 | 14.89 |
| | City of Swan | 16,235 | 7,970 | 49.09 | 2.74 |

(Government of Western Australia 2019)

3.13.2 Heddle vegetation complexes

Vegetation complexes are vegetation associations that are characteristic of various combinations of soil, landform and rainfall. A large part of the SCP has been mapped for vegetation complexes by Heddle et al. (1980). These complexes are closely related to the SCP Dune Systems (Quindalup, Spearwood, Bassendean, and Pinjarra Plain) and north to south variations in climate and rainfall.

Heddle et al. (1980) mapped the vegetation within the survey area as:

- Bassendean Complex Central and South: Vegetation ranges from woodland of *E. marginata* – *C. fraseriana* – *Banksia* spp. to low woodland of *Melaleuca* spp. and sedgelands on the moister sites.
- Southern River Complex: Open woodland of *Corymbia calophylla*, *Eucalyptus marginata*, and *Banksia* spp. on the elevated areas and fringing woodland of *Eucalyptus rudis* and *Melaleuca raphiophylla* along streams.
- Bassendean Complex North: Vegetation ranges from low open forest and low woodland of *Banksia* spp. and *Eucalyptus tottiana* to low woodland of *Melaleuca* spp. and sedgelands on wetter sites.

The remnant extent and reservation status of these vegetation complexes on the SCP south of Moore River and City of Swan is presented in Table 7. Vegetation complex mapping is presented in Figure H.

Table 7: Vegetation complex pre-European and current extent on the SCP south of Moore River, and City of Swan

| Vegetation complex | Area | Pre-European extent (ha) | Current 2013 extent (ha) | % Remaining | Total area remaining in Bush Forever (ha) |
|------------------------------|--------------|--------------------------|--------------------------|-------------|-------------------------------------------|
| Bassendean central and south | SCP | 87,393 | 24,206 | 28 | 4,106 |
| | City of Swan | 4632 | 1484.00 | 32.04 | 1407 |
| Southern river | SCP | 57,172 | 11,255 | 19.69 | 2,514 |
| | City of Swan | 8669 | 1539.85 | 17.76 | 1172 |
| Bassendean north | SCP | 76,134 | 53,518 | 72.19 | 3,859 |
| | City of Swan | 14215 | 7470.10 | 52.55 | 2462 |

(Source: Perth Biodiversity Project 2013)

4 RESULTS

4.1 Desktop assessment

4.1.1 Database searches

4.1.1.1 Threatened and Priority flora database search results

Searches of the DBCA Threatened and Priority Flora database and the WAH Specimen database were undertaken within a 5 km radius of the survey area boundary prior to the 2017 survey.

A total of 46 species of conservation significance were found to occur within the 5 km search radius comprising five TF species, three Priority 1, five Priority 2, twenty-two Priority 3 and eleven Priority 4 flora taxa (Table 8). Table 8 additionally identifies the listed species' protection status under the EPBC Act. Four species are listed as Endangered under the EPBC Act and one Vulnerable.

The listed species were ranked in terms of their "likelihood of occurrence" within the survey area based on proximity of known records and habitat preference. Of the 47 taxa retrieved from the database searches only 15 species were assessed to have a high or moderate likelihood of occurring within the survey area – two of these species (*Anigozanthos humilis* subsp. *chrysanthus* and *Cyathochaeta teretifolia*) are known to occur within the survey area having been recorded during surveys undertaken by RPS (2018) in Spring 2017.

Conservation significant species records in the vicinity of the survey area derived from the database searches are shown in Figure I.

Table 8: Threatened and Priority flora recorded within a 5 km radius of the survey area

| Species | BC Act status* | EPBC Act status† | Soil and landform | Likelihood of occurrence‡ |
|-------------------------------------------------------|----------------|------------------|-----------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|
| <i>Acacia benthamii</i> | 2 | - | Sand. Typically, on limestone breakaways. | Low |
| <i>Acacia oncinophylla</i> subsp. <i>Oncinophylla</i> | 3 | - | Granitic soils. | Low |
| <i>Acacia ridleyana</i> | 3 | - | Grey or yellow/brown sand, gravelly clay, granitic loam. | Low |
| <i>Angianthus micropodioides</i> | 3 | - | Saline sandy soils. River edges, saline depressions, claypans. | Low |
| <i>Anigozanthos humilis</i> subsp. <i>Chrysanthus</i> | 4 | - | Slope with white to grey sand. Underlying geology: Bassendean Dune System. | High - Known to occur within the study area |
| <i>Bolboschoenus medianus</i> | 1 | - | Mud. In water and on riverbanks. | Low |
| <i>Byblis gigantea</i> | 3 | - | Sandy-peat swamps. Seasonally wet areas. | Low |
| <i>Caladenia huegelii</i> | T | EN | Grey or brown sand, clay loam. | High |
| <i>Calectasia elegans</i> | 2 | - | Grey sand. | Moderate |
| <i>Carex tereticaulis</i> | 3 | - | Watercourse, wet. Organic litter. Grey Bassendean Sand over sand. Black peaty sand | Moderate |
| <i>Conospermum undulatum</i> | T | VU | Low plain/swamp. White-grey sand. Bassendean-Southern River complex. Seasonal dampland. Probably burnt within last 5 years. | Moderate |
| <i>Conostylis bracteata</i> | 3 | - | Sand, limestone. Consolidated sand dunes. | Low |
| <i>Cyanicula ixioides</i> subsp. <i>ixioides</i> | 4 | - | Laterite, gravel. | Low |

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| Species | BC Act status* | EPBC Act status† | Soil and landform | Likelihood of occurrence‡ |
|---------------------------------------------------------------------------|----------------|------------------|-----------------------------------------------------------------------------------------------|---------------------------------------------|
| <i>Cyathochaeta teretifolia</i> | 3 | - | Grey sand, sandy clay. Swamps, creek edges. | High - Known to occur within the study area |
| <i>Dampiera triloba</i> | 3 | - | Loamy sand. | Low |
| <i>Darwinia pimelioides</i> | 4 | - | Loam, sandy loam. Granite outcrops. | Low |
| <i>Dodonaea hackettiana</i> | 4 | - | Sand. Outcropping limestone. | Low |
| <i>Drosera occidentalis</i> subsp. <i>occidentalis</i> | 4 | - | Sandy Soils with laterite pebbles | Low |
| <i>Eryngium pinnatifidum</i> subsp. <i>Palustre</i> (G.J. Keighery 13459) | 3 | - | Dampland; grey sand. | Moderate |
| <i>Grevillea curviloba</i> subsp. <i>curviloba</i> | T | EN | Winter wet creek line. Moist, grey sand. | Low |
| <i>Haemodorum loratum</i> | 3 | - | Grey or yellow sand, gravel. | Low |
| <i>Hibbertia spicata</i> subsp. <i>leptotheca</i> | 3 | - | Sand. Near-coastal limestone ridges, outcrops & cliffs. | Unknown |
| <i>Hydrocotyle lemnoides</i> | 4 | - | Swamps | Unknown |
| <i>Hydrocotyle striata</i> | 1 | - | Clay. Springs | Moderate |
| <i>Hypolaena robusta</i> | 4 | - | White sand. Sandplains. | Low |
| <i>Isopogon drummondii</i> | 3 | - | Yellow sand. | Unknown |
| <i>Jacksonia sericea</i> | 4 | - | Calcareous & sandy soils | Moderate |
| <i>Lasiopetalum glutinosum</i> subsp. <i>glutinosum</i> | 3 | - | - | Unknown |
| <i>Lasiopetalum membranaceum</i> | 3 | - | Sand over limestone. | Low |
| <i>Macarthuria keigheryi</i> | T | EN | Slope. Sand dune. Dry grey sand. | Low |
| <i>Meionectes tenuifolia</i> | 3 | - | - | Low |
| <i>Millotia tenuifolia</i> var. <i>laevis</i> | 2 | - | Granite or laterite soils. | Low |
| <i>Phlebocarya pilosissima</i> subsp. <i>pilosissima</i> | 3 | - | White or grey sand, lateritic gravel. | Low |
| <i>Platysace ramosissima</i> | 3 | - | Sandy soils. | Low |
| <i>Poranthera moorokatta</i> | 2 | - | Dampland; light grey to grey sand over light grey-grey clay | Moderate |
| <i>Schoenus capillifolius</i> | 3 | - | Brown mud. Claypans. | Low |
| <i>Schoenus</i> sp. <i>Waroona</i> (G.J. Keighery 12235) | 3 | - | Winter wet flats, dark brown loam clay over clay. | Low |
| <i>Stachystemon</i> sp. <i>Keysbrook</i> (R. Archer 17/11/99) | 1 | - | Dry Flat, grey sand some humus, over humus and sand, well drained. | Moderate |
| <i>Stylidium longitubum</i> | 4 | - | Sandy clay, clay. Seasonal wetlands. | Moderate |
| <i>Stylidium paludicola</i> | 3 | - | Peaty sand over clay. Winter wet habitats. Marri and Melaleuca woodland, Melaleuca shrubland. | Unknown |
| <i>Stylidium trudgenii</i> | 3 | - | Dampland - wetland. Peat, soggy. | Moderate |
| <i>Styphelia filifolia</i> | 3 | - | Flat, slope. Dry, white sand. | Unknown |
| <i>Thelymitra variegata</i> | 2 | - | Sandy clay, sand, laterite. | Unknown |
| <i>Thysanotus glaucus</i> | 4 | - | Yellow sand. | Low |
| <i>Trithuria occidentalis</i> | T | EN | In water, muddy open. | Moderate |
| <i>Verticordia lindleyi</i> subsp. <i>lindleyi</i> | 4 | - | Gravelly soil. | High |

* BC Act

† Additional protection under the EPBC Act.

‡ High: known to occur within 1 km of the survey area and suitable habitat present within the survey area.

Moderate: Suitable habitat present within the survey area.

Unlikely: No suitable habitat present within the survey area.

Unknown: Data deficient.

4.1.1.2 Threatened and Priority ecological communities database search results

Searches of the DBCA ecological community database were undertaken within a 3 km radius of the survey area boundary.

A total of 348 records of nine TECs / PECs were found to occur within the search radius comprising *Banksia Woodlands of the Swan Coastal Plain Ecological Community* (312 records), *Subtropical and Temperate Coastal Saltmarsh Ecological Community* (five records), Shrublands and woodlands on Muchea Limestone (one record), *Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain) Ecological Community* (one record), SCP02 (one record), SCP20a (four records), SCP21c (eight records), SCP22 (six records), and SCP23b (nine records) (Table 9).

Table 9 additionally identifies each community's protection status under the EPBC Act.

Conservation significant ecological community records in the vicinity of the survey area are shown in Figure J.

Table 9: TEC / PEC records within a 3 km radius of the survey area

| TEC / PEC | Description | BC Act status* | EPBC Act status† |
|-------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|------------------|
| Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region | The ecological community is a woodland associated with the SCP of south-west Western Australia. A key diagnostic feature is a prominent tree layer of <i>Banksia</i> , with scattered eucalypts and other tree species often present among or emerging above the <i>Banksia</i> canopy. The understorey is a species rich mix of sclerophyllous shrubs, graminoids and forbs. The ecological community is characterised by a high endemism and considerable localised variation in species composition across its range (Threatened Species Scientific Committee 2016). | Priority 3 | Endangered |
| Subtropical and Temperate Coastal Saltmarsh | The Subtropical and Temperate Coastal Saltmarsh (hereafter Coastal Saltmarsh) ecological community occurs within a relatively narrow margin of the Australian coastline, within the subtropical and temperate climatic zones south of the South-east Queensland IBRA bioregion boundary at 23°37' latitude along the east coast and south of (and including) Shark Bay at 26° on the west coast. The community consists mainly of salt-tolerant vegetation (halophytes) including grasses, herbs, reeds, sedges and shrubs. Succulent herbs and grasses generally dominate and vegetation is generally <0.5 m tall with the exception of some reeds and sedges. Many species of non-vascular plants are also found in saltmarsh, including epiphytic algae, diatoms and cyanobacterial mats. | Priority 3 | Vulnerable |
| Shrublands and woodlands on Muchea Limestone | This community occurs on the heavy soils of the eastern side of the SCP. Known patches include wetland and well-drained habitats, in a variety of landforms (Tauss & Weston 2010). It is defined on the basis of rare limestone-influenced substrates. Where the best developed limestone occurs, near Gingin, the plant community is located on shallow black clay or sandy clay soils on limestone. Typical and common native species in areas of best developed limestone are the tree <i>Casuarina obesa</i> , the mallees <i>Eucalyptus decipiens</i> and <i>Eucalyptus foecunda</i> and the shrubs <i>Melaleuca huegelii</i> , <i>Alyogyne huegelii</i> var. <i>huegelii</i> , <i>Grevillea curviloba</i> ssp. <i>incurva</i> , <i>Grevillea curviloba</i> ssp. <i>curviloba</i> , <i>Grevillea evanescens</i> , <i>Melaleuca acerosa</i> , and the herb <i>Thysanotus arenarius</i> . | Endangered | Endangered |

| TEC / PEC | Description | BC Act status* | EPBC Act status† |
|-------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------|
| Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain) | The habitat of this community is characterised by continuous discharge of groundwater in raised areas of peat. The peat and surrounds provide a stable, permanently moist series of microhabitats. Intact vegetated tumulus springs are only currently recorded at four locations. Typical and common native vascular plant species associated with the tumulus springs are the trees <i>Banksia littoralis</i> , <i>Melaleuca preissiana</i> and <i>Eucalyptus rudis</i> , and the shrubs <i>Taxandria linearifolia</i> , <i>Pteridium esculentum</i> , <i>Astartea fascicularis</i> and <i>Cyclosorus interruptus</i> . The following non-vascular plants have also been located on peat mounds associated with the community: <i>Lycopodium serpentium</i> (bog clubmoss), <i>Riccardia aequicellularis</i> , <i>Jungermannia inundata</i> , <i>Goebelobryum unguiculatum</i> and <i>Hyalolepidozia longiscypha</i> . | Critically Endangered | Endangered |
| SCP02 - Southern wet shrublands, Swan Coastal Plain | This type occurs on Bassendean Dunes and the Pinjarra Plain in seasonally inundated areas and generally has a diverse and dense shrub layer. | Endangered | - |
| SCP20a - <i>Banksia attenuata</i> woodlands over species rich dense shrublands | This type occurs on the Southern River unit (Bassendean System) and Karrakatta unit (Spearwood System). Structurally either <i>Banksia attenuata</i> woodlands or <i>Banksia attenuata</i> – <i>Eucalyptus marginata</i> woodlands this vegetation type is the most species-rich of all the banksia communities with an average species richness of 67.4 species per site. | Endangered | Endangered |
| SCP21c – Low-lying <i>Banksia attenuata</i> woodlands or shrublands | This type occurs sporadically between Gingin and Bunbury, and is largely restricted to the Bassendean system. The type tends to occupy lower lying wetter sites and is variously dominated by <i>Melaleuca preissiana</i> , <i>Banksia attenuata</i> , <i>B. menziesii</i> , <i>Regelia ciliata</i> , <i>Eucalyptus marginata</i> or <i>Corymbia calophylla</i> . Structurally, this community type may be either a woodland or occasionally shrubland. | Priority 3 | Endangered |
| SCP22 - <i>Banksia ilicifolia</i> woodlands | Low lying sites generally consisting of <i>Banksia ilicifolia</i> – <i>B. attenuata</i> woodlands, but <i>Melaleuca preissiana</i> woodlands and scrubs are also recorded. Occurs on Bassendean and Spearwood systems in the central SCP north of Rockingham. Typically has very open understorey, and sites are likely to be seasonally waterlogged. | Priority 2 | Endangered |
| SCP23b - Swan Coastal Plain <i>Banksia attenuata</i> - <i>Banksia menziesii</i> woodlands | These woodlands occur in the Bassendean system, from Melaleuca Park to Gingin. Occurs in reasonably extensive Banksia woodlands north of Perth. | Priority 3 | Endangered |

*BC Act

†These communities have additional protection under the EPBC Act.

4.2 Field survey

4.2.1 Flora

4.2.1.1 Flora statistics

A total of 321 vascular flora taxa were recorded by the current survey of which 246 (76.6%) were native species and 75 (23.4%) were naturalised alien (weed) species. The list of taxa recorded for the survey area is presented in Appendix B. Species recorded by site (both quadrats and relevés) are presented in Appendix C, and detailed quadrat data are presented in Appendix D.

There were several taxa that could not be identified to species level due to inadequate fruiting or flowering material available at the time of the survey. These taxa are labelled “sp.”.

REPORT

The taxa recorded represent 63 families and 189 genera. The families represented by the greatest number of taxa are presented in Table 10. The genera represented by the greatest number of taxa are presented in Table 11.

Table 10: Dominant families within the survey area

| Family | Common name | No. of taxa |
|--------------|-----------------------------|-------------|
| FABACEAE | Acacias and peas | 33 |
| CYPERACEAE | Sedges | 28 |
| MYRTACEAE | Myrtles | 26 |
| ASTERACEAE | Daisies | 24 |
| POACEAE | Grasses | 22 |
| ORCHIDACEAE | Orchids | 19 |
| ASPARAGACEAE | Fringed lilies / mat rushes | 19 |
| PROTEACEAE | Proteas | 12 |

Table 11: Dominant genera within the survey area

| Genus | Common name | No. of taxa |
|---------------------|----------------|-------------|
| <i>Lomandra</i> | Mat rushes | 9 |
| <i>Acacia</i> | Wattles | 8 |
| <i>Schoenus</i> | - | 7 |
| <i>Hibbertia</i> | Guinea flowers | 7 |
| <i>Drosera</i> | Sundews | 6 |
| <i>Pterostylis</i> | - | 5 |
| <i>Caladenia</i> | - | 5 |
| <i>Juncus</i> | - | 5 |
| <i>Lepidosperma</i> | - | 5 |
| <i>Thysanotus</i> | Fringe lilies | 5 |
| <i>Banksia</i> | - | 5 |
| <i>Eucalyptus</i> | - | 5 |

4.2.1.2 Field survey effort

Species accumulation plots were generated for the survey site data using PRIMERV6 SPEC-ACCUM (Graph 2). This expressed the number of species recorded for the field surveys as a function of effort (i.e. number of sites sampled).

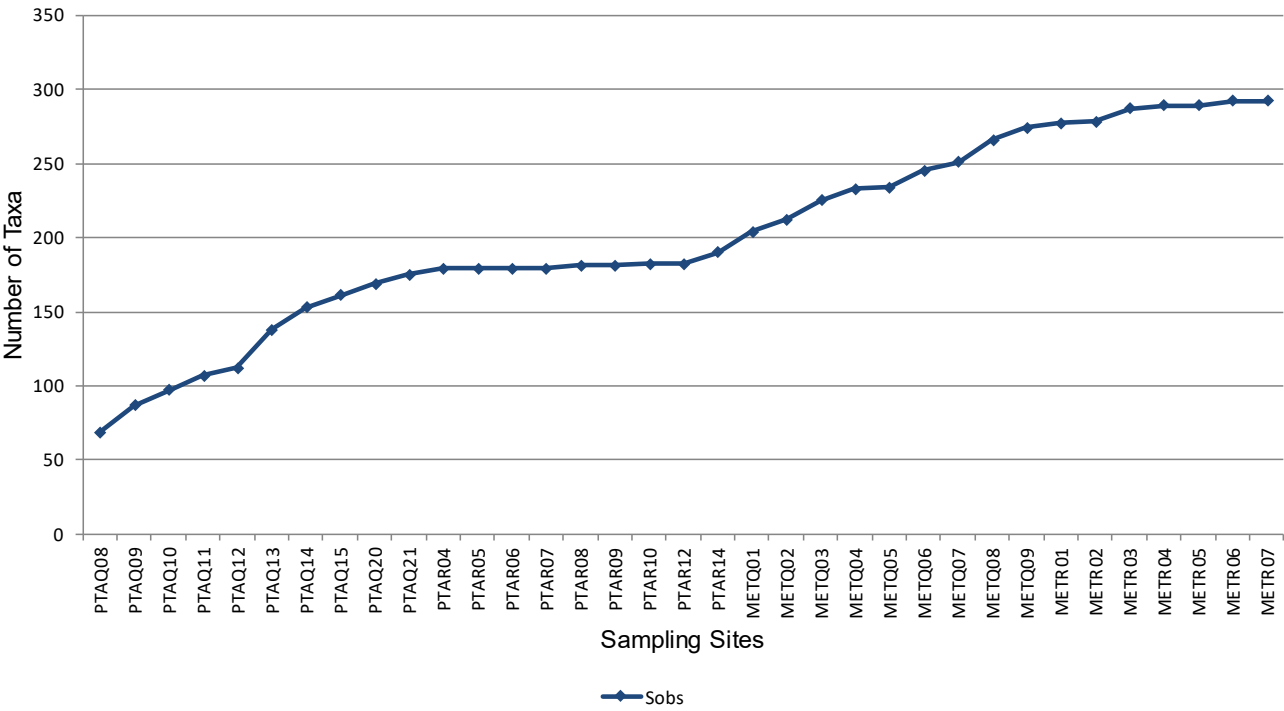
Initially, the analysis was run on the dataset in the order that the sampling sites (quadrats and relevés) were sampled in the field (i.e. chronologically) using the 'Sobs' index. This generated a 'stepped' curve showing the actual cumulative number of taxa recorded as each subsequent floristic site was sampled (Graph 2).

A second analysis was undertaken using the 'UGE' index to generate a smooth curve which was derived from the means of repeated re-sampling of all pooled samples (Graph 3). This curve represents the 'statistical expectation' for the curve shown in Graph 2.

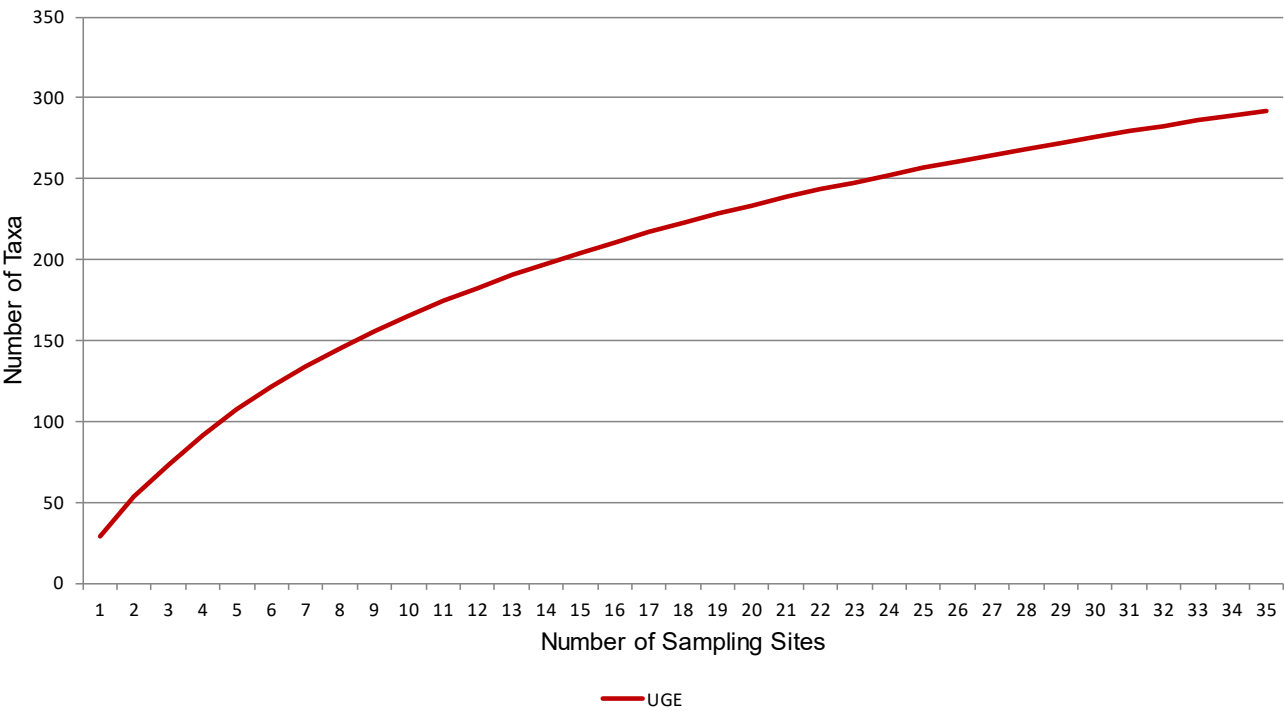
The curves demonstrate that a total of 292 taxa were recorded for the 19 quadrats and 16 relevés. The shape of the curve indicates that fewer new species were recorded with the sampling of each additional site and that the number of sites that would have to be sampled to reach the asymptote (theoretical maximum) would be prohibitively large.

REPORT

It was concluded that the survey effort for the current field survey was good. It should also be noted that an additional 29 taxa were recorded opportunistically bringing the actual total to 321.



Graph 2: Species accumulation curve (Sobs index)



Graph 3: Species accumulation curve (UGE index)

4.2.1.3 Flora of conservation significance

No TF species listed under the BC Act or the EPBC Act were recorded within the survey area.

RPS undertook a targeted search for *Caladenia huegelii* (grand spider orchid) as a separate targeted survey during the species' documented flowering period, on 28 September 2018. The survey involved a systematic search of suitable habitat within the survey area. No *Caladenia huegelii* individuals were recorded for the survey. The methods and outcomes of the targeted survey are presented in Appendix E.

Two PF species listed by the DBCA were recorded within the survey (Figure K) area.

4.2.1.3.1 *Cyathochaeta teretifolia* (P3)

Cyathochaeta teretifolia is a rhizomatous, clumped, robust perennial sedge which grows to 2 m high and 1 m wide. Flowers are brown. The species occurs on grey sand and sandy clay in swamps and along the banks of creeks (WAH 2017).

Cyathochaeta teretifolia was recorded from three floristic quadrats: PTAQ13 (within REW dampland UFI 8679); and METQ07 and PTAQ20 (within CCW sumpland UFI 8548) in the eastern part of Whiteman Park. The species is associated with the wetland vegetation type Mp.Tl.Ct, mapped for the current survey, in which it is a dominant understorey species. Associated species included *Melaleuca preissiana*, *Taxandria linearifolia*, *Dielsia stenostachya* and *Lepidosperma longitudinale* (Plates 1-3).



Plate 1: *Cyathochaeta teretifolia* habitat (PTAQ13)



Plate 2: *Cyathochaeta teretifolia* habitat (PTAQ20)



Plate 3: *Cyathochaeta teretifolia* habitat (METQ07)

4.2.1.3.2 *Anigozanthos humilis* subsp. *chrysanthus* (P4)

Anigozanthos humilis subsp. *chrysanthus* is a rhizomatous, perennial herb growing 0.2 to 0.4 m high (Plate 4). Flowers are characteristically yellow and appear between July and October. The species occurs on grey or yellow sand (WAH 2019).

Anigozanthos humilis subsp. *chrysanthus* was recorded within PTAQ08 and adjacent to PTAQ12 within the Et.Ba.Bm.Ah. *Banksia attenuata* and *B. menziesii* with emergent *Eucalyptus tottiana* low woodland vegetation unit occurring on dune slopes and crests. Associated species included *Allocasuarina humilis*, *Hibbertia hypericoides*, *Conostephium pendulum*, *Astroloma xerophyllum* and *Alexgeorgea nitens* (Plates 4 and 5).



Photo source: WAH 2019

Plate 4: *Anigozanthos humilis* subsp. *chrysanthus* (WAH 2019)



Plate 5: *Anigozanthos humilis* subsp. *chrysanthus* Habitat (PTAQ08)

4.2.1.4 Flora of other conservation significance

There are a number of other criteria (apart from the Commonwealth and Western Australian criteria of TF and PF) under which flora taxa of the Perth Metropolitan Region may be considered to be of 'other' conservation significance. These taxa are listed by *Bush Forever: Volumes 1 & 2* (WAPC 2000) as significant under various categories which include being confined to scarce or refugial habitats; having an uncommon form; belonging to regionally significant populations; being outside, disjunct from, or at the limit of their known geographical range; being undescribed taxonomic entities or being poorly reserved. These taxa are not protected under State or Commonwealth legislation but are required to be assessed as part of flora and vegetation assessments.

A total of six additional taxa recorded within the survey area are conservation significant based on geographic range anomalies, belonging to significant populations, being poorly reserved, or endemic to the SCP or the PMR portion of the SCP (Table 12).

Table 12: Significant flora of the PMR

| Taxon | Other significance* | Location within the survey area |
|---------------------------------------------------|---------------------|----------------------------------------|
| <i>Aotus cordifolia</i> | p, s | PTAQ13, PTAQ20 |
| <i>Burchardia bairdiae</i> | r, s | PTAQ14 |
| <i>Conostephium minus</i> | p, s, e | opportunistic |
| <i>Conostylis aculeata</i> subsp. <i>cygnorum</i> | e | PTAQ08, PTAQ11, PTAQ12 |
| <i>Dielsia stenostachya</i> | e | PTAQ13, PTAQ14, PTAQ15, PTAR10, PTAR12 |
| <i>Verticordia nitens</i> | s | PTAQ15 |

*Adapted from Table 13 (WAPC 2000)

- r - populations at the northern or southern limit of their known geographic range
- d - populations disjunct from their known geographic range
- p - considered to be poorly reserved (applies to all Threatened and Priority taxa)
- s - significant populations (applies to all Threatened and Priority taxa)
- X - considered lost in the PMR
- e - taxa endemic to the SCP
- E - taxa endemic to the SCP in the PMR

4.2.1.5 Introduced flora (weeds)

Seventy-five naturalised alien (weed) species were recorded for the survey area, representing 23.4% of the total flora taxa recorded. Annual and perennial Poaceae species (grasses) and Asteraceae species (daisies) accounted for 37% of the weed species recorded. The most widespread weeds included **Briza maxima*, **Bromus diandrus*, **Ehrharta calycina*, **Pennisetum clandestinus*, **Pentameris airoides* subsp. *airoides*, **Hypochaeris glabra* and **Ursinia anthemoides*. These naturalised bushland weeds were recorded at low densities throughout much of the vegetation within the survey area.

4.2.1.5.1 Declared pests and WONS

The Western Australian Organism List database (DEE 2013) was searched to determine the legal status of each weed recorded, and any control requirements that may apply under the BAM Act . Of the 75 weed species recorded two species (*Zantedeschia aethiopica* [Arum Lily]; and *Moraea flaccida* [Cape Tulip]) were determined to be Declared Pests - s22(2)³, requiring C3⁴ management. None of the weeds recorded were listed as WONS.

4.2.1.5.1.1 *Zantedeschia aethiopica* – arum lily

Zantedeschia aethiopica (Plate 6) is a tall fleshy herb with big, dark green, arrowhead-shaped leaves and large white funnel-shaped 'arum-type' flower structures with a central yellow spike. It is a common ornamental garden plant that has escaped from cultivation. Arum Lily has become a widespread weed, invading mainly damp habitats in pastures, wetlands and forest. All parts of the plant are toxic to humans, stock and pets (DPIRD 2019b).

The species was recorded along the banks of Bennett Brook and within REW UFI 8678.

³Declared Pest - s22(2) - Declared pests must satisfy any applicable import requirements when imported, and may be subject to an import permit if they are potential carriers of high-risk organisms. They may also be subject to control and keeping requirements once within Western Australia.

⁴ C3 - Organisms that should have some form of management applied that will alleviate the harmful impact of the organism, reduce the numbers or distribution of the organism or prevent or contain the spread of the organism.



Photo source: WAH 2019

Plate 6: *Zantedeschia aethiopica*

4.2.1.5.1.2 *Moraea flaccida* – Cape tulip

Moraea flaccida (Plate 7) is a perennial weed introduced from South Africa. This species is a garden escapee which has now become a significant weed throughout southern Australia. Cape Tulip is difficult to control chemically due to the dormancy of corms below the ground. It is highly toxic to stock and may invade pastures (DPIRD 2019b). Cape Tulip was recorded at low densities on the sandplains and flats in some parts of the survey area. The species was not recorded however within any of the sampling sites (quadrats or relevés).



Photo source: DPIRD 2019

Plate 7: *Moraea flaccida*

4.2.2 Vegetation

4.2.2.1 Vegetation units

Eighteen vegetation units were described and mapped including upland, wetland and transitional vegetation types. Additionally, another six units were described which represented highly modified and degraded areas, generally cleared of native vegetation. There are 19 quadrats and 16 relevés within the survey area however the vegetation units were derived from the analysis of a total of 33 quadrats (14 of which were outside the survey area) and 20 relevés (four of which were outside the survey area) as well as mapping notes recorded in the field during the surveys. The 24 mapping units (vegetation and modified) are presented in Figure L-1 to L-5. The 24 mapping units fall into one of six broad groups.

4.2.2.1.1 Modified/cleared

These six mapping units include previously cleared farmland with remnant isolated native trees, the recent clearing for the NorthLink Perth to Darwin Highway and the new Lord Street upgrade, other infrastructure including carparks, buildings and quarries, pine plantations, areas of rehabilitation, and private lots with some remnant trees but no intact native vegetation. These modified / cleared units cover approximately 72.6% (905 ha) of the survey area.

4.2.2.1.2 Marri on low slopes and flats

Three Marri (*Corymbia calophylla*) vegetation units were mapped for the survey area ranging from sparse woodland to closed forest. The units were differentiated based on their co-dominant species, i.e., *Banksia* spp., Jarrah (*Eucalyptus marginata*) generally on lower slopes, or *Melaleuca preissiana* and *Xanthorrhoea preissii* on the flats. This broad vegetation type covers approximately 5.7% (71 ha) of the survey area.

4.2.2.1.3 Low-lying Banksia woodland

Two low-lying Banksia woodland vegetation units were mapped for the survey area. The units were differentiated based on their dominant and co-dominant tree and shrub species. This broad vegetation type covers approximately 1.9% (24 ha) of the survey area.

4.2.2.1.4 Banksia woodland on dune slopes and crests

Two 'upland' Banksia woodland vegetation units were mapped for the upper dune slopes and crests within the survey area. *Banksia attenuata* and *B. menziesii* were the dominant tree species in both units which were differentiated based on the presence of co-dominant tree species (e.g. *Eucalyptus tottiana*), and different dominant shrub species. This broad vegetation type covers approximately 6.8% (85 ha) of the survey area.

4.2.2.1.5 Melaleuca wetland / dampland




Seven Melaleuca wetland vegetation units were mapped for the survey area. This broad vegetation type occurred throughout the floodplains, palusplains, sumplands and damplands which are dominant features within the survey area. *Melaleuca preissiana* was the dominant tree species in this broad vegetation type with *M. raphiophylla* as a dominant or co-dominant in some of the vegetation units. Other co-dominant tree species included *Eucalyptus rudis* subsp. *rudis* and *Corymbia calophylla*. Dominant shrub species differed between the vegetation units. This broad vegetation type covers approximately 4.7% (59 ha) of the survey area.





4.2.2.1.6 Eucalyptus rudis wetland / dampland / creekline





Four *Eucalyptus rudis* subsp. *rudis* wetland vegetation units were mapped for the survey area. This vegetation occurred along the banks (floodplains) of Bennett Brook, extending onto the palusplains. *Melaleuca raphiophylla* occurred as a co-dominant tree species in three of the four vegetation units. This broad vegetation type covers approximately 6.8% (85 ha) of the survey area.





A description of the 24 mapping units is provided in Table 13.

Table 13: Vegetation units mapped for the survey area



| Photograph | Code | Vegetation description | Extent (ha) | Floristic sites |
|-------------------------------------------------------------------------------------|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|------------------------------------------------|
| Marri on low slopes and flats | | | | |
|  | Cc.Em.Xp | <i>Corymbia calophylla</i> Sparse Woodland to Mid Open Forest with <i>Eucalyptus marginata</i> isolated clumps of trees over <i>Xanthorrhoea preissii</i> Shrubland over an exotic Closed Grassland/Forbland | 1.31 (0.1%) | NA |
| No photo available | Cc./Em./Af.B m.Xp. | <i>Corymbia calophylla</i> / <i>Eucalyptus marginata</i> / <i>Allocasuarina fraseriana</i> Sparse Woodland to Mid Open Forest with isolated clumps of trees over <i>Xanthorrhoea preissii</i> Shrubland over an exotic Closed Grassland/Forbland | 17.68 (1.4%) | NA |
|  | Cc.Mp.Xp. | <i>Corymbia calophylla</i> Mid Open Forest to Mid Closed Forest over <i>Melaleuca preissiana</i> Low isolated trees to Low Woodland over <i>Xanthorrhoea preissii</i> isolated Shrubs to Mid Open Shrubland over <i>Dielsia stenostachya</i> Rushland with a mixed exotic Open Grassland | 68.7 (5.5%) | PTAR12 PTAQ15 PTAQ21 METQ01 METQ06 |
| Low-lying Banksia woodland | | | | |
|  | Ba.Bm.Bi.Xp | <i>Banksia attenuata</i> , <i>B. menziesii</i> and <i>B. ilicifolia</i> Low Woodland over <i>Xanthorrhoea preissii</i> Mid Open Shrubland over <i>Scholtzia involucrata</i> Low Sparse Shrubland over an Open to Closed Rushland / Forbland | 19 (1.5%) | PTAR04 |

| Photograph | Code | Vegetation description | Extent (ha) | Floristic sites |
|-------------------------------------------------------------------------------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------------------------------------------------|
|  | Ba.As.Jf | <i>Banksia attenuata</i> Low Isolated Trees over <i>Acacia saligna</i> and <i>Jacksonia furcellata</i> Tall Sparse Shrubland over a mixed exotic Closed Grassland | 4.9 (0.4%) | METR06 |
| Banksia woodland on dune slopes and crests | | | | |
|  | Et.Ba.Bm.Ah | <i>Banksia attenuata</i> and <i>B. menziesii</i> Low Woodland with <i>Eucalyptus tottiana</i> Isolated Trees over <i>Allocasuarina humilis</i> Mid Open Shrubland over <i>Hibbertia hypericoides</i> , <i>Conostephium pendulum</i> and <i>Astroloma xerophyllum</i> Low Open Shrubland to Low Sparse Shrubland over <i>Alexgeorgea nitens</i> Sparse Rushland | 76.1 (6.1%) | PTAQ08 PTAQ09 PTAQ10 PTAQ11 PTAQ12 PTAR07 |
|  | Ba.Bm.Si.Po | <i>Banksia attenuata</i> and <i>B. menziesii</i> Low Woodland over a mixed Low Shrubland including <i>Scholtzia involucreta</i> , <i>Eremaea pauciflora</i> var. <i>pauciflora</i> , <i>Hibbertia hypericoides</i> and <i>Calytrix angulata</i> Low Shrubland over <i>Patersonia occidentalis</i> var. <i>occidentalis</i> Sparse Forbland | 8.5 (0.7%) | METQ08 METQ09 |
| Melaleuca wetland / dampland | | | | |
|  | Cc.Tl.Pe | <i>Corymbia calophylla</i> Mid Open Forest over <i>Taxandria linearifolia</i> Tall Closed Shrubland to Tall Sparse Shrubland over <i>Pteridium esculentum</i> Mid Closed Shrubland to Mid Sparse Shrubland | 1.49 (0.1%) | NA |

| Photograph | Code | Vegetation description | Extent (ha) | Floristic sites |
|-------------------------------------------------------------------------------------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|--------------------------------------|
|  | Mp.Tl.Ct. | <i>Melaleuca preissiana</i> isolated trees to Mid Closed Forest over <i>Taxandria linearifolia</i> Tall Closed Shrubland to Tall Sparse Shrubland over an Open to Closed Rushland / Sedgeland including <i>Cyathochaeta teretifolia</i> , <i>Dielsia stenostachya</i> and <i>Lepidosperma longitudinale</i> | 7.6 (0.6%) | PTAQ13 PTAQ20 METQ07 |
|  | Mp.Tl.Ca | <i>Melaleuca preissiana</i> isolated trees to Mid Closed Forest over <i>Taxandria linearifolia</i> Tall Closed Shrubland to Tall Sparse Shrubland over an Open to Closed Rushland / Sedgeland including <i>Cyathochaeta avenacea</i> , <i>Dielsia stenostachya</i> , <i>Lepidosperma longitudinale</i> and <i>Baumea juncea</i> | 1.26 (0.1%) | PTAQ14 PTAR09 PTAR10 |
|  | Mp.Xp. | <i>Melaleuca preissiana</i> Low isolated trees to Low Woodland over <i>Xanthorrhoea preissii</i> isolated Shrubs to Mid Open Shrubland over a mixed exotic Open Grassland | 18.2 (1.5%) | NA |
|  | Mp.As. | <i>Melaleuca preissiana</i> Low Woodland to Low Open Forest over <i>Astartea scoparia</i> Mid Shrubland to Mid Sparse Shrubland over a mixed Open Sedgeland/Rushland/For bland/Grassland | 5.7 (0.5%) | PTAR05 PTAR06 PTAR08 METR02 |

| Photograph | Code | Vegetation description | Extent (ha) | Floristic sites |
|-------------------------------------------------------------------------------------|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------------------|
|  | Mr./ Standing Water | <i>Melaleuca raphiophylla</i> over a mixed exotic Closed Forbland/Sedgeland on wetland fringe and over standing water in wetland | 24 (1.9%) | METR07 |
|  | Mr.Ml.Tl.As. | <i>M. raphiophylla</i> Low Woodland over <i>M. lateritia</i> , <i>Taxandria linearifolia</i> and <i>Astartea affinis</i> Tall Shrubland over <i>Centella asiatica</i> Low Forbland on wetland fringe and standing water in wetland | 1.8 (0.1%) | METR01 |
| <i>Eucalyptus rudis</i> wetland / dampland | | | | |
|  | Er.Mr.As/Tl. | <i>Eucalyptus rudis</i> subsp. <i>rudis</i> Mid Open Forest over <i>Melaleuca raphiophylla</i> Low Woodland over <i>Astartea scoparia</i> / <i>Taxandria linearifolia</i> isolated Shrubs over <i>Juncus pallidus</i> and <i>Lepidosperma longitudinale</i> Sparse Sedgeland over <i>Centella asiatica</i> Open Forbland | 21 (1.7%) | PTAR14 METQ03 |
|  | Er.Mr.Ll. | <i>Eucalyptus rudis</i> and <i>Melaleuca raphiophylla</i> Closed Forest over <i>Lepidosperma longitudinale</i> Sedgeland | 2.6 (0.2%) | METQ02 METQ04 METQ05 |

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| Photograph | Code | Vegetation description | Extent (ha) | Floristic sites |
|------------------------------------------------------------------------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|------------------|
|  | Er.Mr. | <i>Eucalyptus rudis</i> subsp. <i>rudis</i> and <i>Melaleuca raphiophylla</i> Mid Open Forest over a mixed exotic Closed Forbland / Grassland | 55.4 (4.4%) | NA |
|  | Er. | <i>Eucalyptus rudis</i> Closed an exotic Closed Grassland | 5.8 (0.5%) | NA |
| Modified / cleared | | | | |
| C/M | | Completely cleared or modified. Includes private lots and infrastructure (roads, carparks, buildings, quarries) - some remnant trees but no intact native vegetation | 311.1 (25%) | NA |
| Cc./Mp./Er. Cleared | | Isolated remnant <i>Corymbia calophylla</i> , <i>Melaleuca preissiana</i> and/or <i>Eucalyptus rudis</i> over pasture/weeds - previously cleared | 320 (25.7%) | NA |
| Cc./Mp.Xp. Cleared | | Isolated remnant <i>Corymbia calophylla</i> and / or <i>Melaleuca preissiana</i> and <i>Xanthorrhoea preissii</i> over weeds - previously cleared | 217.3 (17.4%) | NA |
| Rehab. | | Rehabilitated areas and native regrowth (post clearing) | 33 (2.6%) | METR04 METR05 |
| Eucs. | | Planted eastern states Eucalypts | 1.1 (0.1%) | NA |
| Pp. | | <i>Pinus pinaster</i> plantation | 23.2 (1.8%) | METR03 |

4.2.2.2 Floristic community type (FCT) assignment

4.2.2.2.1 Multivariate analysis of floristic data

4.2.2.2.1.1 Data compatibility

Floristic data from the 19 quadrats sampled for the 2017, 2018 and 2019 surveys were considered compatible with the SCP (Gibson et al. 1994) and Supplementary (Keighery et al. 2012) datasets due to consistencies in quadrat size (10 m × 10 m), nomenclature, species-richness (indicative of sampling effort) and vegetation condition between the test sites and the combined SCP and Supplementary dataset.

4.2.2.2.1.2 Hierarchical cluster analysis and FCTs

The Hierarchical Cluster Analyses was undertaken using PRIMERV6 comparing the floristics of each test site from the current survey with the combined 1098 site SCP and Supplementary dataset.

PTA (2017) and MET (2018) survey quadrats (test sites)

An analysis was initially run on the floristic data from the 19 test sites (quadrats) sampled in 2017, 2018 and 2019 (Appendix F; Graph F-1), and the 19 quadrats plus the 16 relevé (unbounded) sites (35 sites total) (Appendix F; Graph F-2), to determine existing groupings based on floristic similarities between sites. Landform was added as a factor to investigate the influence of landscape position and substrate on floristic composition. The outcomes of this analysis assisted in the vegetation unit mapping for the survey area. Graph F-1 shows the 19 quadrat sites forming two distinct groups (wetland and dryland), and three statistically significant clusters (denoted by the black line) within the wetland sites and three statistically significant clusters within the dryland group.

Analysis of all 35 quadrat and relevé sites together resulted in two distinct groups; one group comprising predominantly wetland and creek line sites, and the other group comprising upland sites (on dune slopes and crests), sand flats, and several wetland sites. These groups formed total of 12 significant clusters correlating broadly to landform and dominant tree and shrub species (Graph F-2).

Combined SCP and supplementary datasets (Keighery et al. 2012)

A Hierarchical Cluster Analysis was run on the combined SCP and Supplementary (Keighery et al. 2012) dataset to see if the output showed similar groupings to the SCP dataset. Keighery et al. (2012) made the following proviso regarding the updated dataset: "It is important to know that the data in this dataset are not ideal for floristic community type analysis due to inconsistencies in the grouping and splitting of some species compared to that used in the Gibson et al. (1994) analysis. This dataset is not the exact dataset used to analyse FCTs for Bush Forever (Western Australian Planning Commission)".

The dendrogram for the combined SCP and Supplementary dataset shows differences in clustering of sites to the original Gibson analysis, however, despite these differences the majority of the sites did group according to their FCTs and within the four supergroups.

PTA (2017) and MET (2018) survey quadrats plus the combined SCP and supplementary datasets

All the 19 quadrat test sites were then added to the combined SCP and Supplementary dataset and a Hierarchical Cluster Analysis run. The dendrogram output from the analysis showed 13 of the sites showing a strong affinity to one FCT, however five of the survey sites showed affinities to more than one FCT (Table 14).

Each of the test sites was then added separately to the combined SCP and Supplementary dataset in an effort to minimise disruption to the original groupings and to clarify mixed FCT affinities. This analysis resolved some but not all of these mixed affinities. The relevant portions of the classification dendrograms for each of the survey sites are presented in Appendix F, Graphs F-3 to F-21.

4.2.2.2 Landform and species occurrence as an indicator of FCT

When assigning FCTs to the vegetation, consideration was also given to the landform on which each vegetation type is located, as well as indicator species recorded for the survey.

4.2.2.3 Geographic distribution of FCTs

Geographic distribution of FCTs was an additional factor considered in assigning FCTs to vegetation units within the survey area. Proximity of SCP (Gibson et al. 1994) and Supplementary (Keighery et al. 2012) study sites to the survey area, on like soils and landforms lent strength to the classification results and helped in some cases to resolve mixed affinities.

A summary of the determination of FCTs for each of the floristic quadrat sites and their state-listed conservation significance is presented in Table 14. Further discussion on the FCT determinations for the sites with mixed FCT affinities follows.

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Table 14: Floristic community type (FCT) determination

| Survey sites | FCT - SCP + supp. data (all sites) | FCT - SCP + supp. data (SSI) | FCT – Supergroup 3 Data (SSI) | FCT – Supergroup 2 Data (SSI) | Geographic distribution of FCTs | Soil, landform, species presence | Final FCT determination | Significance of final FCT determination (state) | Significance of final FCT determination (national) | Current survey mapping unit |
|--------------|---------------------------------------|------------------------------|-------------------------------|-------------------------------|--------------------------------------------------|----------------------------------|-------------------------|-------------------------------------------------|----------------------------------------------------|-----------------------------|
| PTAQ08 | FCT23a | FCT23a | FCT23a | - | FCT23a | FCT23a | FCT23a | - | Endangered | <i>Et.Ba.Bm.Ah.</i> |
| PTAQ09 | FCT23a | FCT23a; FCT23b | FCT23a; FCT23b | - | FCT23a; FCT23b | FCT23a; FCT23b | FCT23a / FCT23b | Endangered (If FCT23b) | Endangered | <i>Et.Ba.Bm.Ah.</i> |
| PTAQ10 | FCT23a | FCT23a | FCT23a | - | FCT23a | FCT23a | FCT23a | - | Endangered | <i>Et.Ba.Bm.Ah.</i> |
| PTAQ11 | FCT23a | FCT23a | FCT23a | - | FCT23a | FCT23a | FCT23a | - | Endangered | <i>Et.Ba.Bm.Ah.</i> |
| PTAQ12 | FCT23a | FCT23a | FCT23a | - | FCT23a | FCT23a | FCT23a | - | Endangered | <i>Et.Ba.Bm.Ah.</i> |
| PTAQ13 | FCT11; FCT06; FCTS17; FCTS07 | FCT13; FCTS17 | - | FCT13; FCTS17 | FCTS17 | FCTS17 | FCTS17 | Other conservation significance | - | <i>Mp.Tl.Ct.</i> |
| PTAQ14 | FCT11; FCT06; FCTS17; FCTS07 | FCT04; FCTS02 | - | FCT04; FCTS02 | FCT11; FCTS02; FCT04; FCTS17; FCTS07 | FCTS07 | FCTS07 | - | - | <i>Mp.Tl.Ca.</i> |
| PTAQ15 | FCT11 | FCT11 | - | - | FCT11 | FCT11 | FCT11 | - | - | <i>Cc.Mp.Xp.</i> |
| PTAQ20 | FCT11; FCT06; FCTS17; FCTS07 | FCT13; FCTS17 | - | FCT11 | FCT11; FCT06; FCTS17; FCTS07 | FCTS17; FCTS07 | FCTS17 | Other conservation significance | - | <i>Mp.Tl.Ct.</i> |
| PTAQ21 | FCT11 | FCT11 | - | - | FCT11 | FCT11 | FCT11 | - | - | <i>Cc.Mp.Xp.</i> |
| METQ01 | FCT04; FCT05 | FCT04; FCT05; FCTS02 | - | FCT04; FCT05 | FCT04; FCT05 | FCT04 | FCT04 | - | - | <i>Cc.Mp.Xp.</i> |
| METQ02 | FCT11 | FCT11 | - | - | FCT11 | FCT11 | FCT11 | - | - | <i>Er.Mr.Ll.</i> |
| METQ03 | FCT15; FCTS07 | FCT15 | - | FCT15; FCT13 | FCT15; FCT11 | FCT11 | FCT11 | - | - | <i>Er.Mr.As/Tl.</i> |
| METQ04 | FCT11 | FCTS07 | - | FCTS07 | FCTS07 | FCTS07 | FCTS07 | - | - | <i>Er.Mr.Ll.</i> |
| METQ05 | FCT11 | FCT11 | - | - | FCT11 | FCT11 | FCT11 | - | - | <i>Er.Mr.Ll.</i> |
| METQ06 | FCT11 | FCT11 | - | - | FCT11 | FCT11 | FCT11 | - | - | <i>Cc.Mp.Xp.</i> |

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| Survey sites | FCT - SCP + supp. data (all sites) | FCT - SCP + supp. data (SSI) | FCT – Supergroup 3 Data (SSI) | FCT – Supergroup 2 Data (SSI) | Geographic distribution of FCTs | Soil, landform, species presence | Final FCT determination | Significance of final FCT determination (state) | Significance of final FCT determination (national) | Current survey mapping unit |
|--------------|---------------------------------------|--------------------------------------------------|-------------------------------|-------------------------------|---------------------------------|----------------------------------|-------------------------|-------------------------------------------------|----------------------------------------------------|-----------------------------|
| METQ07 | FCT11; FCT06; FCTS17; FCTS07 | FCT05 (FCT11; FCT06; FCTS17; FCTS07) | - | FCT05 (loose affiliation) | FCT05; FCTS17; FCTS07 | FCTS17; FCTS07 | FCTS17 | Other conservation significance | - | <i>Mp.Tl.Ct.</i> |
| METQ08 | FCT23a | FCT23c | FCT23c | - | FCT23c | FCT23c | FCT23c | - | Endangered | <i>Ba.Bm.Si.Po.</i> |
| METQ09 | FCT23a | FCT23a | FCT23a | - | FCT23c; FCT23a | FCT23a | FCT23a | - | Endangered | <i>Ba.Bm.Si.Po.</i> |

4.2.2.2.4 FCT determinations for sites with mixed affinities

4.2.2.2.4.1 Seasonal wetland sites (Supergroup 2)

Twelve of the 19 floristic quadrats sampled for the current assessment represented seasonal wetland community type (Supergroup 2) vegetation (Gibson et al. 1994) (Table 14).

Six of the seasonal wetland sites were assigned to FCT11 based on the multivariate analysis results, and consideration of location, soil, landform and species presence. FCT11 – Wet forests and woodlands is well-reserved and has a ‘low risk’ conservation status (Gibson et al. 1994).

Three sites (PTAQ13, PTAQ20 and METQ07) were in wetland vegetation on the eastern side of Whiteman Park (Figure K-3). When analysed against the SCP and Supplementary dataset these sites had affinities with FCT11 – Wet forests and woodlands, FCT13 – Deeper woodlands on heavy soils, and FCTS17 - *Eucalyptus rudis*/*Taxandria linearifolia* wetlands in Bassendean Dunes, and one site (METQ07) had additionally had affinities with FCT05 – Mixed shrub damplands. These results, however, were not particularly strong with the similarity between the three test sites and the SCP and Supplementary sites less than 30%. Many of the SCP and Supplementary study sites belonging to these FCTs also showed low levels of similarity in the cluster analysis suggesting that the original groupings of the Gibson et al. (1994) SCP dataset had been somewhat disrupted by the inclusion of the additional 590 sites from the Supplementary studies. This was noted by Keighery et al. (2012) in the explanatory notes which accompanied the Supplementary dataset.

The floristic composition, and soil and landform on which the three test sites occurred was further investigated in an effort to resolve the mixed FCT affinities for these sites, and it was concluded that all three sites were most likely to represent FCTS17 based on location, landform and substrate, and the presence of species both common to, and indicators for, FCTS17 (Table 15).

Table 15: Common and indicator species for FCTS17 recorded within PTAQ13, PTAQ20 and METQ07

| Taxa | PTAQ13 | PTAQ20 | METQ07 |
|-----------------------------------|--------|--------|--------|
| <i>Astartea</i> sp. | x | x | |
| <i>Baumea juncea</i> | | | |
| <i>Eucalyptus rudis</i> | x | | |
| <i>Lepidosperma longitudinale</i> | x | | |
| <i>Melaleuca preissiana</i> | x | x | x |
| <i>Pteridium esculentum</i> | | x | |
| <i>Taxandria linearifolia</i> | x | x | x |
| <i>Aotus cordifolia</i> | x | x | |
| <i>Cyathochaeta teretifolia</i> | x | x | x |
| <i>Taxandria linearifolia</i> | x | x | x |

PTAQ13, PTAQ20 and METQ07 were mapped for the current survey as *Mp. TI.Ct.* - *Melaleuca preissiana* isolated trees to Mid Closed Forest over *Taxandria linearifolia* Tall Closed Shrubland to Tall Sparse Shrubland over an Open to Closed Rushland/Sedgeland including *Cyathochaeta teretifolia*, *Dielsia stenostachya* and *Lepidosperma longitudinale*.

The remaining two wetland sites, PTAQ14 and METQ04, were assigned to FCTS07 - Northern woodlands to forests over tall sedgelands alongside permanent wetlands.

4.2.2.2.4.2 Supergroup 3 - uplands centred on Bassendean dunes sites

Seven of the 19 floristic quadrats sampled for the current assessment represented uplands centred on Bassendean dunes community type (Supergroup 3) vegetation (Gibson et al. 1994) (Table 14).

Five of these upland sites were assigned to FCT23a based on the multivariate analysis results, and consideration of location, soil, landform and species presence. FCT23a – Central *Banksia attenuata* - *Banksia menziesii* woodlands is well-reserved and has a 'low risk' conservation status (Gibson et al. 1994).

One site, PTAQ09, showed affinities to both FCT23a and the state-listed Priority 3 PEC FCT23b which is considered 'poorly reserved' with a conservation status of 'Susceptible'.

The upland sites representing these FCTs were described and mapped as two *Banksia* vegetation units: *Ba.Bm.Si.Po*; and *Et.Ba.Bm.Ah*., described in Table 13.

4.2.2.3 TECs and PECs within the survey area

The results of the floristic analysis (Section 4.2.2.2; Table 14) determined which FCTs were present within the survey area and subsequently identified the potential presence of one state-listed conservation significant ecological community, *SCP23b - Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands*. One floristic quadrat from the current survey (PTAQ09), located in the south western section of the survey area, showed affinities to both FCT23a and FCT23b (which represents the Priority 3 PEC *SCP23b*) (Figure N). Coffey (2015) recorded FCT23b within the survey area during their assessment and their record has been added to the DBCA database as shown in Figure I. The documented presence of this FCT in close proximity to PTAQ09 lends strength to the likelihood that this site does represent the conservation significant FCT23b (*SCP23b - Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands*)..

Those areas in Good or better condition belonging to *Banksia* woodland FCTs within the survey area (FCT23a and FCT23a/FCT23b, and FCT23c), described and mapped as *Ba.Bm.Si.Po*; and *Et.Ba.Bm.Ah* (Figures L1 to L-5) comprise the EPBC- listed TEC *Banksia Woodlands of the Swan Coastal Plain Ecological Community*, which is also listed by the State as the Priority 3 PEC *Banksia dominated woodlands of the Swan Coastal Plain IBRA region*. The extent of this TEC within the survey area is shown in Figure N.

4.2.2.4 Vegetation condition

Vegetation condition within the survey area ranged from Excellent to Completely Degraded (Figures L-1 to L-5, and Table 16). A large proportion of the survey area (88%) was in Degraded or worse condition. These areas comprised previously cleared farmland with remnant isolated trees, recent clearing for the NorthLink Perth to Darwin Highway and the new Lord Street upgrade, buildings, roads, tracks, bushland regeneration areas, pine plantation and developed private lots. The Degraded condition throughout much of the remnant trees over pasture vegetation units is due to historical grazing by livestock and kangaroos and weed infestation. Within the intact bushland portions, condition ranged from Good to Excellent but these areas were generally small, isolated, and surrounded by cleared paddocks in Completely Degraded condition. Much of the low-lying vegetation, on the sand flats and throughout the palusplain was in Degraded, or at best Good, condition despite the presence of a dense tree canopy, again the result of historical grazing and infestation by weeds. The vegetation in the best condition was recorded on the slopes and crests of dunes and comprised *Banksia* woodland with a dense or mid-dense shrub layer. These intact *Banksia* woodland areas appeared to be very healthy and exhibited structural integrity and complexity with evidence of recruitment of tree, shrub and herb / grass species from the soil seed bank, and generally low disturbance from weeds. Species richness in the *Banksia* vegetation units was generally high. Several small patches of wetland vegetation were mapped in Good, Very Good and Excellent condition in the eastern side of Whiteman Park (Figure L-2).

Table 16: Vegetation condition within the survey area

| Vegetation condition | | Survey area | |
|----------------------|---------------------------------|---------------|----------------|
| | | Hectares (ha) | Percentage (%) |
| E | Excellent | 8.3 | 0.7 |
| VG | Very Good | 28.9 | 2.3 |
| G-VG | Good to Very Good | 8.5 | 0.7 |
| G | Good | 38.9 | 3.1 |
| G-D | Good to Degraded | 63.3 | 5.1 |
| D | Degraded | 220.0 | 17.7 |
| D-CD | Degraded to Completely Degraded | 10.3 | 0.8 |
| CD | Completely Degraded | 868.9 | 69.7 |

5 DISCUSSION

5.1 Floristic diversity and representation

In assessing the conservation significance of flora within the survey area, consideration is given to rarity, biodiversity, endemism and representativeness of the flora in the area.

5.1.1 Rarity

The rarity of the flora was assessed via the various categories of TF (protected under the BC Act and under the EPBC Act) and PF (listed by DBCA).

No TF were recorded within the survey area.

Two PF species as currently listed by DBCA were recorded within the survey area: *Cyathochaeta teretifolia* (P3), and *Anigozanthos humilis* subsp. *chrysanthus* (P4).

- *Cyathochaeta teretifolia* was associated with the conservation significant ecological community FCTS17 - *Eucalyptus rudis*/*Taxandria linearifolia* wetlands in Bassendean Dunes and was recorded from three floristic quadrats; PTAQ13, PTAQ20 and METQ07 in the eastern part of Whiteman Park. All populations of this taxon within the PMR of the SCP are considered significant; the taxon is also poorly reserved.
- *Anigozanthos humilis* subsp. *chrysanthus* was recorded within PTAQ08 and adjacent to PTAQ12 within the *Et.Ba.Bm.Ah. Banksia attenuata* and *B. menziesii* with emergent *Eucalyptus tottiana* low woodland vegetation unit occurring on dune slopes and crests (representative of FCT23a and the EPBC-listed TEC, *Banksia Woodlands of the Swan Coastal Plain Ecological Community*).

Six species of 'other' conservation significance on the SCP were recorded within the survey area. The species and the reason for their conservation significance is as follows:

- *Aotus cordifolia* - all populations within the PMR of the SCP are considered significant; the taxon is poorly reserved; the taxon is associated with a conservation significant ecological community (FCTS17).
- *Burchardia bairdiae* - all populations within the PMR of the SCP are considered significant; the population is at the limit of its known geographic range.
- *Conostephium minus* - all populations within the PMR of the SCP are considered significant; the taxon is poorly reserved; the taxon is endemic to the SCP.
- *Conostylis aculeata* subsp. *cygnorum* - the taxon is endemic to the SCP.
- *Dielsia stenostachya* - the taxon is endemic to the SCP.
- *Verticordia nitens* - the population is at the limit of its known geographic range.

Rarity of the flora within the survey area was assessed as moderately high.

5.1.2 Biodiversity

A total of 246 native vascular flora taxa were recorded for the survey area.

5.2 Vegetation conservation significance

5.2.1 Bioregional representation

On a regional scale the survey area is mapped as Vegetation Associations 949; 1001; 1018 and 1009 (Shepherd et al. 2002), and Bassendean Complex Central and South; Southern River Complex and Bassendean Complex North (Hedde et al. 1980). Of the four vegetation associations, three have between 10% and 30% of their original (pre-European) extent remaining and less than 3% of their current extent protected for conservation (Government of Western Australia 2016).

Of the three Heddle et al. (1980) vegetation complexes represented within the survey area, Bassendean Complex Central and South and Southern River Complex have between 10% and 30% of their original (pre-European) extent remaining and have 17% and 22% respectively remaining in Bush Forever. Most of the survey area belongs to the Southern River Complex (Figure G).

5.2.2 Threatened and Priority ecological communities

The database search results revealed that there are several known TEC and PEC records and / or their buffers within the survey area (Figure J). A description of the six conservation significant ecological communities identified as occurring within, or having a buffer intersecting with, the survey area is presented in Table 17 and discussed in greater detail below.

Table 17: TEC and PEC records within the survey area derived from the database search results

| TEC / PEC | Description | BC Act status* | EPBC Act status† | Record / buffer within survey area |
|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------|----------------------------------------------------------------------------------------------------|
| Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region | The ecological community is a woodland associated with the SCP of south-west Western Australia. A key diagnostic feature is a prominent tree layer of Banksia, with scattered eucalypts and other tree species often present among or emerging above the Banksia canopy. The understorey is a species rich mix of sclerophyllous shrubs, graminoids and forbs. The ecological community is characterised by a high endemism and considerable localised variation in species composition across its range (Threatened Species Scientific Committee 2016). | Priority 3 | Endangered | Numerous records and buffers (200 m) intersect the survey area |
| Shrublands and woodlands on Muehea Limestone | This community occurs on the heavy soils of the eastern side of the SCP. Known patches include wetland and well-drained habitats, in a variety of landforms (Tauss & Weston 2010). It is defined based on rare limestone-influenced substrates. Where the best developed limestone occurs, near Gingin, the plant community is located on shallow black clay or sandy clay soils on limestone. Typical and common native species in areas of best developed limestone are the tree <i>Casuarina obesa</i> , the mallees <i>Eucalyptus decipiens</i> and <i>Eucalyptus foecunda</i> and the shrubs <i>Melaleuca huegelii</i> , <i>Alyogyne huegelii</i> var. <i>huegelii</i> , <i>Grevillea curviloba</i> ssp. <i>incurva</i> , <i>Grevillea curviloba</i> ssp. <i>curviloba</i> , <i>Grevillea evanescens</i> , <i>Melaleuca acerosa</i> , and the herb <i>Thysanotus arenarius</i> . | Endangered | Endangered | The survey area intersects the 500 m buffer of one record at the northern tip of the survey area |
| Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain) | The habitat of this community is characterised by continuous discharge of groundwater in raised areas of peat. The peat and surrounds provide a stable, permanently moist series of microhabitats. Intact vegetated tumulus springs are only currently recorded at four locations. Typical and common native vascular plant species associated with the tumulus springs are the trees <i>Banksia littoralis</i> , <i>Melaleuca preissiana</i> and <i>Eucalyptus rudis</i> , and the shrubs <i>Taxandria linearifolia</i> , <i>Pteridium esculentum</i> , <i>Astartea fascicularis</i> and <i>Cyclosorus interruptus</i> . The following non-vascular plants have also been located on peat mounds associated with the community: <i>Lycopodium serpentium</i> (bog clubmoss), <i>Riccardia aequicellularis</i> , <i>Jungermannia inundata</i> , <i>Goebelobryum unguiculatum</i> and <i>Hyalolepidozia longiscypha</i> . | Critically Endangered | Endangered | The survey area intersects the 2,000 m buffer of one record at the northern end of the survey area |

| TEC / PEC | Description | BC Act status* | EPBC Act status† | Record / buffer within survey area |
|-------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|------------------|----------------------------------------------------------------------------------------------------------|
| SCP02 - Southern wet shrublands, Swan Coastal Plain | This type occurs on Bassendean Dunes and the Pinjarra Plain in seasonally inundated areas and generally has a diverse and dense shrub layer. | Endangered | - | The survey area intersects the 500 m buffer of one record in the south-western corner of the survey area |
| FCT 21c – Low-lying <i>Banksia attenuata</i> woodlands or shrublands | This type occurs sporadically between Gingin and Bunbury and is largely restricted to the Bassendean system. The type tends to occupy lower lying wetter sites and is variously dominated by <i>Melaleuca preissiana</i> , <i>Banksia attenuata</i> , <i>B. menziesii</i> , <i>Regelia ciliata</i> , <i>Eucalyptus marginata</i> or <i>Corymbia calophylla</i> . Structurally, this community type may be either a woodland or occasionally shrubland. | Priority 3 | Endangered | The survey area intersects one record in the south-western portion of the survey area |
| SCP23b - Swan Coastal Plain <i>Banksia attenuata</i> - <i>Banksia menziesii</i> woodlands | These woodlands occur in the Bassendean system, from Melaleuca Park to Gingin. Occurs in reasonably extensive <i>Banksia</i> woodlands north of Perth. | Priority 3 | Endangered | The survey area intersects one record in the south-western portion of the survey area |

5.2.2.1 Commonwealth-listed Threatened ecological communities

The survey area intersects the buffers of numerous records and / or buffers of the *Banksia Woodlands of the Swan Coastal Plain Ecological Community*, which encompasses all *Banksia* woodland FCTs including those with state-listed conservation significance as well as those not currently listed at state level as conservation significant (Figure J). The *Banksia Woodlands of the Swan Coastal Plain Ecological Community* within the survey area, is represented by the two *Banksia* woodland vegetation units mapped and described for the survey area.

Multivariate analysis of the floristic data indicated the potential presence of the *Tumulus Springs (Organic Mound Springs Swan Coastal Plain) Ecological Community* (at sites PTAQ13, PTAQ20 and METQ07) within the wetlands of Whiteman Park. Val English from the DBCA visited these potential records in late 2018 and concluded that none of this wetland vegetation represented records of the TEC (Appendix G).

The buffer of one record of *Shrublands and woodlands on Muchea Limestone Ecological Community* intersects the very northern tip of the survey area but this community does not occur within the survey area.

Tumulus Springs (Organic Mound Springs Swan Coastal Plain) Ecological Community and *Banksia Woodlands of the Swan Coastal Plain Ecological Community* and their representation within the survey area are discussed in the following sections.

5.2.2.1.1 *Banksia* woodlands of the Swan Coastal Plain ecological community

The *Banksia* Woodland vegetation mapped for the survey area corresponds to the *Banksia Woodlands of the Swan Coastal Plain Ecological Community*. In order to qualify as a legitimate TEC record the *Banksia* vegetation within the survey area must satisfy the key diagnostic characteristics for the ecological community as set out in the Conservation Advice for the species (DEE 2016) in terms of its location and physical environment, soils and landform, structure and composition. It must:

- Occur within the SCP IBRA bioregion
- Occur on well-drained, low nutrient soils on deep Bassendean sands
- Have a distinctive upper sclerophyllous layer of low trees, dominated by *Banksia attenuata* (and/or *B. ilicifolia*), have an emergent tree layer (*Eucalyptus marginata*), have an understorey of a layer of sclerophyllous shrubs of various heights and a herbaceous ground layer of cord rushes, sedges and perennial and ephemeral forbs, that sometimes includes grasses.

Additionally, the vegetation must meet the minimum condition threshold of Good (adapted from Keighery 1994 and Trudgen 1988).

Finally, the vegetation must meet the minimum patch size thresholds (≥ 0.5 ha in Excellent condition; ≥ 1 ha in Very Good condition; or ≥ 2 ha in Good condition).

Two Banksia woodland units were described and mapped for the survey area. All the Banksia Woodland vegetation within the survey area meets the diagnostic characteristics for the TEC. Banksia woodland vegetation, encompassing the two mapped Banksia woodland vegetation units (Figures L-1 to L-5) within the survey area in Good or better condition (Figures M-1 to M-5) also meet the minimum condition and patch size thresholds for the TEC. There were however many areas of Banksia woodland that do not meet the minimum condition and patch size thresholds and therefore do not qualify for recognition as records of *Banksia Woodlands of the Swan Coastal Plain Ecological Community*.

Areas of Banksia woodland vegetation within the survey area which do satisfy the above criteria and therefore are representative of the *Banksia Woodlands of the Swan Coastal Plain Ecological Community* are mapped in Figure N.

5.2.2.1.2 Communities of tumulus springs (organic mound springs, Swan Coastal Plain)

The habitat of this community is characterised by continuous discharge of groundwater in raised areas of peat. The peat and surrounds provide a stable, permanently moist series of microhabitats. Intact vegetated tumulus springs are currently recorded from only four recorded locations on the SCP.

The heavy clay soils of the Guildford Formation on the eastern side of the SCP have been formed through the accumulation of deposits eroded from the hills of the Darling Range to the east. Between Bayswater and Muchea on the eastern extremities of the Bassendean Dune system, the tumulus springs historically occurred where the sands and clays meet. The Bassendean sands contain the large superficial aquifer known as the Gngangara Mound. This groundwater is forced to the surface at a series of discharge points on the eastern boundary of the aquifer where waters encounter the relatively impervious Guildford clays. Discharge areas form springs, bogs, and swamps (CALM 2006).

Historically, the tumulus springs were common within their narrow range. The swamps, lakes, dams and springs form a north - south line parallel to the Darling Scarp and corresponding to the junction between the Bassendean Sands and the Guildford Clays. The tumulus springs have typically been excavated to create farm dams or cleared and sealed with limestone to provide pasture for horses and cattle. The northern portion of the survey area lies within the buffer of a *Tumulus Springs (Organic Mound Springs Swan Coastal Plain) Ecological Community* record (Figure J).

RPS determined from the multivariate analysis of the floristic data that sites PTAQ13, PTAQ20 and METQ07 within the wetlands of Whiteman Park represented potential records of the EPBC-listed *Tumulus Springs (Organic Mound Springs Swan Coastal Plain) Ecological Community*. This determination was made based on the presence of species known to be common to, and an indicator of, the community type; the location of the sites (on the boundary of the Bassendean Dune and Pinjarra Plain systems); the sites' proximity to a known record of the community type; and the characteristic hydrology of the sites (wetlands maintained by an artesian spring).

In order to further investigate the potential presence of this TEC within the survey area, DBCA representative Val English visited the wetlands where the floristic sites were located and on closer inspection determined that none of the vegetation within the survey area represented this TEC. This was due to the absence of 'raised peat'. Confirmation of this is provided in the form of written correspondence from DBCA attached (Appendix G).

5.2.2.2 State-listed threatened and priority ecological communities

One state-significant communities was determined to be present within the survey area. its representation within the survey area is discussed below.

5.2.2.2.1 *Banksia* dominated woodlands of the Swan Coastal Plain IBRA region

Banksia dominated woodlands of the Swan Coastal Plain IBRA region is a state-listed Priority 3 PEC. It is characterised by a canopy most commonly dominated or co-dominated by *Banksia attenuata* and/or *B. menziesii*. This community typically occurs on well drained, low nutrient soils on sandplain landforms, particularly deep Bassendean and Spearwood sands and occasionally on Quindalup sands.

This PEC is synonymous with the nationally-listed *Banksia Woodlands of the Swan Coastal Plain Ecological Community* TEC and its extent within the survey area is shown in Figure N.

5.2.2.3 Other conservation significant ecological communities

5.2.2.3.1 *Eucalyptus rudis*/*Taxandria linearifolia* wetlands in Bassendean Dunes (FCTS17)

Eucalyptus rudis/*Taxandria linearifolia* wetlands in Bassendean Dunes (FCTS17) was determined to be present within the survey area via the multivariate analysis of the floristic data. It was represented by wetland sites PTAQ13, PTAQ20 and METQ07. This community type is considered 'rare' on the SCP (Keighery et al. 2012).

5.2.3 Maintenance of ecological processes and natural systems

The survey area consists predominantly of isolated pockets of intact native wetland and upland vegetation surrounded by highly modified and degraded tracts of cleared or modified land. *Australia's Biodiversity Conservation Strategy 2010-2030* (Natural Resource Management Ministerial Council (NRMMC) 2010) asserts the importance of promoting conservation across land tenures to ensure the survival of the small isolated remnants of vegetation that characterise much of the PMR portion of the SCP, to maintain ecological connectivity in the landscape, and to protect the biodiversity they maintain. Maintaining and restoring habitat connectivity is critical to ensuring species' resilience and to maintaining ecological processes and systems (NRMMC 2010).

The survey area intersects Regional Ecological Linkages as identified by Del Marco et al. (2004) at several locations (Figure F). These linkages provide connectivity between areas of refugial habitat for flora and fauna species to the north, south, east and west of the survey area and are integral to the maintenance of biodiversity within the region. These linkages happen to intersect with the areas within the survey area that have the highest conservation significance, for example, Bennett Brook and the wetlands identified as likely FCTS17 records within Whiteman Park.

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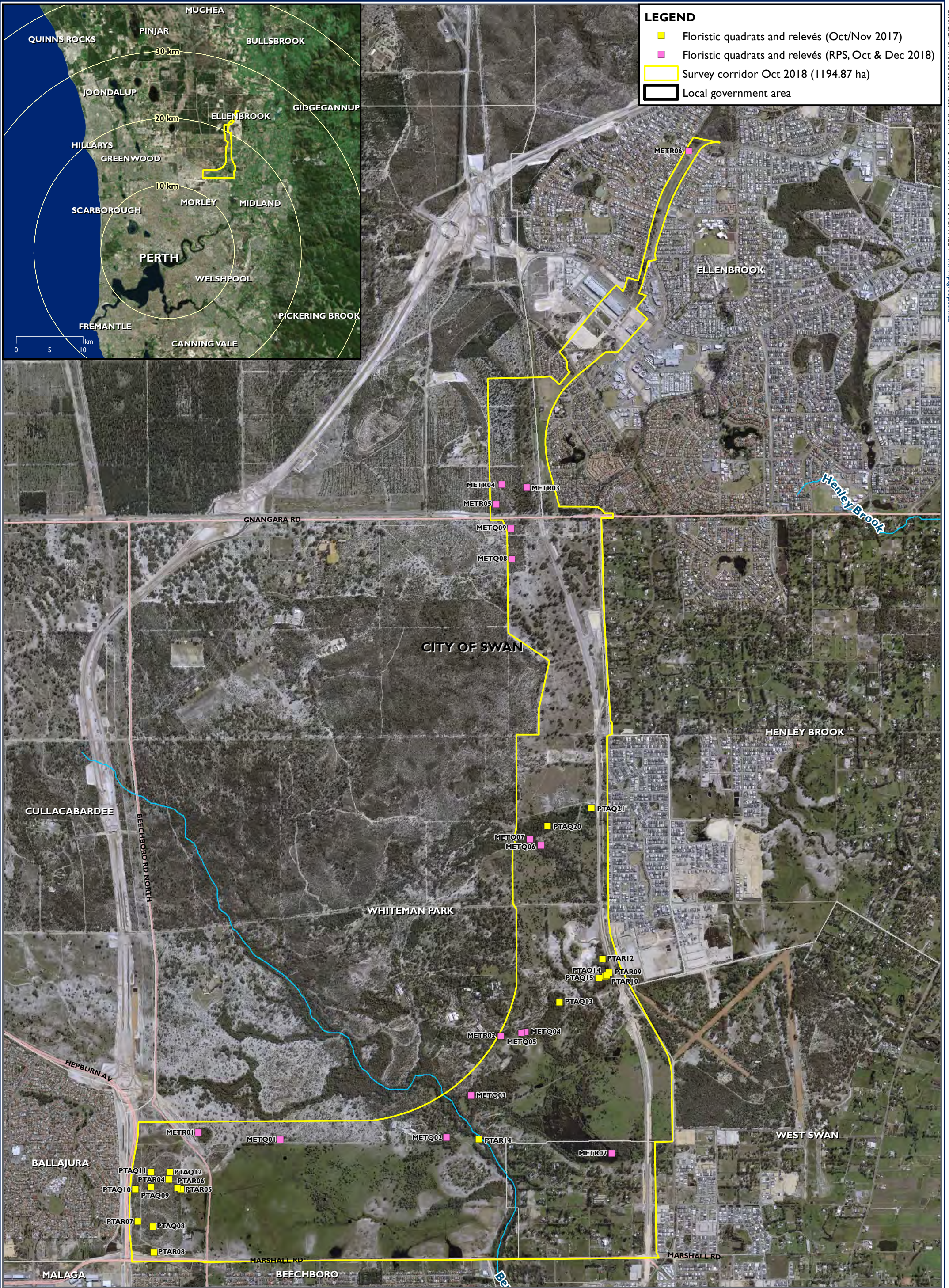
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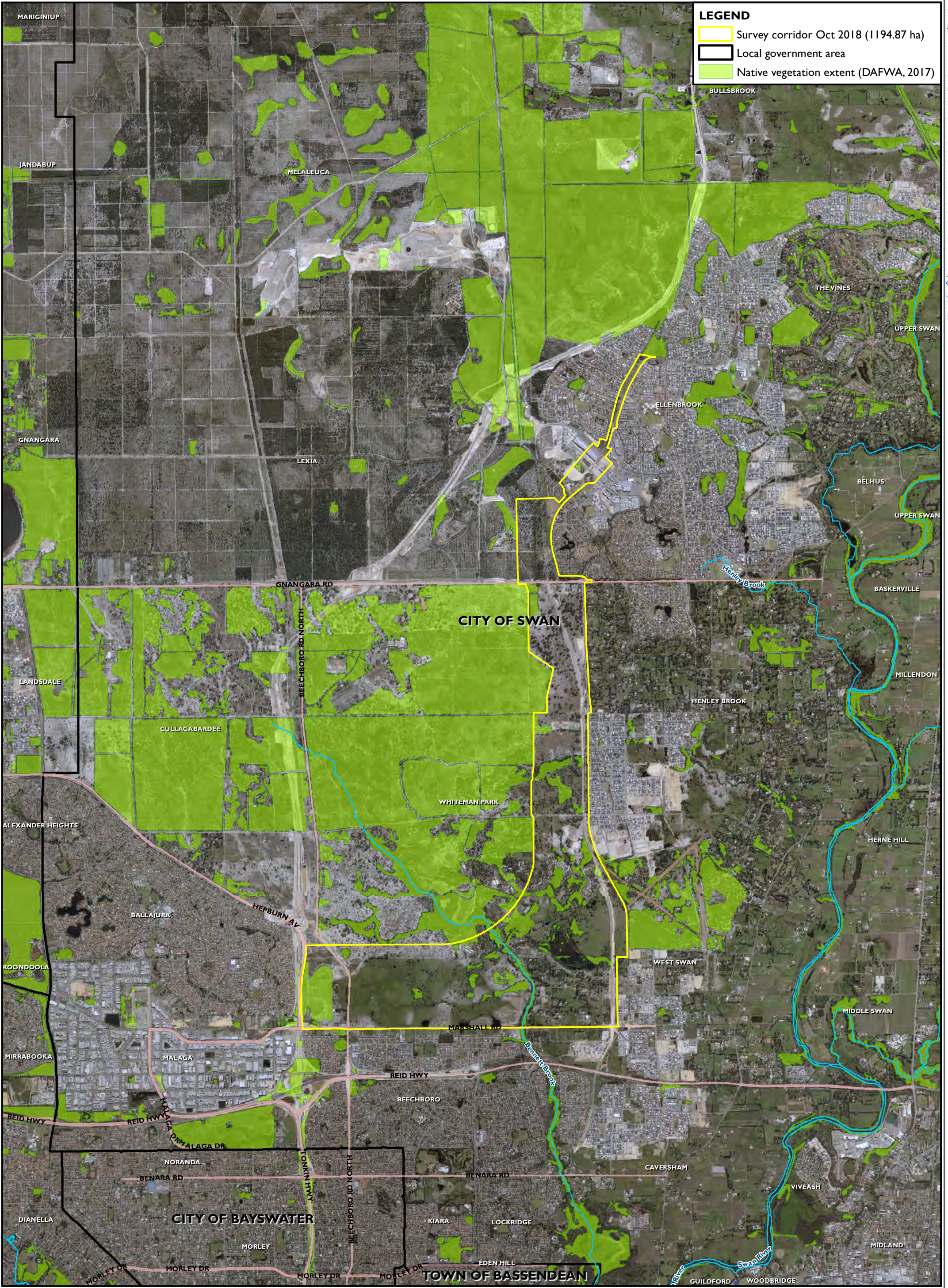
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FIGURES





LEGEND

- Survey corridor Oct 2018 (1194.87 ha)
- Local government area
- Native vegetation extent (DAFWA, 2017)

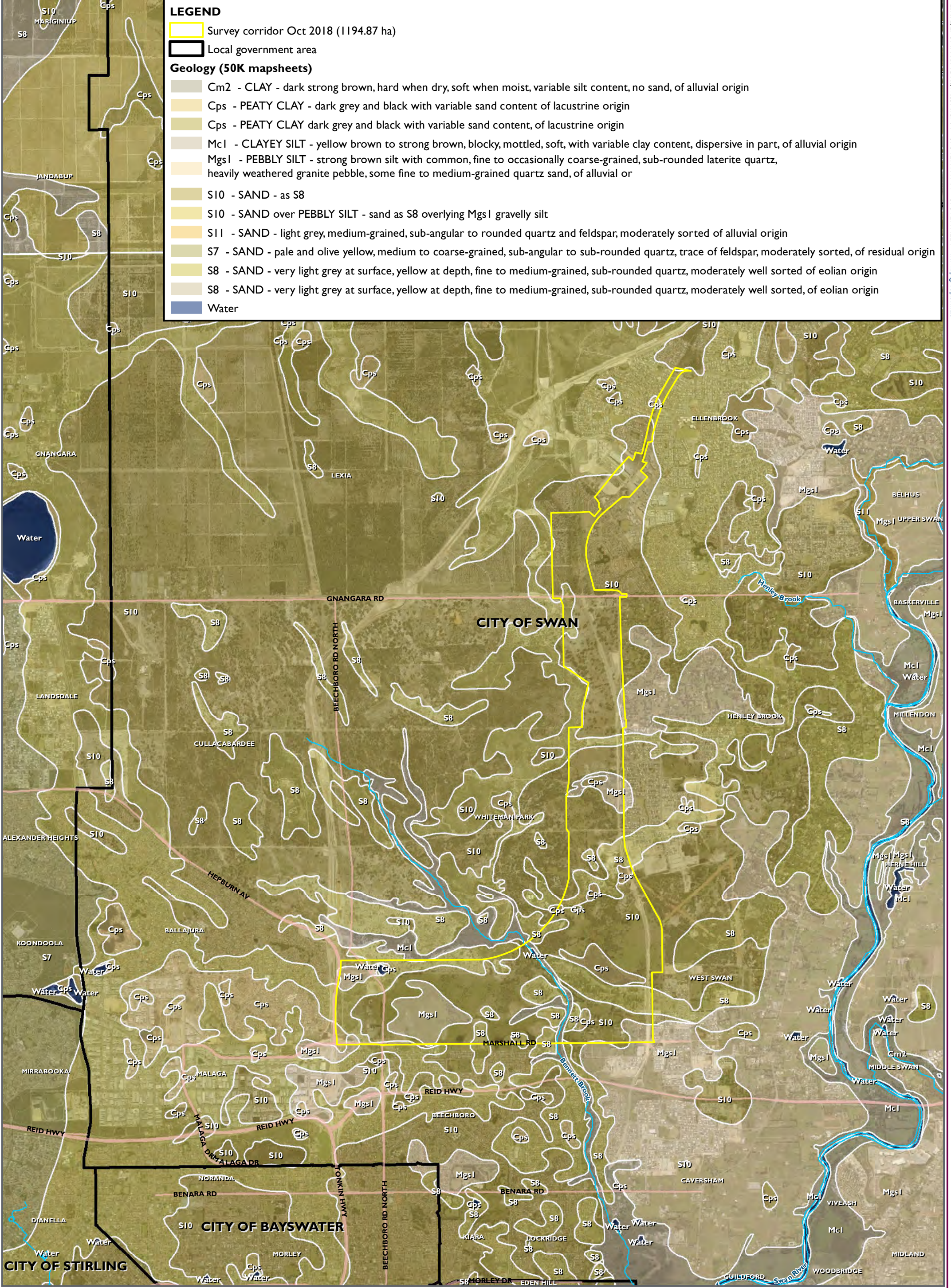


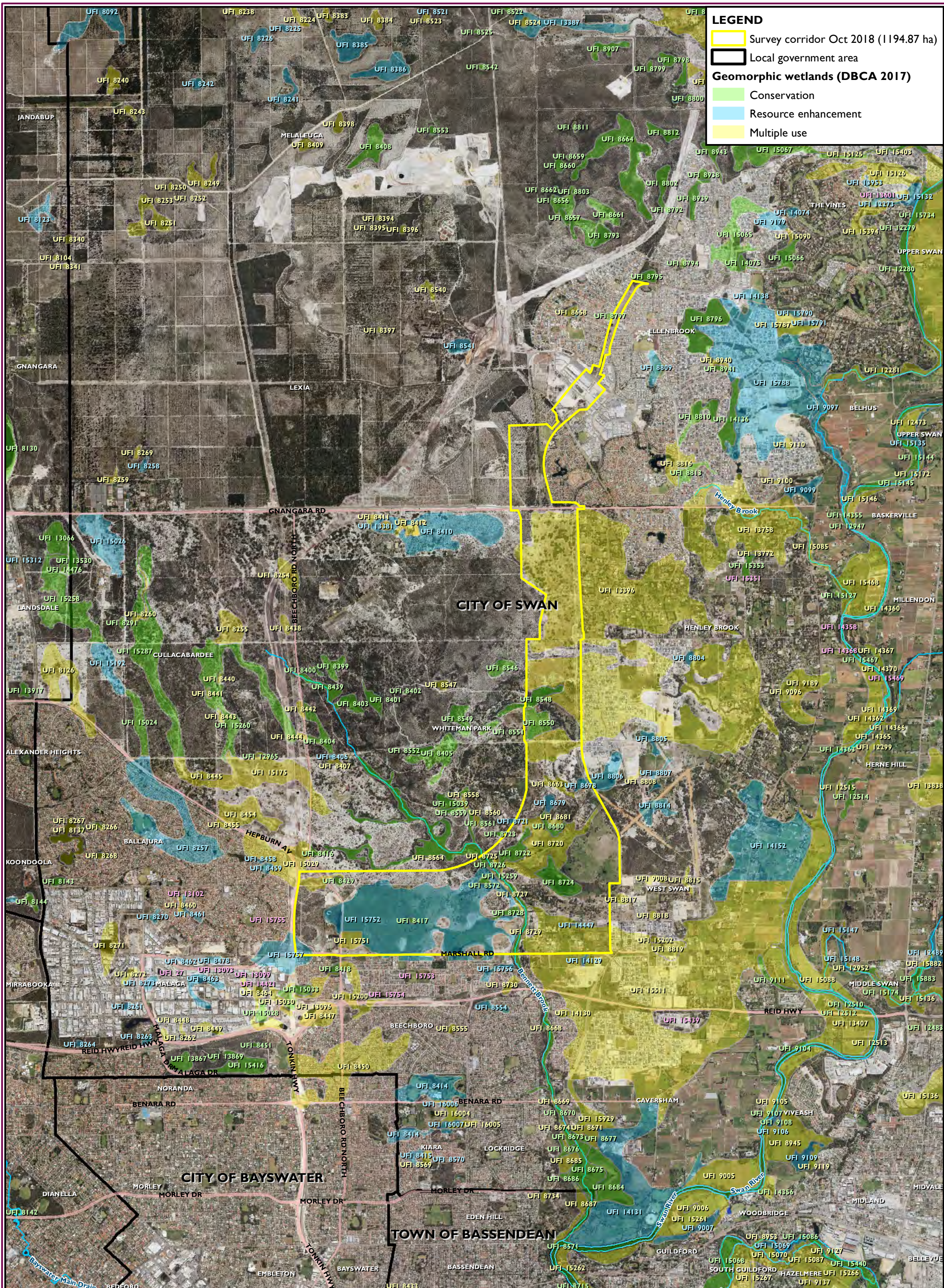
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Figure B

Native vegetation extent





LEGEND

- Survey corridor Oct 2018 (1194.87 ha)
- Local government area
- Geomorphic wetlands (DBCA 2017)**
 - Conservation
 - Resource enhancement
 - Multiple use

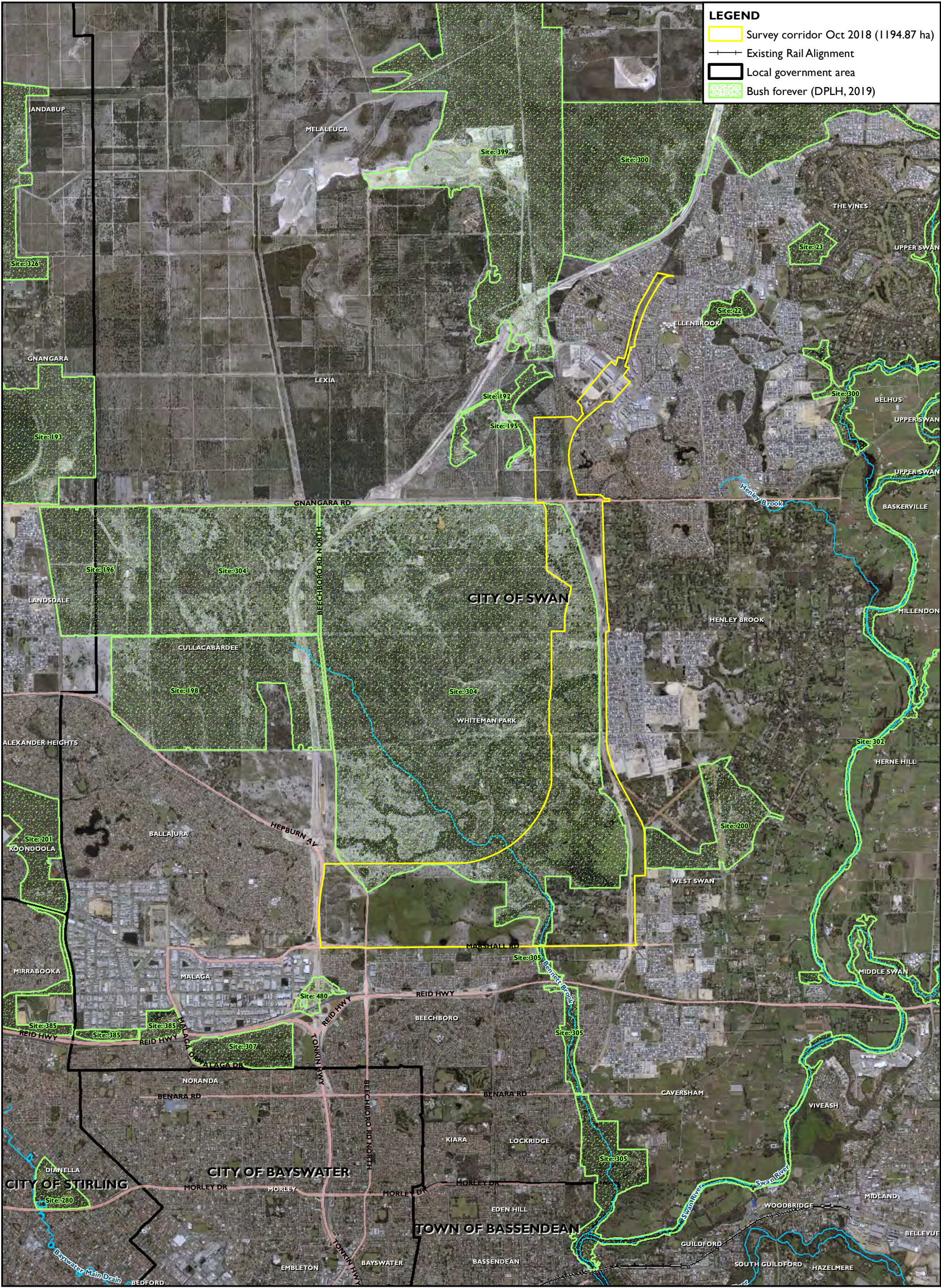


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Figure D

Geomorphic wetlands of the Swan Coastal Plain



LEGEND

- Survey corridor Oct 2018 (1194.87 ha)
- Existing Rail Alignment
- Local government area
- Bush forever (DPLH, 2019)

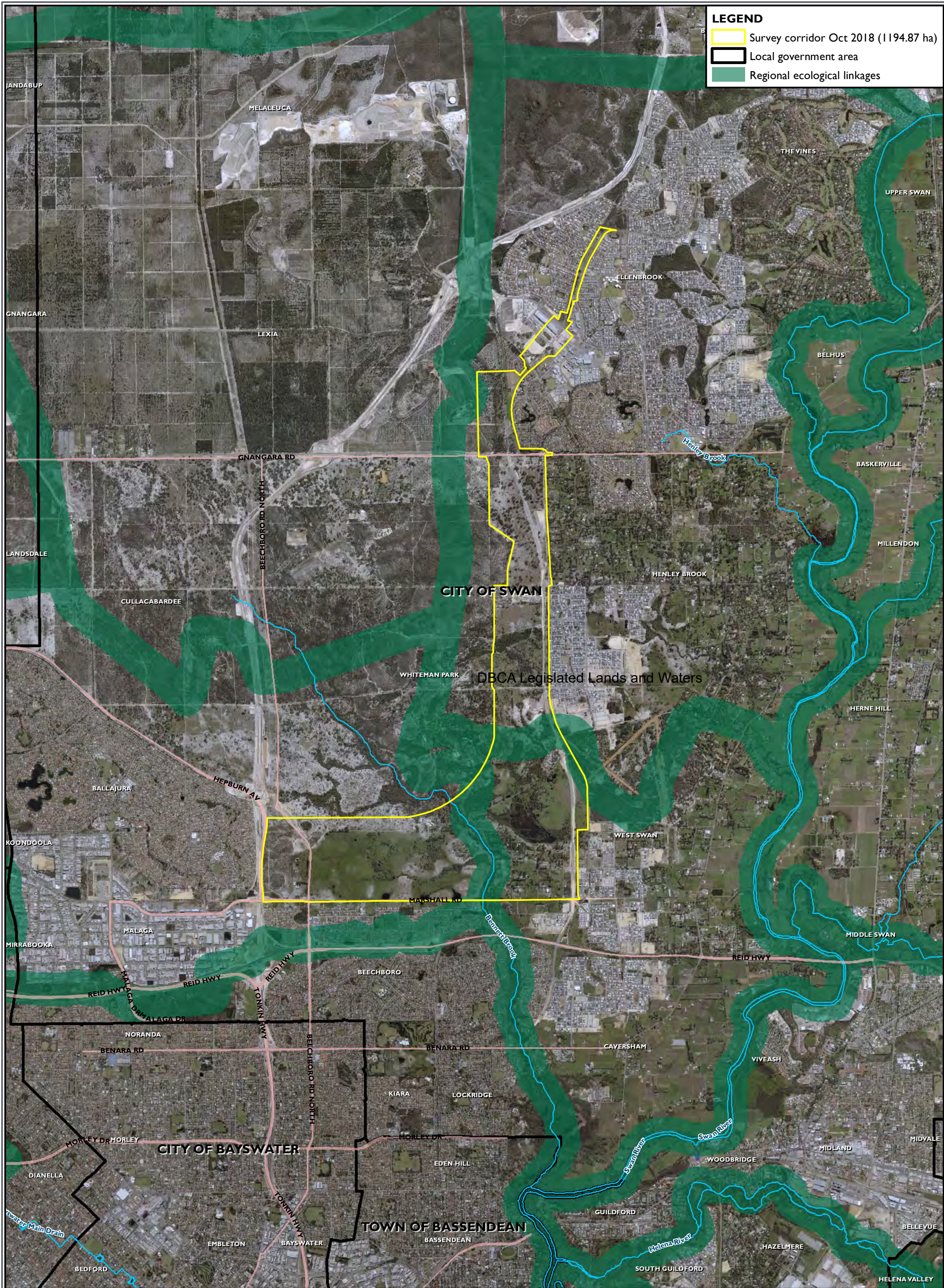


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Figure E

Bush forever sites



LEGEND

- Survey corridor Oct 2018 (1194.87 ha)
- Local government area
- Regional ecological linkages

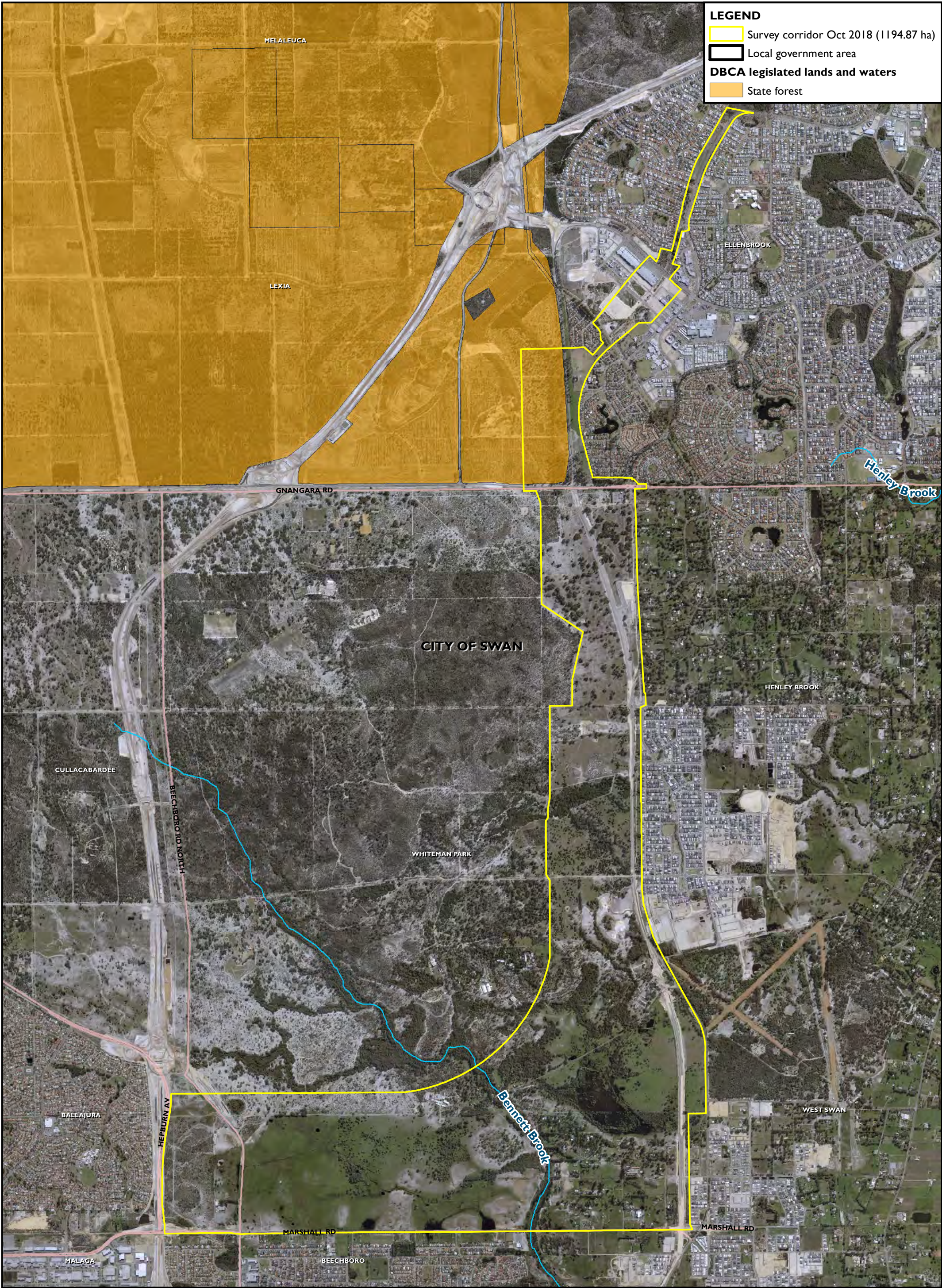
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Figure F
Regional ecological linkages



LEGEND

- Survey corridor Oct 2018 (1194.87 ha)
- Local government area
- DBCA legislated lands and waters**
- State forest



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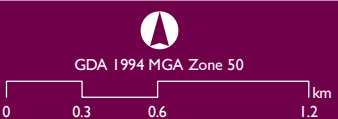


Figure G

DBCA Legislated lands and waters

Survey corridor Oct 2018 (1194.87 ha)

Local government area

Hedde vegetation complexes (Hedde et al. 1980)

Bassendean Complex-Central and South

Bassendean Complex-North

Bassendean Complex-North-Transition Vegetation Complex

Guildford Complex

Karrakatta Complex-Central and South

Pinjar Complex

Southern River Complex

Swan Complex

Yanga Complex

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GDA 1994 MGA Zone 50

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Figure H

Vegetation complex mapping

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