

Level 1 Flora and Vegetation Survey – Bussell Highway, Hutton Rd to Sabina River (32.10 – 43.92 SLK)



Prepared for Fulton Hogan
Services

January 2014

Ecoedge Environmental Pty Ltd
t: 61 8 97211377
PO Box 1180 Bunbury, 6231
Western Australia
enquiries@ecoedge.com.au
ABN: 89 136 929 989



Version	Purpose	Origin	Review	Review date	Ecoedge release approval	Issue date
v1		TB	R Smith	6 Dec 13		
v2		TB, RS	R Smith	9 Dec 13		
v3		TB, RS	R Smith, M Strang	10 Dec 13		
v4		TB, RS	M Strang	12 Dec 13		
v5		TB, RS	M Strang	13 Dec 13		
v6		TB, RS	M Strang	17 Dec 13		
Final Draft	Released for client review		N McCarthy	05 Feb 14	M Strang	31 Jan 14
Final	Released to client				M Strang	05 Feb 14

Executive Summary

Fulton Hogan on behalf of Main Roads WA engaged Ecoedge to conduct a Level 1 flora and vegetation assessment consistent with EPA Guidance Statement 51 “Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia” (EPA, 2004) over approximately 12 km of road reserve along Bussell Highway, between Hutton Road and Sabina River (32.10 – 43.92 SLK). Main Roads WA is conducting investigations as part of a plan to upgrade this section of the Bussell Highway to a dual carriageway by the construction of a second carriageway to the south of the existing road.

The field survey part of the flora and vegetation assessment was carried out on 22nd and 23rd October 2013, with a follow-up field visit on 19th December to identify species of *Verticordia* which had not been in flower at the time of the initial survey.

Two hundred and thirty seven plant species were identified within the Survey Area of which 52 were naturalised or planted species. Representation was highest amongst the Fabaceae with 34 taxa (including 11 introduced species) and Myrtaceae (30 taxa).

No Declared Rare Flora pursuant to subsection (2) of section 23F of the *Wildlife Conservation Act (1950)* or flora listed as Endangered pursuant to section 179 of the *Environmental Protection Biodiversity Conservation Act (1999)* were found in the Survey Area. Four Priority taxa as defined by the Department of Parks and Wildlife (DPaW, 2013i); *Eucalyptus rudis* subsp. *cratyantha* (P4), *Synaphea petiolaris* subsp. *simplex* (P2), *S. hians* (P3) and *Verticordia attenuata* (P3) were found within the Survey Area.

Nine vegetation units were recognised within the Survey Area, three of them mainly consisting of non-native species, another three of them being essentially wetland communities (Units B, G and H) with the remainder being woodlands on sandy soils. One of the latter, however, (Unit D) may include wetland plant species in damper areas. None of the vegetation units appears to constitute a Threatened Ecological Community. However, vegetation units G, H and D in particular have conservation value both because they contain Priority plant species and because of their unusual floristic composition. It is recommended that the areas of native vegetation within the survey area in Good or better condition (only 11% of the total area) should be protected where practicable.

The Survey Area is mapped as Southern River Complex, Abba (AF, Ad) and Ludlow (Lw) vegetation complexes (Hedde *et al.*, 1980, Matiske and Havel, 1998, Molloy *et al.*, 2007). All of these complexes are poorly reserved, with less than 5% of the pre-European Area in formal and informal conservation reserves.

Contents

Executive Summary.....	3
Statement of limitations	7
Reliance on Data	7
Report for Benefit of Client.....	7
1 Introduction	8
1.1 Objectives.....	8
1.2 Biogeographic region	9
1.3 Site location and features	9
1.4 Geology	9
1.5 Vegetation.....	13
1.6 Threatened and Priority Ecological Communities.....	16
1.7 Threatened and Priority Flora	17
1.8 Regional Ecological Linkages	27
2 Methods.....	29
3 Limitations.....	32
4 Results	33
4.1 Flora including Rare Flora	33
4.2 Vegetation Units	47
4.3 Vegetation Condition	55
5 Discussion.....	63
5.1 Rare Flora	63
5.2 Vegetation Units	63
5.3 Vegetation Unit B.....	63
5.4 Vegetation Unit C.....	63
5.5 Vegetation Unit D.....	64
5.6 Vegetation Unit E	65
5.7 Vegetation Unit G	65
5.8 Vegetation Unit H	65
5.9 Environmentally Sensitive Areas (ESAs).....	66
5.10 Conservation Status of Vegetation Complexes within the Survey Area	67
5.11 Recommendations	67
6 References	68
7 Appendix 1. Protected Matters Search Tool Report (attached)	74

8	Appendix 2. List of Vascular Flora Identified within the Survey Area.....	75
9	Appendix 3. Photographs of Vegetation Units	85

Table of Tables

Table 1.	Soil Mapping Units occurring within the Survey Area	13
Table 2.	Vegetation complexes within the Survey Area	15
Table 3.	Vegetation Complexes with regard to the EPA and Commonwealth retention targets (DEC 2007).	16
Table 4.	Ecological community data search information (DPaW 2013a, 2013b; SEWPaC 2013b).....	17
Table 5.	Definitions of Declared Rare and Priority List flora.....	18
Table 6.	Categories of Threatened Species under the <i>EPBC Act</i> (SEWPaC, 2013b).....	19
Table 7.	List of Declared Rare and Priority List flora known to occur within 10 km of the survey area.	26
Table 8.	Vegetation condition ratings according to the scale of Keighery (1994).....	30
Table 9.	Limitations with regard to assessment adequacy and accuracy.....	32
Table 10.	Locations of Priority Flora within the Survey Area.....	34
Table 11.	Areas of each of the Vegetation Units.	55
Table 12.	Areas and percentage totals of each vegetation condition rating.....	56

Table of Figures

Figure 1. Aerial Photograph showing location of Survey Area	11
Figure 2. Soil landscapes occurring within the Survey Area	12
Figure 3. Havel and Mattiske (2000) Vegetation complexes mapped as occurring within the Survey Area	14
Figure 4. The location of the regional ecological linkage axis lines passing directly through the Survey Area	28
Figure 5. Reference diagram of Survey Area sections.	31
Figure 6. Weed locations within the Survey Area Section 1	35
Figure 7. Weed locations within the Survey Area Section 2	36
Figure 8. Weed locations within the Survey Area Section 4	37
Figure 9. Weed locations within the Survey Area Section 6	38
Figure 10. Priority flora locations within the Survey Area Section 1	39
Figure 11. Priority flora locations within the Survey Area Section 2	40
Figure 12. Priority flora locations within the Survey Area Section 3	41
Figure 13. Priority flora locations within the Survey Area Section 4	42
Figure 14. Priority flora locations within the Survey Area Section 5	43
Figure 15. Priority flora locations within the Survey Area Section 6	44
Figure 16. <i>Eucalyptus rudis</i> subsp. <i>cratyantha</i> (P4)	45
Figure 17. <i>Synaphea petiolaris</i> subsp. <i>simplex</i> (P2)	46
Figure 18. <i>Synaphea hians</i> (P3)	46
Figure 19. <i>Verticordia attenuata</i> (P3)	47
Figure 20. Vegetation Units of Section 1 of the Survey Area	48
Figure 21. Vegetation Units of Section 2 of the Survey Area	49
Figure 22. Vegetation Units of Section 3 of the Survey Area	50
Figure 23. Vegetation Units of Section 4 of the Survey Area	51
Figure 24. Vegetation Units of Section 5 of the Survey Area	52
Figure 25. Vegetation Units of Section 6 of the Survey Area	53
Figure 26. Vegetation condition of Section 1 of the Survey Area	57
Figure 27. Vegetation condition of Section 2 of the Survey Area	58
Figure 28. Vegetation condition of Section 3 of the Survey Area	59
Figure 29. Vegetation condition of Section 4 of the Survey Area	60
Figure 30. Vegetation condition of Section 5 of the Survey Area	61
Figure 31. Vegetation condition of Section 6 of the Survey Area	62

Statement of limitations

Reliance on Data

In the preparation of this report, Ecoedge has relied on data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report. Unless stated otherwise in the report, Ecoedge has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report are based in whole or in part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Ecoedge will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, unavailable, misrepresented or otherwise not fully disclosed to Ecoedge.

Report for Benefit of Client

The report has been prepared for the benefit of the Client and for no other party. Ecoedge assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including, without limitation, matters arising from any negligent act or omission of Ecoedge or for any loss or damage suffered by any other party relying on the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions, and should make their own enquiries and obtain independent advice in relation to such matters.

1 Introduction

Ecoedge was engaged by Fulton Hogan Services in October 2013 to undertake a Level 1 flora and vegetation assessment over approximately 35 ha of remnant vegetation along Bussell Highway in the Shire of Capel and the City of Busselton. The survey was carried out as part of investigations into the proposed extension of the dual carriageway to the south of the current roadway.

The Survey Area was visited on 22nd and 23rd October and 19th December 2013 to carry out the assessment. The vegetation survey was undertaken in accordance with the Environmental Protection Authority (EPA) Guidance Statement 51, “Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia” (EPA, 2004).

This report compiles findings of the field survey.

1.1 Objectives

The scope and objectives of the flora survey for the study area were to carry out a Level 1 flora and vegetation assessment to determine whether there are any significant flora values within the Survey Area. The survey scope specified the following requirements:

- Conduct an assessment of flora and vegetation values within the study area;
- Conduct a review of other literature to summarise the values of flora and vegetation significance in the project area;
- Review the documented flora and vegetation of significance, based on Department of Parks and Wildlife (DPaW) records (databases);
- Conduct a field assessment to:
 - identify the vascular flora species present;
 - determine the presence or absence of Declared Rare Flora (DRF), Priority or Significant Species;
 - assess conservation significance of vegetation and flora;
 - define and spatially map vegetation condition;
 - define and spatially map vegetation communities; (achieved through the installation of a number of floristic relevés)
 - define and map threatened and priority ecological communities
 - a review of the local and regional significance of the plant communities in terms of their intrinsic value, extent and condition against Government of Western Australia (2013a).
 - Determine whether the Survey Area is within an Environmentally Sensitive Area (ESA)

1.2 Biogeographic region

The Survey Area is located within the Perth Coastal Plain (SWA2) sub-region of the Swan Coastal Plain Biogeographic region as defined in the Interim Biogeographical Regionalisation for Australia (IBRA) (Australian Government, 2009).

1.3 Site location and features

The Survey Area is situated approximately 6.0 km east of the Busselton town site on the Swan Coastal Plain (**Figure 1**). Elevation on site falls from 20 m above sea level (ASL) in the north-east to 10 m in the south west.

The Survey Area is located on Freehold land, crown land and public roads. According to the Shire of Busselton Town Planning Scheme 20, the Survey Area is currently zoned as Highway, adjacent to agriculture and recreation zones. Under the Shire of Capel Town Planning Scheme 7, the Survey Area is currently zoned as Primary Regional Road adjacent to rural and state forest zones.

1.4 Geology

The Survey Area is situated on the Swan Coastal Plain, which consists of a series of geomorphological elements which are sub-parallel to the present coastline (McArthur and Bettenay, 1960). Each of these geomorphic elements has distinctive geology, vegetation, topography and soils. The western portion of the Swan Coastal Plain is comprised of a series of three successive coastal dune systems representing the geological history of shoreline movement and aeolian deposition of marine particles. The dominant dune systems in the Swan Coastal Plain, from west to east, are Quindalup Dunes, Spearwood Dunes and Bassendean Dunes. In Busselton region (i.e. south of the Capel River), the Quindalup Dunes are adjoined in the east to the Ludlow Plains, which in turn are adjoined in the east and south by the Abba Plains. The Abba Plains are bounded in the east by the Blackwood Plateau (Tille and Lantzke, 1990).

Within the Swan Coastal Plain, the Survey Area is situated on soils of three different land form systems (**Figure 2**):

Abba System (213Ab): The Abba system is very flat, poorly drained and characterised by wet soils and semi-wet soils, pale deep sands, pale sandy earths and grey deep sandy duplexes (Hanran-Smith, 2002).

Spearwood Dune System (211Sp): The Spearwood Dunes are situated between the Quindalup Dunes and the Bassendean Dunes and are separated from the Bassendean Dunes by a line of swamps and lakes. The Spearwood Dune system is of aeolian origin and is comprised of red/brown, yellow and pale yellow/grey sands. It is characterised by limestone capped peaks and low dunes and swales of shallow pale grey sands over yellow sands (McArthur and Bettenay, 1960).

Bassendean System (212Bs): The Bassendean Dune System is the oldest of the aeolian deposits and consists of low hills of siliceous sand interspersed with poorly drained areas (McArthur and Bettenay, 1960).

Soil Mapping Units occurring within the Survey Area are presented in **Table 1**.

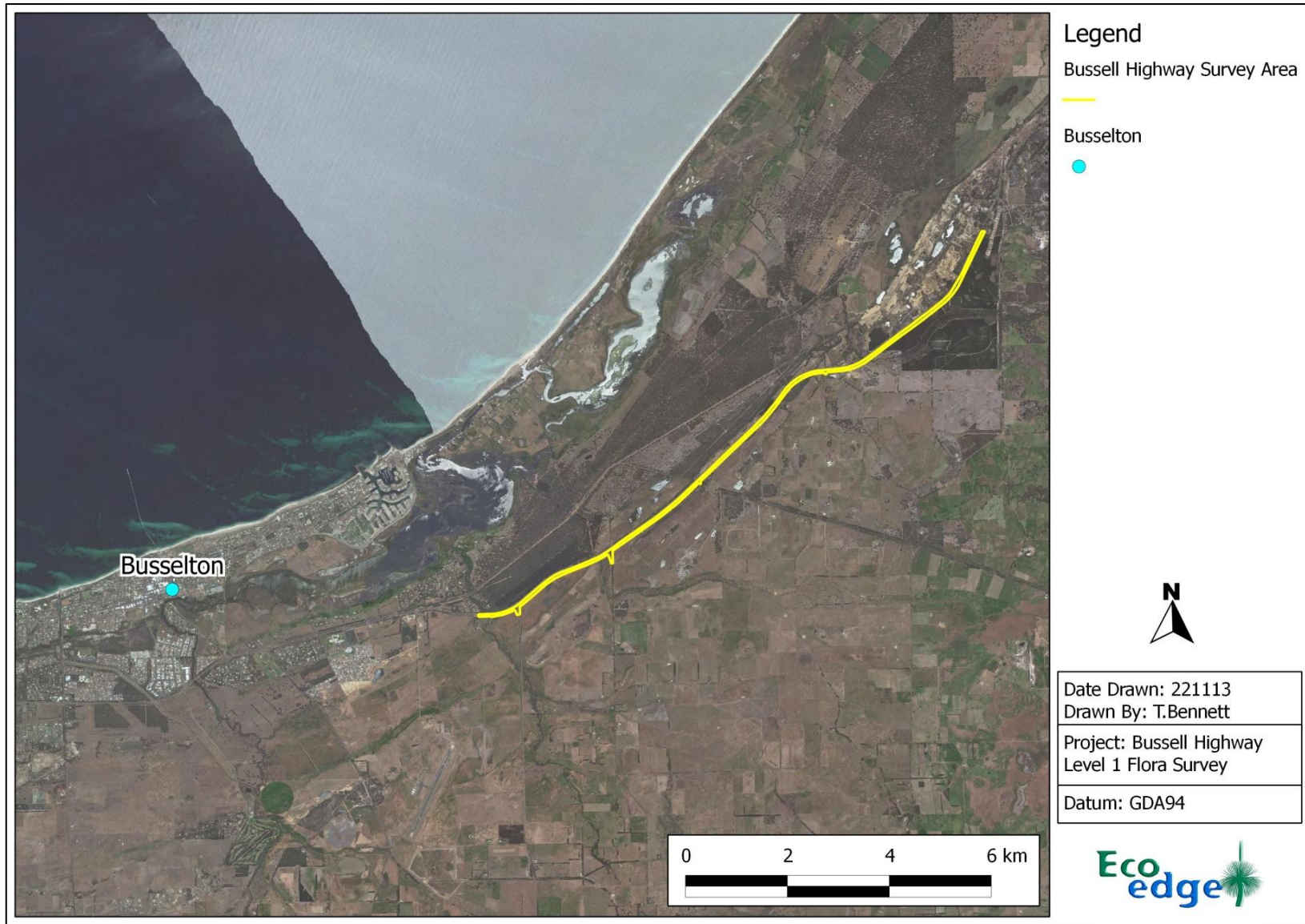


Figure 1. Aerial Photograph showing location of Survey Area

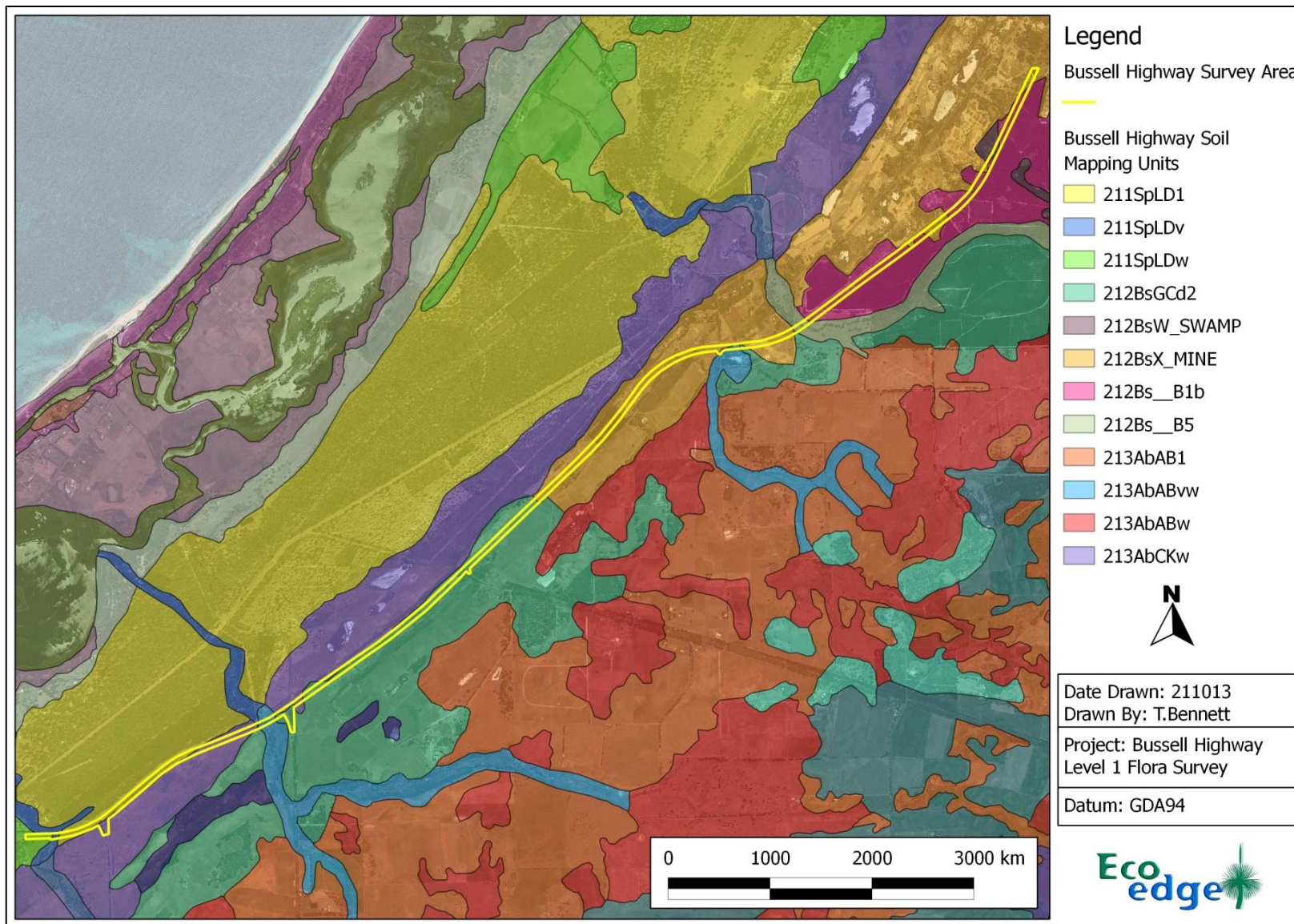


Figure 2. Soil landscapes occurring within the Survey Area

Soil Mapping Unit	Description
211SpLD1	Flats and very low dunes. Deep yellow brown siliceous sands over limestone (i.e. Spearwood Sands).
211SpLDV	Narrow floodplains in small depressions along creeks and rivers. Sandy alluvial soils.
211SpLDw	Flats with poor subsoil drainage in winter. Deep yellow brown siliceous sands over limestone (i.e. Spearwood Sands).
212BsGCd2	Gently sloping low dunes and rises (0-5% gradients) with deep bleached sands.
212BsW_SWAMP	Bassendean system swamp
212BsX_MINE	Mine. Disturbed land.
212Bs_B1b	Very low relief dunes of undulating sand plain with deep bleached grey sandy A2 horizons and pale yellow B horizons.
212Bs_B5	Shallowly incised stream channels of minor creeks and rivers with deep grey siliceous sands or bleached sands, underlain at depths generally greater than 1.5 m by clay or less frequently a strong iron-organic hardpan.
213AbBvw	Small narrow swampy depressions along drainage lines. Alluvial soils.
213AbCKw	Poorly drained flats with heavy clayey (Cokelup) soils. Some areas saline in summer.

Table 1. Soil Mapping Units occurring within the Survey Area

1.5 Vegetation

The Survey Area supports approximately 35 ha of remnant vegetation.

The South West Biodiversity Project Mapping and Information Installment 2 (Molloy *et al.*, 2007) provides a map of the vegetation complexes in the South West region. The WALGA mapping utilises the Regional Forest Agreement (RFA) mapping (Mattiske and Havel, 1998) as well as the Swan Coastal Plain (SCP) mapping (Hedde *et al.*, 1980).

Approximately 5.9 ha of remnant vegetation on site was mapped by Havel and Mattiske (2000) as Abba Complex and 9.8 ha as Ludlow Complex while the remaining 19.3 ha was mapped by Hedde *et al.* (1980) (outside of the area mapped by Havel and Mattiske) as Southern River Complex (**Figure 3, Table 2**).

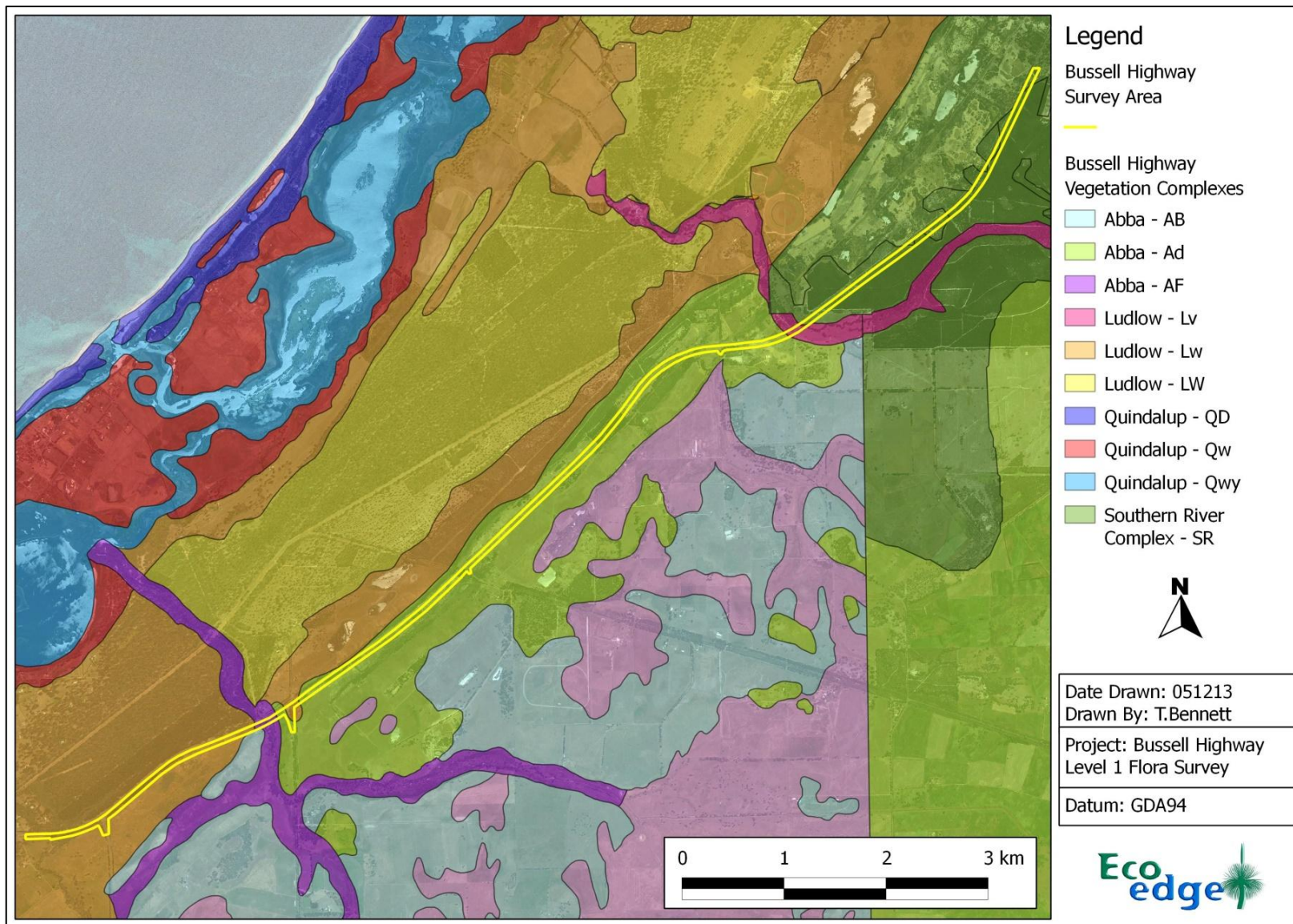


Figure 3. Havel and Mattiske (2000) Vegetation complexes mapped as occurring within the Survey Area

Vegetation Complex	Vegetation Complex Code	Description
Southern River Complex	SR	Open woodland of <i>Corymbia calophylla</i> - <i>Eucalyptus marginata</i> - <i>Banksia</i> spp. With fringing woodland of <i>Eucalyptus rudis</i> - <i>Melaleuca raphiophylla</i> along creek beds.
Abba	AB	Woodland and open forest of <i>Corymbia calophylla</i> on flats and low rises in the humid zone.
Abba	AF	Woodland of <i>Corymbia calophylla</i> - <i>Agonis flexuosa</i> and tall shrubland of Myrtaceae-Proteaceae species on terraces and valley floors in the humid zone.
Abba	Ad	Woodland of <i>Corymbia calophylla</i> - <i>Agonis flexuosa</i> - <i>Allocasuarina fraseriana</i> - <i>Nuytsia floribunda</i> on mild slopes in the humid zone.
Ludlow	Lv	Woodland of <i>Corymbia calophylla</i> , <i>Agonis flexuosa</i> , <i>Melaleuca raphiophylla</i> , <i>Melaleuca viminea</i> and <i>Eucalyptus rudis</i> . Typical understorey species include <i>Astartea fascicularis</i> , <i>Aotus gracillima</i> , <i>Pteridium esculentum</i> , <i>Xanthorrhoea brunonis</i> with sedge species <i>Juncus pallidus</i> , <i>Juncus kraussii</i> , <i>Lepidosperma longitudinale</i> , <i>Baumea vaginalis</i> and <i>Baumea juncea</i> .
Ludlow	Lw	Open woodland of <i>Melaleuca raphiophylla</i> and sedgelands of Cyperaceae-Restionaceae spp. on broad depressions in the subhumid zone.

Table 2. Vegetation complexes within the Survey Area

In 2001, the Commonwealth of Australia stated National Targets and Objectives for Biodiversity Conservation, which recognised that the retention of 30%, or more, of the pre-clearing extent of each ecological community was necessary if Australia's biological diversity was to be protected (Environment Australia, 2001). This level of recognition is in keeping with the targets set in the EPA's Position Statement on the 'Environmental protection of native vegetation in Western Australia: clearing of native vegetation, with particular reference to the agricultural area' (EPA, 2000). With regard to conservation status the EPA has set a target of 15% of pre-European extent for each ecological community to be protected in a comprehensive, adequate and representative reserve system (EPA, 2006).

Table 3 lists the percentage remaining of each vegetation complex and the percentage of each vegetation complex in formal and formal plus informal reserves. It lists whether each vegetation complex meets the Commonwealth's 30% target (Environment Australia, 2001) and the EPA's 15% target (EPA, 2006). It is evident in **Table 3** that none of the vegetation complexes present within the Study Area meets the Commonwealth's 30% target and the EPA's 15% target.

Vegetation Complex	% Remaining of pre-European	Is the 30% Target Met?	% in Formal Reserves	% in Formal + All Informal Reserves	Is the 15% Target Met?
Southern River - SR	18.9%	No	1.9%	1.9%	No
Abba – AB	4.6%	No	0.0%	0.0%	No
Abba – AF	11.2%	No	1.2%	1.2%	No
Abba – Ad	19.7%	No	0.1%	0.1%	No
Ludlow – Lv	19.6%	No	10.8%	10.8%	No
Ludlow - Lw	16.7%	No	4.3%	4.3%	No

Table 3. Vegetation Complexes with regard to the EPA and Commonwealth retention targets (DEC 2007).

1.6 Threatened and Priority Ecological Communities

Ecological communities are defined by Western Australia’s Department of Parks and Wildlife (DPaW, previously the Department of Environment and Conservation (DEC)) as “...naturally occurring biological assemblages that occur in a particular type of habitat. They are the sum of species within an ecosystem and, as a whole, they provide many of the processes which support specific ecosystems and provide ecological services.” (DEC, 2010a).

A threatened ecological community (TEC) is one which is found to fit into one of the following categories; ‘presumed totally destroyed’, ‘critically endangered’, ‘endangered’ or ‘vulnerable’ (DEC, 2010a). Possible threatened ecological communities that do not meet survey criteria are added to DPaW’s Priority Ecological Community Lists under Priorities 1, 2 and 3. Ecological Communities that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5 (DEC, 2010a). Threatened Ecological Communities can also be listed under the Environment Protection and Biodiversity Conservation Act (1999) (*EPBC Act*) (Department of Sustainability, Environment, Water, Population and Communities (SEWPaC, 2013a).

Results of a DPaW data search for threatened or priority ecological communities known to occur within 5 km of the Survey Area are presented in **Table 3** (DPaW, 2013a, 2013b, 2013c). Communities listed under the *EPBC Act* occurring within a 10 km radius of the Survey Area, as detailed in a Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) Protected Matters Search Tool query, are also noted ((SEWPaC, 2013b). The complete Protected Matters Search Tool results are included in **Appendix 1**.

Community Name	Community Description	Status (WA)	Status (EPBC Act)
Herb rich saline shrublands in clay pans - SCP07	Community occurs on heavy clay soils that are generally inundated from winter into mid-summer. This community is dominated by either <i>Melaleuca viminea</i> , <i>Melaleuca uncinata</i> , <i>Melaleuca cuticularis</i> or <i>Casuarina obesa</i> or a mixture of these species.	VU	CR
Herb rich shrublands in clay pans - SCP08	Situated on heavy soils, this community type is the clay pan communities which can be dominated by <i>Viminaria juncea</i> , <i>Melaleuca viminea</i> , <i>M. lateritia</i> or <i>M. uncinata</i> but also occasionally by <i>Eucalyptus wandoo</i> .	VU	CR
Dense shrublands on clay flats - SCP09	Shrublands or open woodlands of clay flats that are inundated for long periods.	VU	CR
Shrublands on dry clay flats SCP10a	Rapidly drying clay flats that generally have shallower microtopography than other clay pan community types or else have thin skeletal soils.	EN	CR
Shrublands on southern Swan Coastal Plain Ironstones (Busselton area) (10b)	Rapidly drying clay flats that occur on small areas of ironstone with thin skeletal soils in the Busselton Area.	CR	EN

Table 4. Ecological community data search information (DPaW 2013a, 2013b; SEWPaC 2013b).

1.7 Threatened and Priority Flora

Species of flora and fauna are defined as having Declared Rare (Threatened) or Priority conservation status where their populations are restricted geographically or threatened by local processes. The DEC recognises these threats of extinction and consequently applies regulations towards population and species protection.

Declared Rare (Threatened) Flora species are gazetted under Subsection 2 of Section 23F of the *Wildlife Conservation Act* (1950) (*WC Act*) and therefore it is an offence to 'take' or damage rare flora without Ministerial approval. Section 23F of the *WC Act* 1950-1980 defines 'to take' as "... to gather, pick, cut, pull up, destroy, dig up, remove or injure the flora or to cause or permit the same to be done by any means."

Priority Flora are under consideration for declaration as 'rare flora', but are in need of further survey (Priority One to Three) or require monitoring every 5-10 years (Priority Four). **Table 4** presents the categories of Declared Rare and Priority Flora as defined by the *WC Act* (DPaW 2013d).

Conservation code	Category
R	Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection and have been gazetted as such.
P1	Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
P2	Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
P3	Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora', but are in need of further survey.
P4	Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

Table 5. Definitions of Declared Rare and Priority List flora

Threats of extinction of species are also recognised at a Federal Government level and are categorised according to the *EPBC Act* (SEWPaC, 2013c). Under the *EPBC Act*, a species may be listed in one of six categories; the definitions of these categories are summarised in **Table 6**.

Threatened or Priority flora occurring within 3.5 km of the Survey Area generated from a DPaW data search (DPaW, 2013e) and a Naturemap data search (DPaW 2013f) are listed in **Table 6**. Taxa listed under the *EPBC Act* (based on results of the Protected Matters Search Tool query (SEWPaC, 2013b)) are listed in **Appendix 1**. Based on an assessment of their preferred habitats, not all of the species listed in **Table 6** would potentially occur within the Survey Area.

Category	Definition
Extinct (Ex)	A native species is eligible to be included in the extinct category at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
Extinct in the Wild (ExW)	A native species is eligible to be included in the extinct in the wild category at a particular time if, at that time (a) it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered (CE)	A native species is eligible to be included in the critically endangered category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered (E)	A native species is eligible to be included in the endangered category at a particular time if, at that time (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable (V)	A native species is eligible to be included in the vulnerable category at a particular time if, at that time (a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.
Conservation Dependent (CD)	A native species is eligible to be included in the conservation dependent category at a particular time if, at that time, the species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

Table 6. Categories of Threatened Species under the *EPBC Act* (SEWPaC, 2013b).

Species	WC Act Status (EPBC Act status in brackets)	Flowering	Habitat	Likelihood of occurrence
<i>Acacia benthamii</i>	P2	Aug - Sept	Sand. Typically on limestone breakaways.	Very Low
<i>Acacia flagelliformis</i>	P4	Jul - Sep	Sandy soils. Winter-wet areas.	Moderate
<i>Acacia semitrullata</i>	P4	May - Oct	White/grey sand, sometimes over laterite, clay. Sandplains, swampy areas.	Moderate
<i>Amperea micrantha</i>	P2	Oct - Nov	Sandy soils.	Moderate
<i>Andersonia ferricola</i>	P1	Oct	White sand or red-brown loam over ironstone. Seasonally wet flats.	Low
<i>Angianthus drummondii</i>	P3	Oct - Dec	Grey or brown clay soils, ironstone. Seasonally wet flats.	Low
<i>Aponogeton hexatepalus</i>	P4	Jul - Oct	Mud. Freshwater: ponds, rivers, claypans.	Low
<i>Banksia meisneri</i> subsp. <i>ascendens</i>	P4	Apr - Sep	White or grey sand. Swampy flats.	Low
<i>Banksia nivea</i> subsp. <i>uliginosa</i>	T (E)	Aug - Sep	Sandy clay, gravel.	Low
<i>Banksia squarrosa</i> subsp. <i>argillacea</i>	T (V)	Jun – Nov	White/grey sand, gravelly clay or loam. Winter-wet flats, clay flats.	Low
<i>Blennospora doliiformis</i>	P3	Oct - Nov	Grey or red clay soils over ironstone. Seasonally-wet flats.	Moderate
<i>Bolboschoenus medianus</i>	P1		Mud. In water and on river banks.	Moderate
<i>Boronia anceps</i>	P3	Sep – Dec or Jan	White sand, gravelly laterite. Seasonally swampy heaths.	Moderate

Species	WC Act Status (EPBC Act status in brackets)	Flowering	Habitat	Likelihood of occurrence
<i>Boronia humifusa</i>	P1	Jun or Sep	Gravelly clay loam over laterite. Jarrah - Marri open forest.	Low
<i>Boronia tetragona</i>	P3	Oct - Dec	Black/white sand, laterite, brown sandy loam. Winter-wet flats, swamps, open woodland.	Moderate
<i>Brachyscias verecundus</i>	T (CE)	Oct - Nov	In a moss sward. On a granite outcrop. Winter wet flats	
<i>Caladenia busselliana</i>	T (E)	Sep – Oct	Sandy loam. Winter-wet swamps	Moderate
<i>Caladenia huegelii</i>	T (E)	Sep - Oct	Grey or brown sand, clay loam.	Low
<i>Caladenia procera</i>	T (CE)	Sept – Oct	Rich clay loam, alluvial loamy flats, jarrah / marri / peppermint woodland, dense heath, sedges.	Moderate
<i>Caladenia speciosa</i>	P4	Sep - Oct	White, grey or black sand.	Moderate
<i>Calectasia cyanea</i>	T (CE)	Jun - Oct	White, grey or yellow sand, gravel.	None
<i>Caloathamnus quadrifidus</i> subsp. <i>teretifolius</i>	P4	Nov – Dec		Low
<i>Calytrix</i> sp. Tutunup	P2	Oct	Yellow-grey clayey loam, red clayey loam, laterite, ironstone. Slopes and flats, winter-wet areas, grazed paddocks.	Low
<i>Cardamine paucijuga</i>	P2	Sep - Oct	In moist to dry habitats.	High
<i>Centrolepis caespitosa</i>	P4		White sand, clay. Salt flats, wet areas.	Moderate
<i>Chamaescilla gibsonii</i>	P3	Sep	Clay to sandy clay. Winter-wet flats, shallow water-filled claypans.	High

Species	WC Act Status (EPBC Act status in brackets)	Flowering	Habitat	Likelihood of occurrence
<i>Chamelaucium</i> sp. C Coastal Plain	T (V)	Oct – Dec		Moderate
<i>Chamelaucium</i> sp. Yoongarillup	P4	Jul - Oct	Loams, damp sandy loams. Jarrah, Marri forest.	Very Low
<i>Chordifex gracilior</i>	P3	Sep – Dec	Peaty sand. Swamps.	Low
<i>Chorizema carinatum</i>	P3	Oct - Dec	Sand, sandy clay.	Low
<i>Conospermum paniculatum</i>	P3	Jul – Nov	Sandy or clayey soils. Swampy areas, plains, slopes.	Low
<i>Darwinia whicherensis</i>	T (E)	Oct - Nov		Low
<i>Diuris drummondii</i>	T (V)	Nov - Jan	Low-lying depressions, swamps.	Moderate
<i>Drakaea elastica</i>	T (E)	Oct - Nov	White or grey sand. Low-lying situations adjoining winter-wet swamps.	Moderate
<i>Eryngium</i> sp. Ferox	P3	Nov	Grey to brown loamy to sandy clay, brown cracking clay. Winter-wet flats, swamps, dried claypans, ridges.	Moderate
<i>Eryngium</i> sp. Subdecumbens	P3	Nov	Grey to brown loamy to sandy clay, brown cracking clay. Winter-wet flats, swamps, dried claypans, ridges.	Moderate
<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>	P4	Jul - Sep	Loam. Flats, hillsides.	High
<i>Franklandia triaristata</i>	P4	Aug - Oct	White or grey sand.	Low
<i>Gastrolobium</i> sp. Yoongarillup	P1	Aug - Oct	Jarrah-Marri forest, white sand, gravel	Low
<i>Grevillea brachystylis</i> subsp. <i>brachystylis</i>	P3	Aug – Nov	Black sand, sandy clay. Swampy situations.	Low
<i>Grevillea bronwenae</i>	P3	Jun - Dec	Grey sand over laterite, lateritic loam. Hillslopes.	Low

Species	WC Act Status (EPBC Act status in brackets)	Flowering	Habitat	Likelihood of occurrence
<i>Grevillea elongata</i>	T (V)	Oct	Gravelly clay, sandy clay, sand. Road verges, swamps, creek banks.	Low
<i>Grevillea maccutcheonii</i>	T (E)	Mar or May or Dec	Shallow soils over laterite, clay. Seasonally inundated sites.	Low
<i>Hakea oldfieldii</i>	P3	Aug – Oct	Red clay or sand over laterite. Seasonally wet flats.	Low
<i>Isopogon formosus</i> subsp. <i>dasylepis</i>	P3	Jun – Dec	Sand, sandy clay, gravelly sandy soils over laterite. Often swampy areas.	Low
<i>Jacksonia gracillima</i>	P3	Oct - Nov		Moderate
<i>Johnsonia inconspicua</i>	P3	Oct – Nov	White-grey or black sand. Low dunes, winter-wet flats.	Moderate
<i>Kennedia lateritia</i>	T (E)	Oct		Low
<i>Lambertia echinata</i> subsp. <i>occidentalis</i>	T (E)	Feb or Apr or Dec	White sandy soils over laterite, orange/brown-red clay over ironstone.	Low
<i>Lambertia orbifolia</i> subsp. <i>Scott River Plains</i>	T (E)	Oct - Jan	Yellow-brown sandy clay, grey sand, sandy gravel, laterite.	Low
<i>Lasiopetalum membranaceum</i>	P3	Sep - Dec	Sand over limestone.	Low
<i>Laxmannia jamesii</i>	P4	May-Jul	Grey sand. Winter-wet locations.	Low
<i>Leucopogon</i> sp. Busselton	P2	Aug - Sep	<i>Pericalymma ellipticum</i> wet shrubland, Marri-Jarrah woodland.	Low
<i>Lepyrodia heleocharoides</i>	P3	Dec	Moist peaty sand. Dry or seasonally inundated heath or woodland, swamps.	Low
<i>Loxocarya magna</i>	P3	Sep – Nov	Sand, loam, clay, ironstone. Seasonally inundated or damp habitats.	Low

Species	WC Act Status (EPBC Act status in brackets)	Flowering	Habitat	Likelihood of occurrence
<i>Meeboldina thysanantha</i>	P3	Dec	Sand. Swamps.	Low
<i>Meionectes tenuifolia</i>	P3			Low
<i>Adelphacme minima</i>	P3	Oct - Dec	Grey sand. Peaty swampy areas.	Moderate
<i>Montia australasica</i>	P2		Melaleuca woodland	Moderate
<i>Myriophyllum echinatum</i>	P3	Nov	Clay. Winter-wet flats.	Low
<i>Ornduffia submersa</i>	P4	Sep – Oct		Low
<i>Petrophile latericola</i>	T (E)	Nov	Red lateritic clay. Winter-wet flats.	Low
<i>Pimelea ciliata</i> subsp. <i>longituba</i>	P3	Oct-Dec	Grey sand over clay, loam.	Low
<i>Puccinellia vassica</i>	P1	Sep - Nov	Saline soils. On the outer margins of coastal saltmarshes	Low
<i>Pultenaea pinifolia</i>	P3	Oct-Nov	Loam or clay. Floodplains, swampy areas.	Low
<i>Schoenus benthamii</i>	P3	Oct - Nov	White, grey sand, sandy clay. Winter-wet flats, swamps.	Moderate
<i>Schoenus loliaceus</i>	P2	Aug - Nov	Sandy soils. Winter-wet depressions.	Moderate
<i>Schoenus natans</i>	P4	Oct	Winter-wet depressions.	Moderate
<i>Schoenus pennisetis</i>	P1	Aug - Sep	Grey or peaty sand, sandy clay. Swamps, winter-wet depressions.	Moderate
<i>Stylidium longitubum</i>	P3	Oct - Dec	Sandy clay, clay. Seasonal wetlands.	Low
<i>Stylidium squamellosum</i>	P2	Oct - Nov	Brown to red-brown clay loam. Winter-wet habitats and depressions, open woodland, shrubland.	Low
<i>Stylidium striatum</i>	P4	Oct - Nov	Brown clay loam over laterite. Hillslopes. Jarrah/Marri forest, Wandoo woodland.	Low

Species	WC Act Status (EPBC Act status in brackets)	Flowering	Habitat	Likelihood of occurrence
<i>Synaphea hians</i>	P3	Jul – Nov	Sandy soils. Rises.	High
<i>Synaphea petiolaris</i> subsp. <i>simplex</i>	P2	Sep – Oct	Sandy soils. Flats, winter-wet areas.	High
<i>Tetraria australiensis</i>	T (V)	Nov - Dec		Low
<i>Tetradlea parvifolia</i>	P3	Oct	Jarrah, woodland, wandoo woodland, gravelly soils.	Low
<i>Thelymitra variegata</i>	P3	Jun - Sep	Sandy clay, sand, laterite.	Low
<i>Thomasia laxiflora</i>	P3	Oct – Nov	Gravelly soils.	Low
<i>Thysanotus glaucus</i>	P4	Oct - Mar	White, grey or yellow sand, sandy gravel.	Moderate
<i>Trichocline</i> sp. Treeton	P2	Nov - Jan	Sand over limestone, sandy clay over ironstone. Seasonally wet flats.	Moderate
<i>Tripterococcus brachylobus</i>	P4	Nov – Dec or Feb	Grey sand, red clay, laterite, often moist. Low-lying flats.	Moderate
<i>Tripterococcus paniculatus</i>	P4	Oct - Nov	Grey, black or peaty sand. Winter-wet flats.	Moderate
<i>Verticordia attenuata</i>	P3	Dec - May	White or grey sand. Winter-wet depressions	High
<i>Verticordia densiflora</i> var. <i>pedunculata</i>	T (E)	Dec - Jan	Grey/yellow sand, sandy loam. Winter-wet low-lying areas.	Moderate
<i>Verticordia lehmannii</i>	P4	Jan or Apr – Aug or Dec	Sandy clay. Winter-wet flats.	Moderate
<i>Verticordia lindleyi</i> subsp. <i>lindleyi</i>	P4	May or Nov – Dec or Jan	Sand, sandy clay. Winter-wet depressions.	Moderate
<i>Verticordia plumosa</i> var. <i>ananeotes</i>	T (E)	Nov – Dec	Sandy loam. Seasonally inundated plains.	Moderate

Species	WC Act Status (EPBC Act status in brackets)	Flowering	Habitat	Likelihood of occurrence
<i>Verticordia plumosa</i> var. <i>vassensis</i>	T (E)	Sep - Feb	White/grey sand. Winter-wet flats.	High

Table 7. List of Declared Rare and Priority List flora known to occur within 10 km of the survey area.

Some of the species listed in **Table 7** could potentially occur within the survey area, based on an assessment of their preferred habitats. All would have either been flowering at the time of survey or could be identified in the field without flowers at the time of the survey.

1.8 Regional Ecological Linkages

Ecological linkages were defined in Molloy *et al.* (2009) in their report on the South West Regional Ecological Linkages (SWREL) Project as;

“A series of (both contiguous and non-contiguous) patches which, by virtue of their proximity to each other, act as stepping stones of habitat which facilitate the maintenance of ecological processes and the movement of organisms within, and across, a landscape.”

The Molloy *et al.* (2009) report is the result of collaboration between the Western Australian Local Government Association’s *South West Biodiversity Project* and the DEC’s *Swan Bioplan* to provide a tool for the identification of ecological linkages and guidance for the protection of linkages through planning policy documents.

It is stressed in the above report, however, that the proximity value of an ecological linkage is not intended to replace the need to consider the other biodiversity conservation values of a patch of remnant vegetation. Regional Ecological Linkages link protected patches of regional significance by retaining the best (condition) patches available as stepping stones for flora and fauna between regionally significant areas. This increases the long-term viability of all the constituent areas (Molloy *et al.*, 2009).

The *South West Regional Ecological Linkages Technical Report* (Molloy *et al.*, 2009) identifies two regional ecological linkage axis lines passing through the Study Area. As a result of the location of these, different patches of remnant vegetation within the Study Area are assigned to proximity categories ‘1a’, ‘1b’, ‘1c’, ‘2a’, ‘2b’ and ‘2c’ which are the highest to sixth highest categories (**Figure 4**). This means that a small portion of the vegetation within the Survey Area directly forms part of an identified regional ecological linkage while the majority is within varying degrees of proximity to those linkages.

While there is no statutory basis for regional ecological linkages identified through the SWREL project, the importance of ecological linkages have been recognised as an environmental policy consideration in EPA and Planning policy over the last decade (EPA, 2009 and references therein). In its statement regarding the SWREL Project, the EPA stated that even though Ecological Linkages are just one measure of the conservation values of a patch of remnant vegetation it expected that:

In preparing plans and proposals for development, consideration will be given to both the site-specific biodiversity conservation values of patches of native vegetation, as well as the landscape function and core linkage significance of a patch in supporting the maintenance of ecological linkage (EPA, 2009).

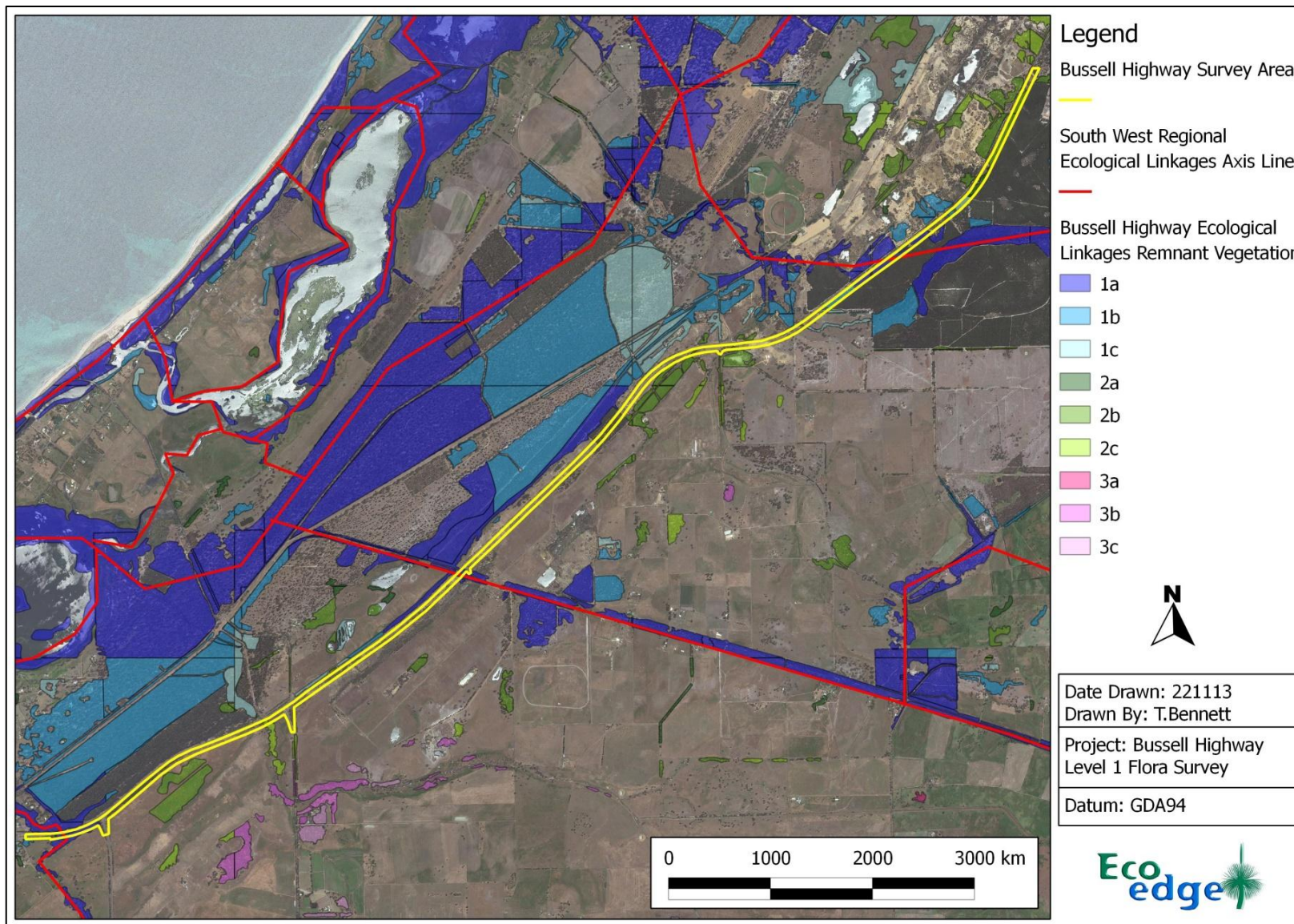


Figure 4. The location of the regional ecological linkage axis lines passing directly through the Survey Area.

2 Methods

The field survey part of the flora and vegetation assessment was carried out on 22nd and 23rd October 2013, consistent with the requirements of EPA (2004). Another field visit was made on 19th December 2013 to identify species of *Verticordia* which had not been in flower at the time of the initial survey. The Survey Area was searched using the random meander method as described in Cropper (1993).

A comprehensive list of native and introduced species was compiled. Species composition, vegetation structure and vegetation condition notes were compiled at 50 unmarked relevés within the Survey Area to be used, along with aerial photography, in mapping vegetation type and condition. Flora species that were not identified in the field were collected or photographed for later identification. Taxonomy and conservation status of flora species was checked against Department of Parks and Wildlife databases (DPaW, 2013g; DPaW 2013h).

Vegetation condition was assessed according to the scale of Keighery (1994) (**Table 8**).

Score	Description
Pristine (1)	Pristine or nearly so, no obvious signs of disturbance.
Excellent (2)	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good (3)	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good (4)	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded (5)	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded (6)	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Table 8. Vegetation condition ratings according to the scale of Keighery (1994).

As the Survey Area is long and narrow. To enable interpretation of field data in map format, it has been divided up into six sections, as shown in **Figure 5**.

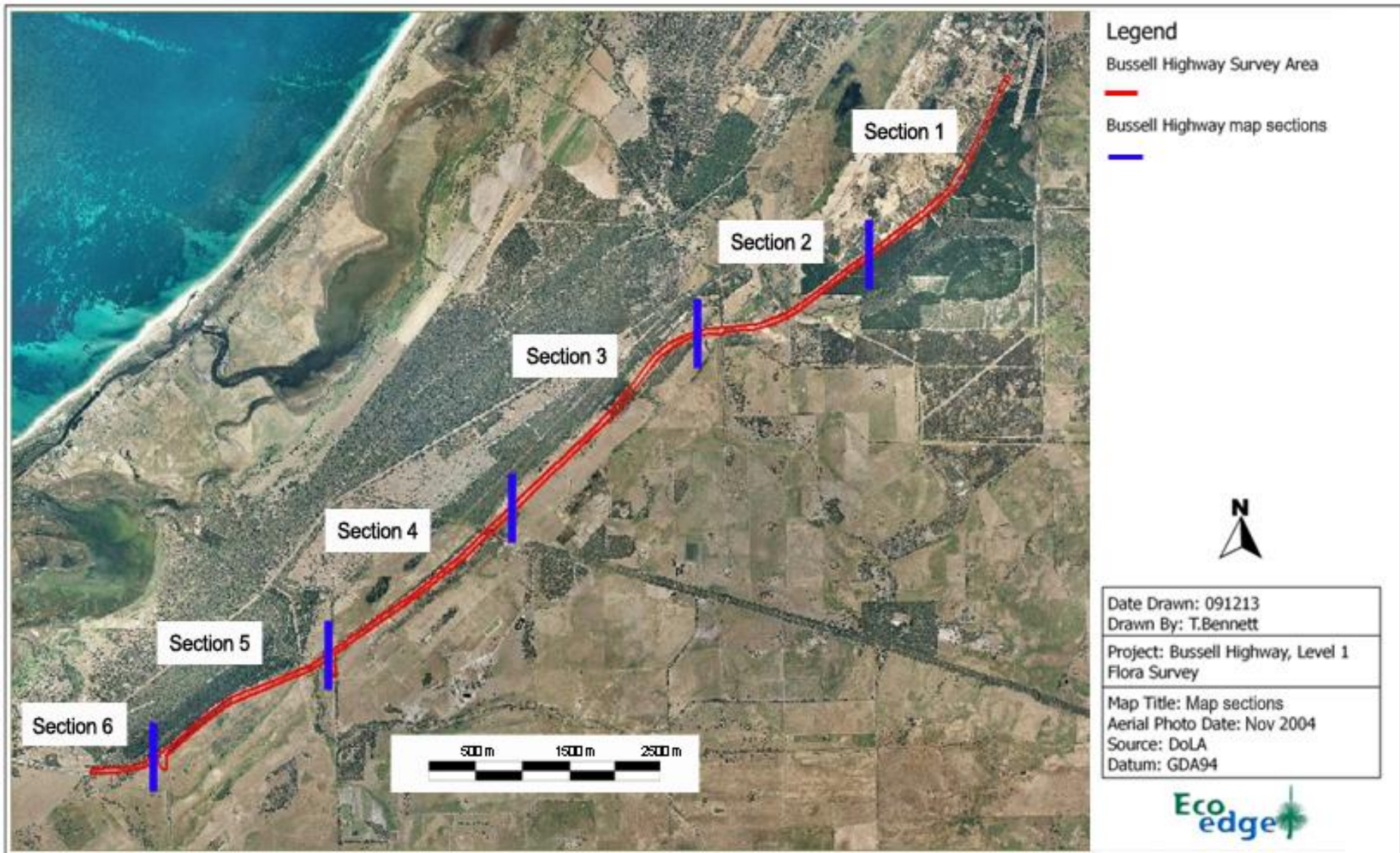


Figure 5. Reference diagram of Survey Area sections.

3 Limitations

Potential limitations with regard to the assessment are addressed in **Table 9**.

Aspect	Constraint	Comment
Scope	No	The survey scope was prepared in consultation with the stakeholders and was designed to comply with EPA requirements.
Proportion of flora identified	Negligible	The main survey was carried out late October - a time which experience has shown to be the prime flowering time for flora on the southern Swan Coastal Plain and Whicher Scarp. It is estimated that 90-95% of species in the remnant vegetation were identified.
Availability of contextual information	Minor	Comprehensive regional surveys of remnant vegetation, as well as more localised surveys, have been carried out on the Swan Coastal Plain.
Completeness of the survey	Negligible	Vegetation within the study area was thoroughly search on foot. Further assessments outside the spring season would add to the completeness of the species list but probably only marginally affect the conclusions presented.
Skill and knowledge of the botanists	Negligible	The senior field botanist conducting the survey has had extensive experience in botanical survey in south west Australia over a period of 25 years.

Table 9. Limitations with regard to assessment adequacy and accuracy.

4 Results

4.1 Flora including Rare Flora

Two hundred and thirty seven plant species were identified within the Survey Area of which 52 were naturalised or planted species (**Appendix 2**). Representation was highest amongst the Fabaceae with 34 taxa (including 11 introduced species) and Myrtaceae (30 taxa).

The locations of key species of known and potential environmental weeds are shown in **Figure 6 to 9** below. Some of these, such as *Acacia dealbata*, while not rated as a 'High' risk species (CALM, 1999) have potential to spread throughout the vegetation of the Survey Area. Information on the presence of these species was recorded during the survey as these infestations are currently still small enough to control.

No Declared Rare Flora pursuant to subsection (2) of section 23F of the *Wildlife Conservation Act (1950)* or flora listed as Endangered pursuant to section 179 of the *EPBC Act* were found in the Survey Area.

Four Priority taxa as defined by the Department of Parks and Wildlife (DPaW, 2013i); *Eucalyptus rudis* subsp. *cratyantha* (P4), *Synaphea petiolaris* subsp. *simplex* (P2), *S. hians* (P3) and *Verticordia attenuata* (P3) were found within the Survey Area. The distribution of these taxa is shown in **Figures 10 to 15** and locations of individual plants or groups of plants is shown in **Table 10**.

Waypoint	Easting	Northing	Species	Status	# Indivs
859	357060.1	6277368.1	<i>Synaphea petiolaris</i> subsp. <i>Simplex</i>	P1	3
860	356557.1	6276915.9	<i>Verticordia attenuata</i>	P3	1
861	356480.4	6276864.1	<i>Verticordia attenuata</i>	P3	2
862	356896.7	6277190.7	<i>Verticordia attenuata</i>	P3	1
867	355871.0	6276413.9	<i>Verticordia attenuata</i>	P3	20
868	355900.8	6276418.8	<i>Verticordia attenuata</i>	P3	3
869	355930.2	6276455.0	<i>Verticordia attenuata</i>	P3	5
870	355949.3	6276466.9	<i>Verticordia attenuata</i>	P3	20
871	355960.2	6276457.1	<i>Verticordia attenuata</i>	P3	20
872	355984.0	6276490.2	<i>Verticordia attenuata</i>	P3	10
873	356005.1	6276491.2	<i>Verticordia attenuata</i>	P3	50
874	356028.6	6276501.8	<i>Verticordia attenuata</i>	P3	50
875	356054.2	6276524.1	<i>Verticordia attenuata</i>	P3	100
877	362481.4	6281903.1	<i>Verticordia attenuata</i>	P3	10
878	362471.4	6281881.0	<i>Verticordia attenuata</i>	P3	20
594	362344.3	6281592.5	<i>Synaphea hians</i>	P3	5
595	362347.2	6281568.7	<i>Synaphea hians</i>	P3	5
619	360420.2	6279798.7	<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>	P4	
622	359616.3	6279562.1	<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>	P4	
624	359387.1	6279564.9	<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>	P4	
627	357068.4	6277390.5	<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>	P4	
628	356951.6	6277252.0	<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>	P4	
629	356897.6	6277212.8	<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>	P4	
641	355456.6	6276086.6	<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>	P4	
643	355150.1	6275928.1	<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>	P4	
644	355063.0	6275895.3	<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>	P4	
645	353578.4	6274937.1	<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>	P4	
646	353733.2	6275094.9	<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>	P4	
647	353455.4	6274919.0	<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>	P4	

Table 10. Locations of Priority Flora within the Survey Area

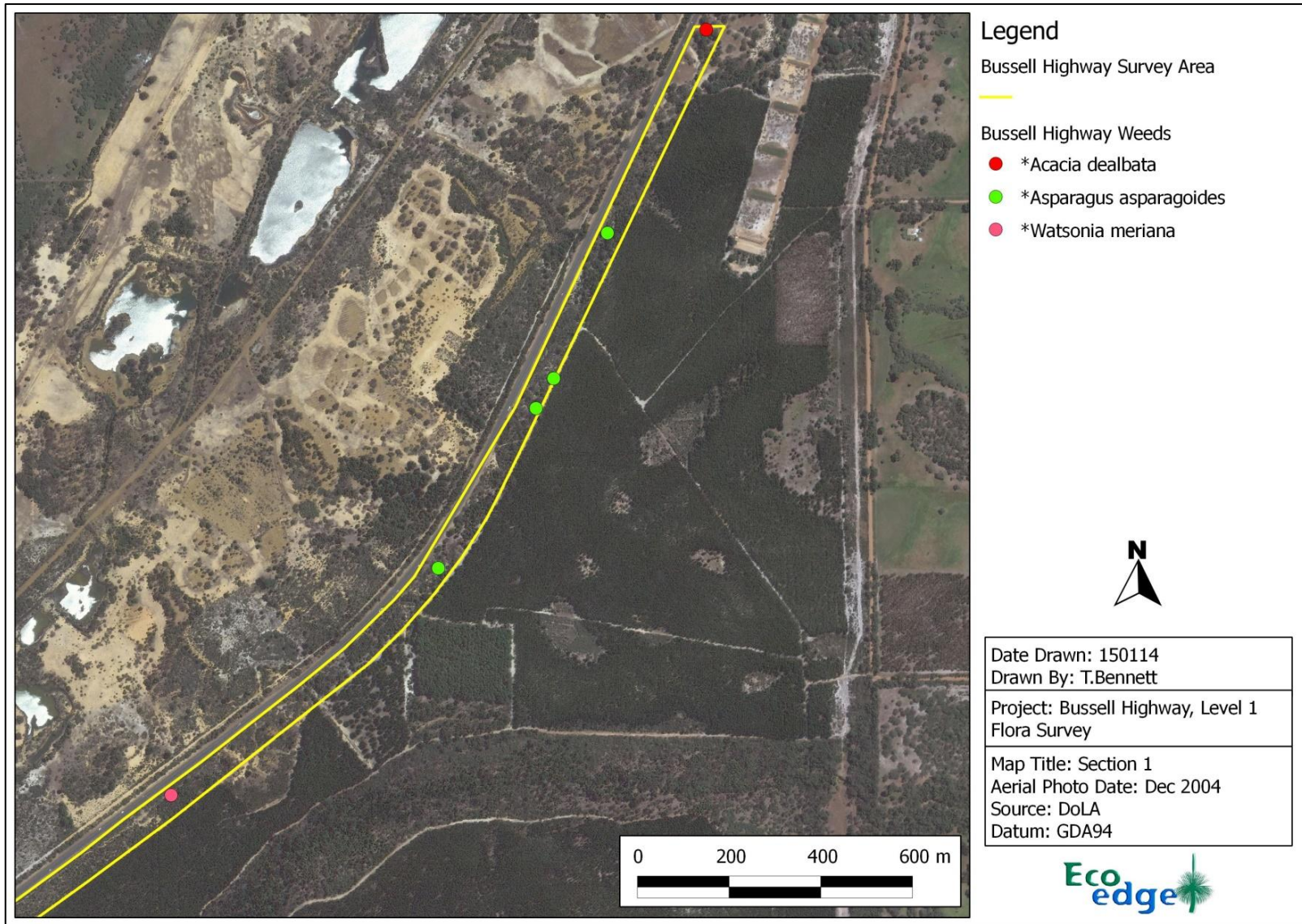


Figure 6. Weed locations within the Survey Area Section 1

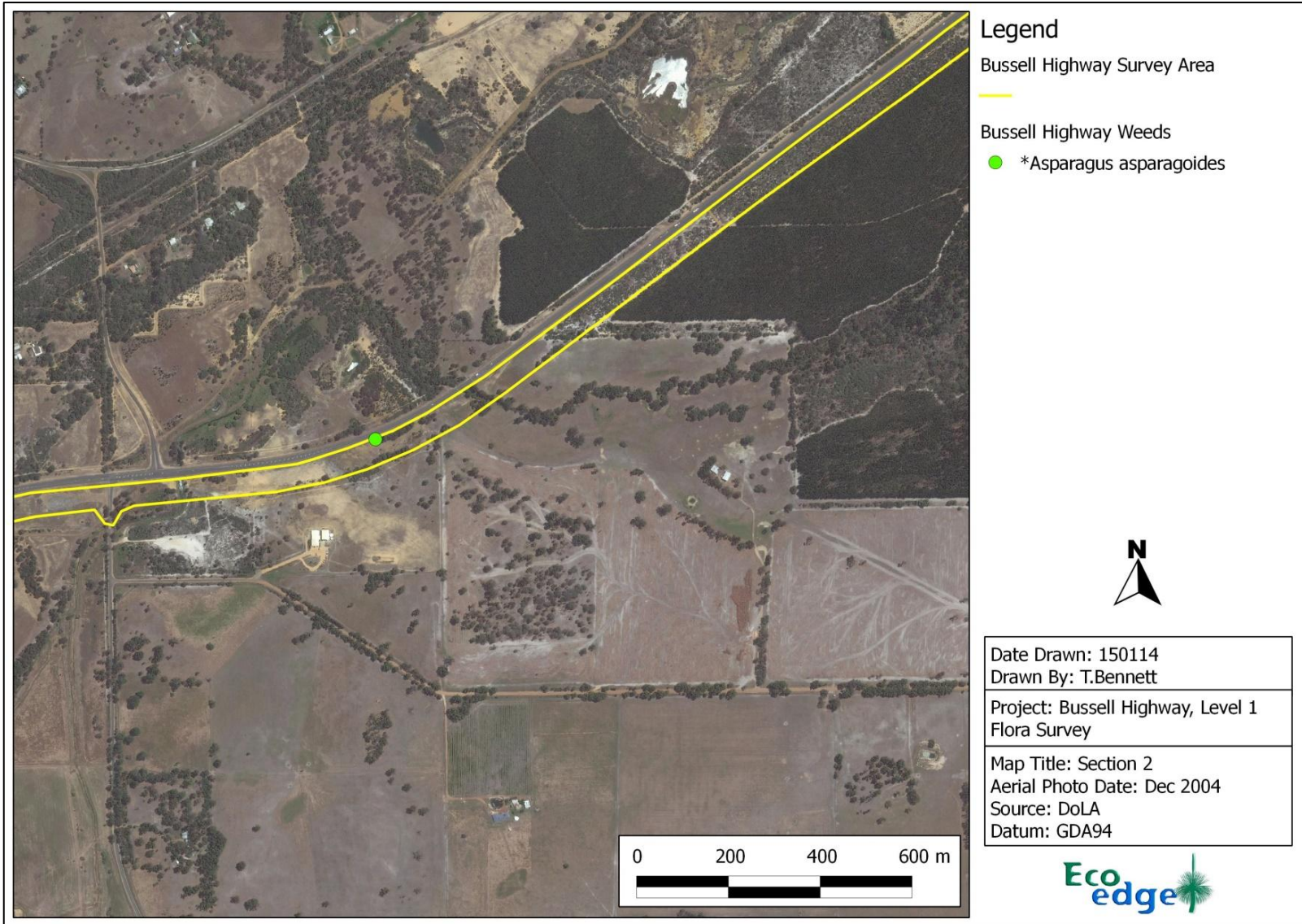


Figure 7. Weed locations within the Survey Area Section 2

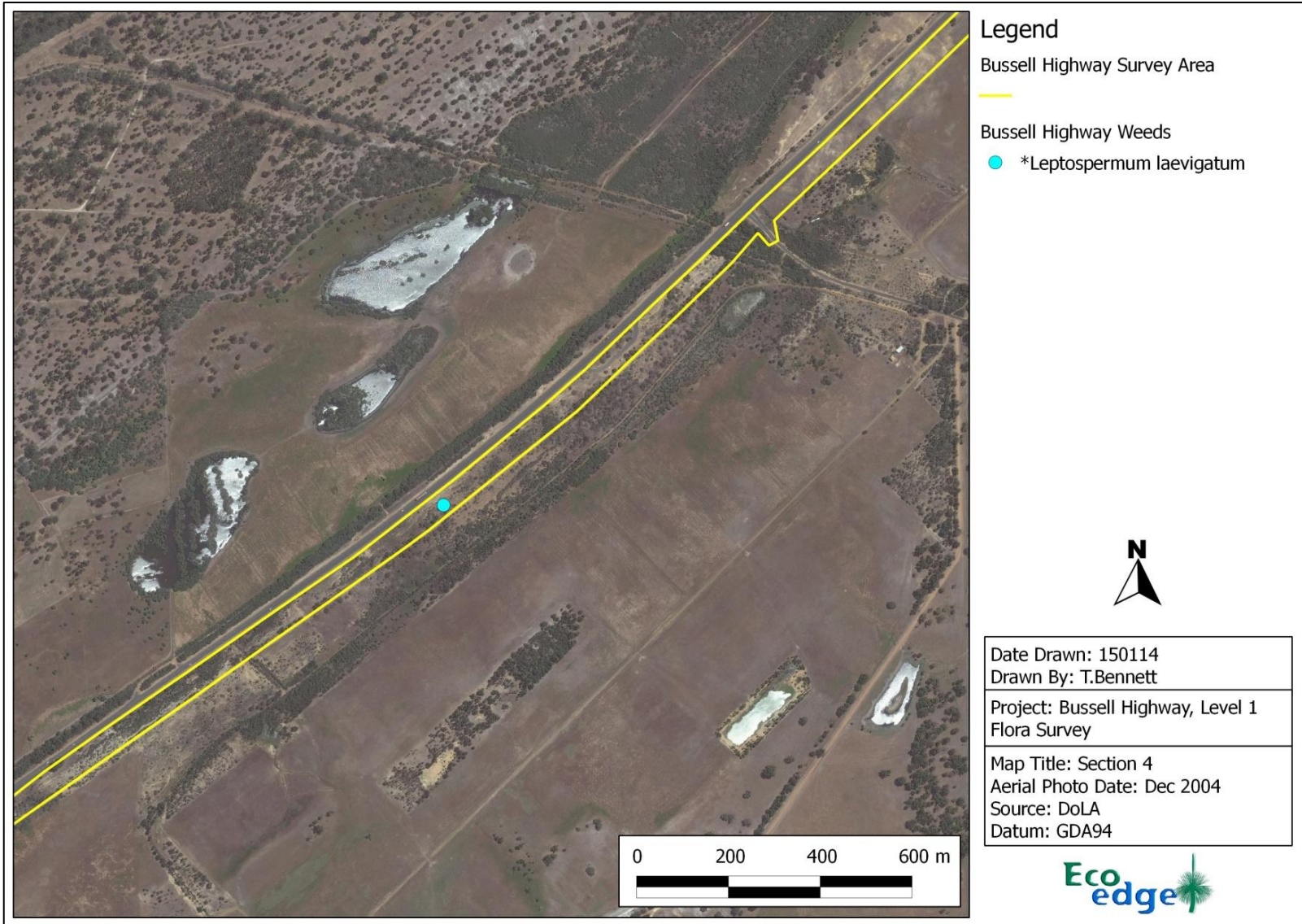


Figure 8. Weed locations within the Survey Area Section 4

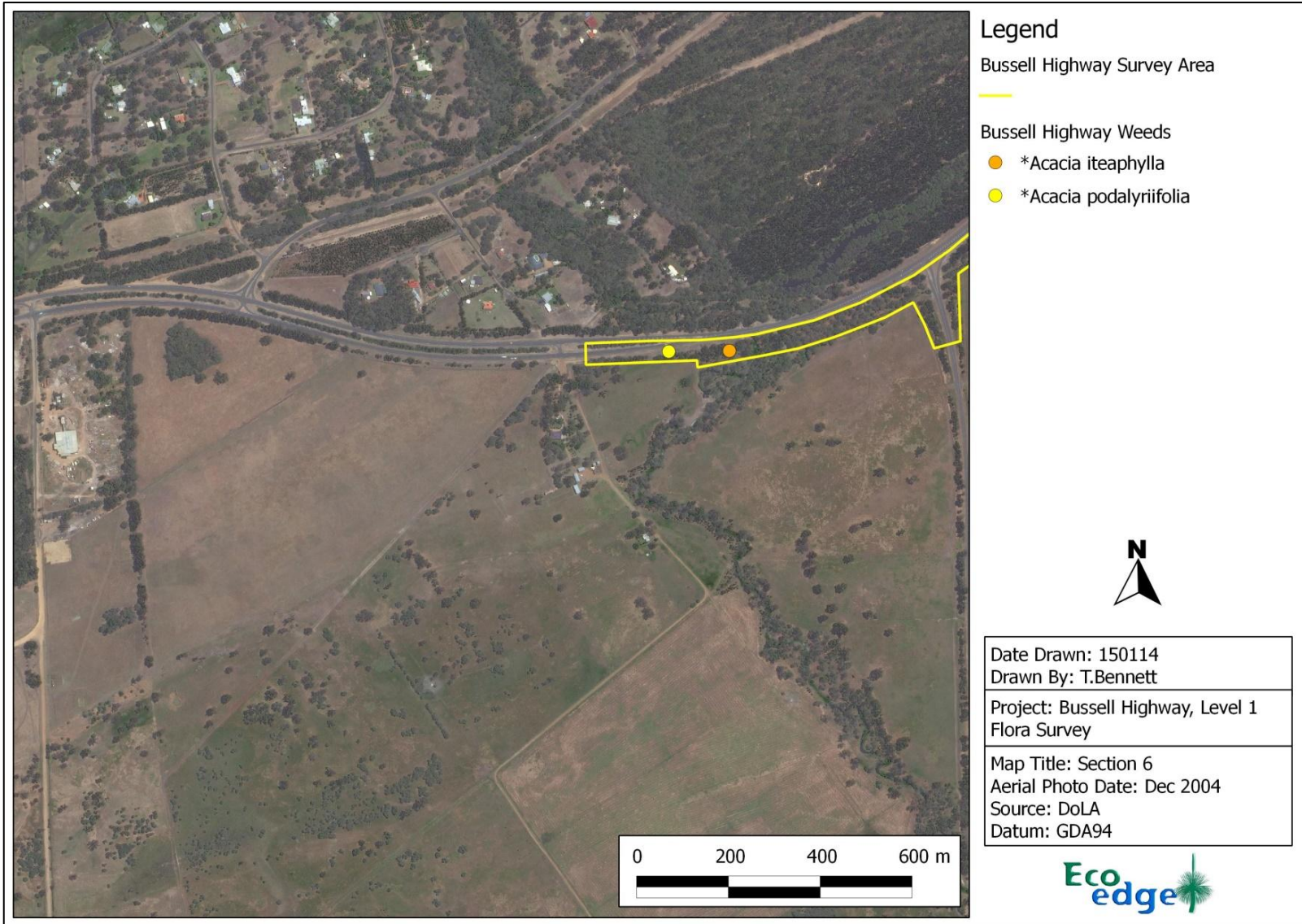


Figure 9. Weed locations within the Survey Area Section 6

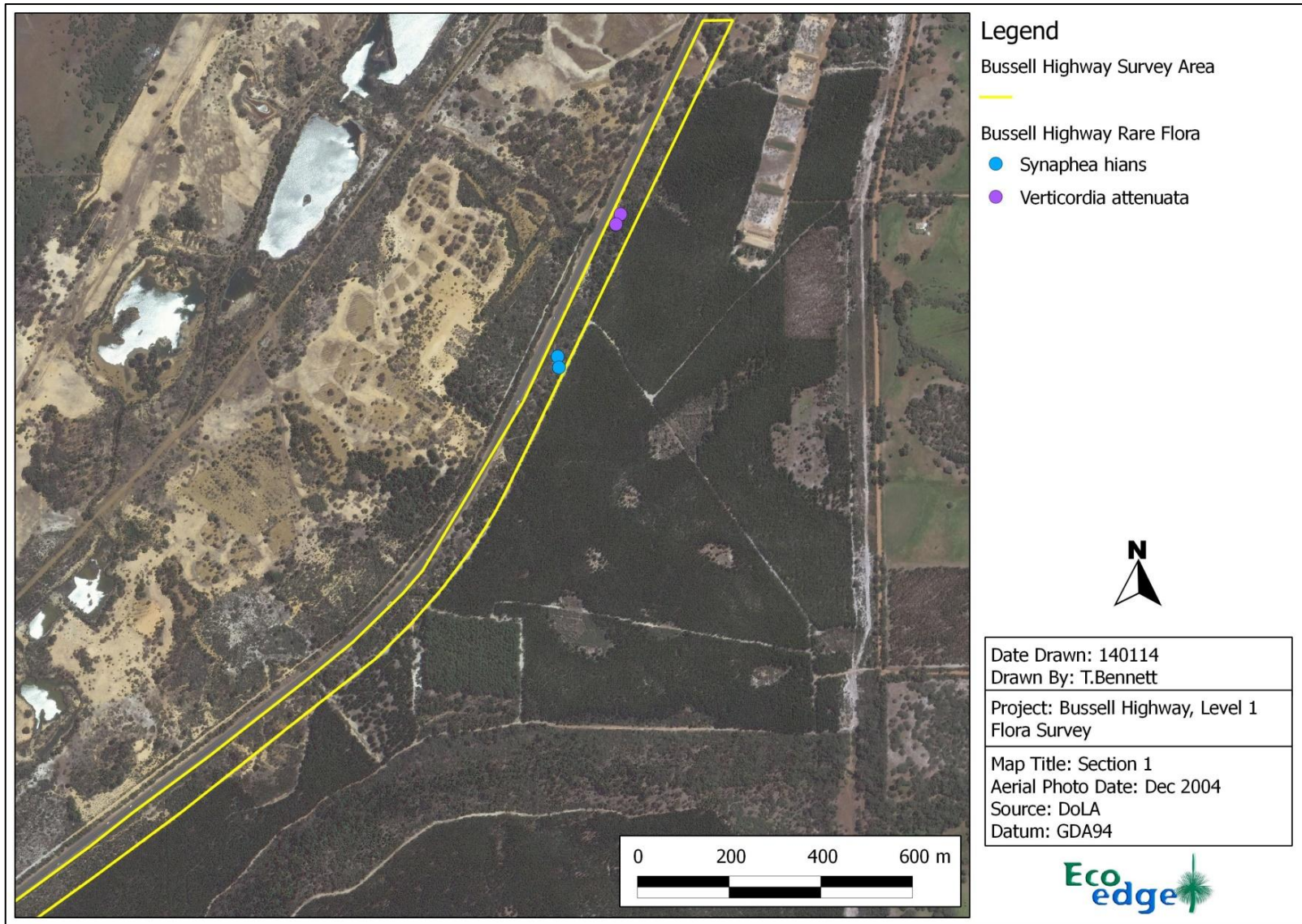


Figure 10. Priority flora locations within the Survey Area Section 1

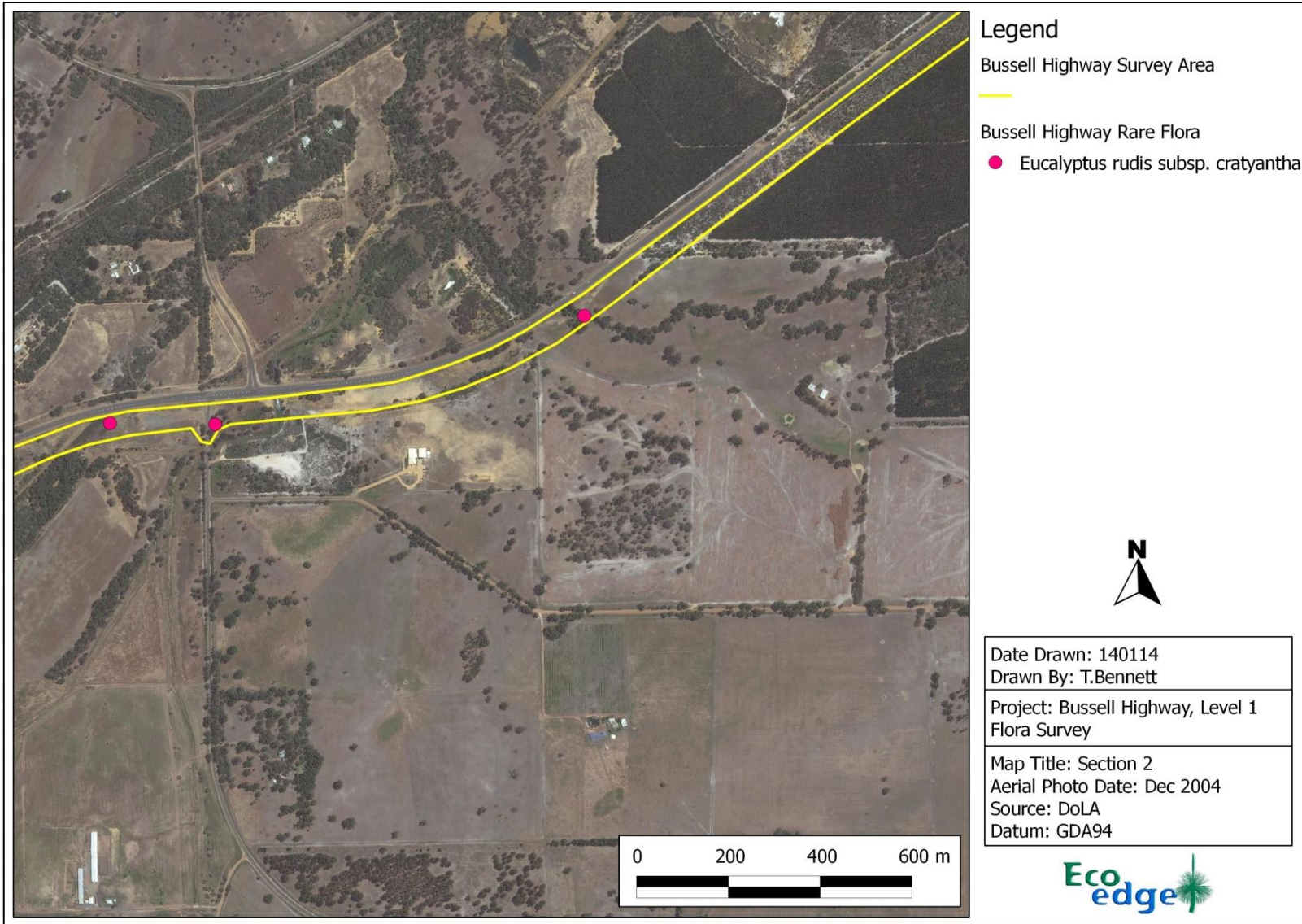


Figure 11. Priority flora locations within the Survey Area Section 2

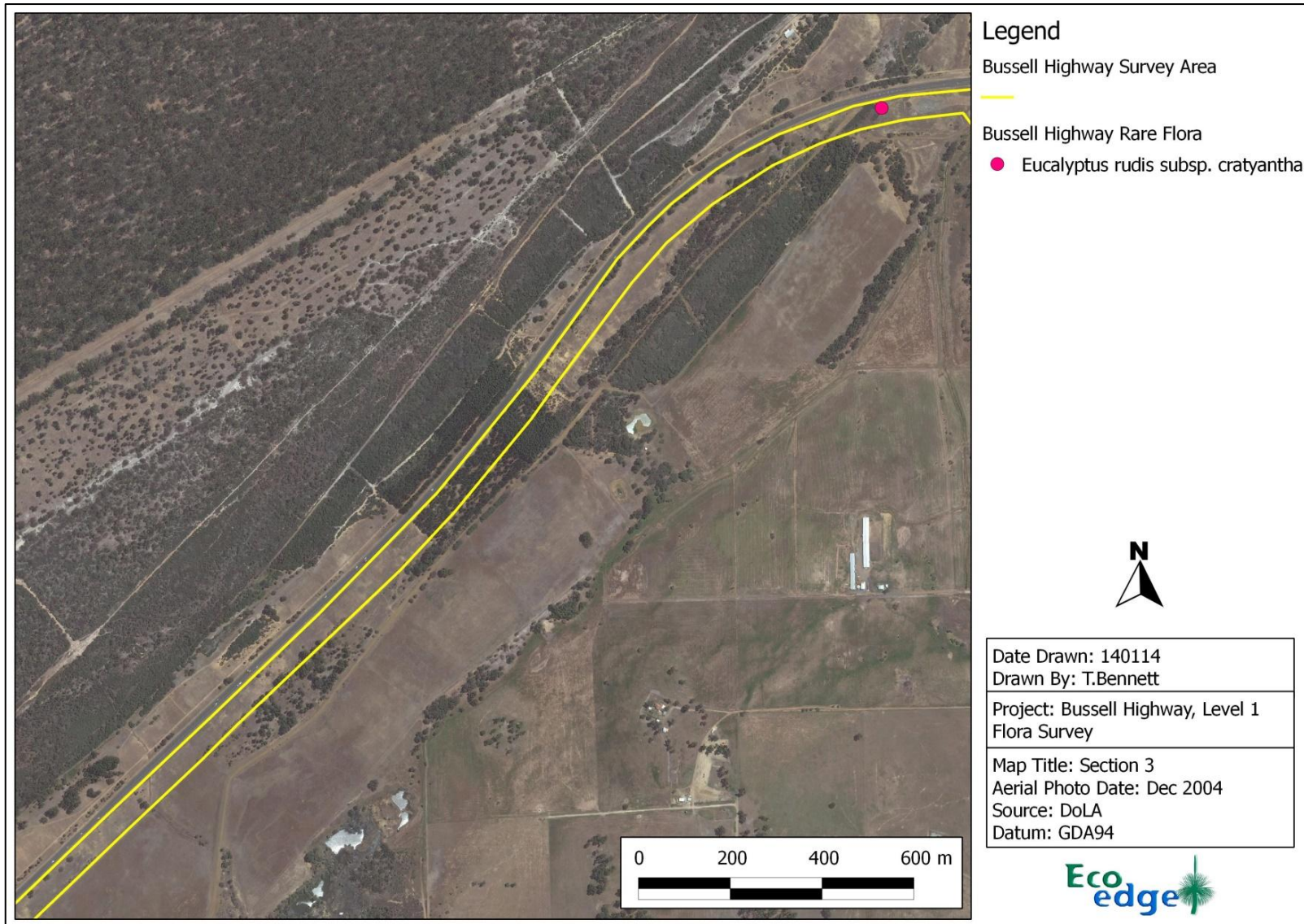


Figure 12. Priority flora locations within the Survey Area Section 3

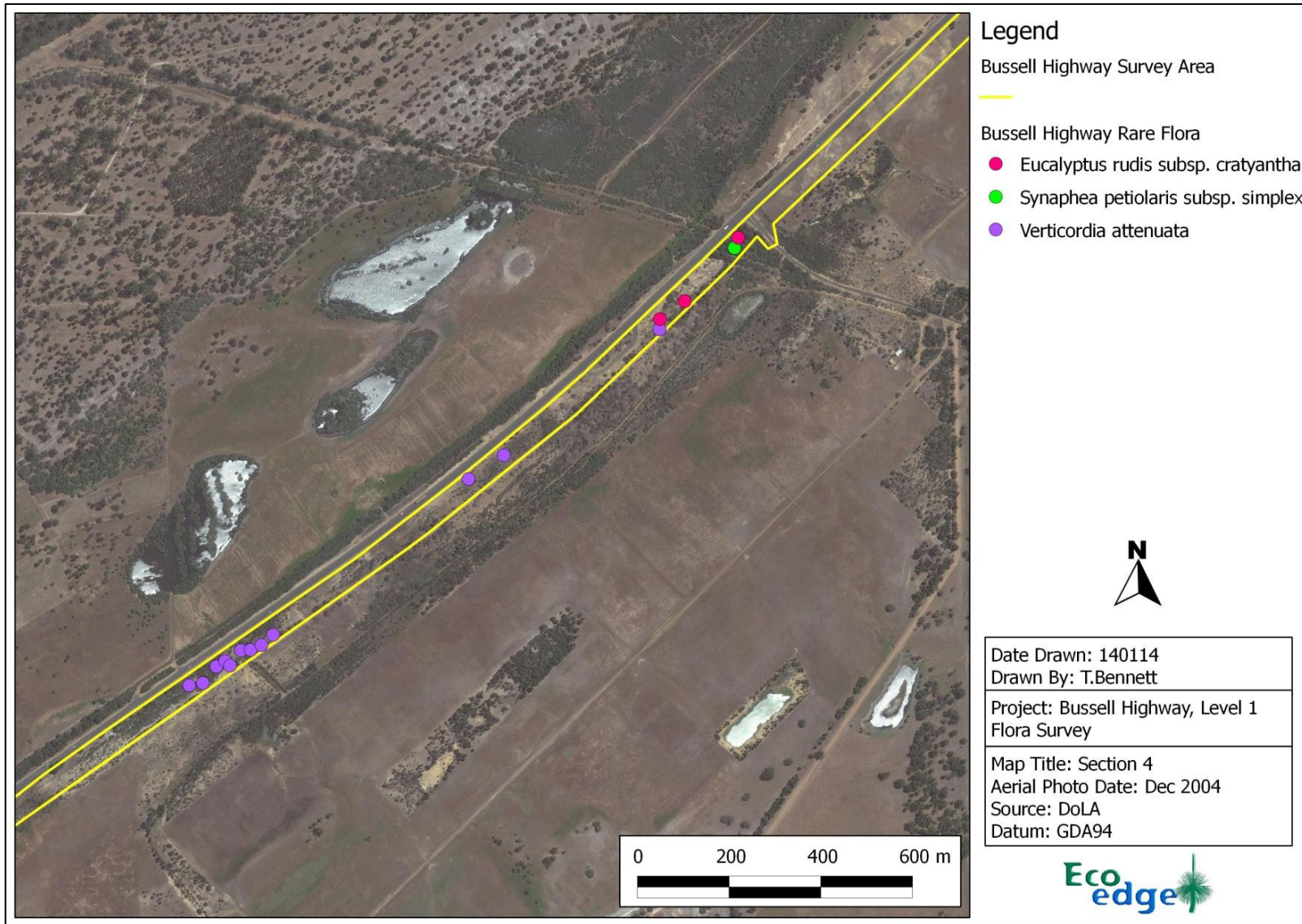


Figure 13. Priority flora locations within the Survey Area Section 4

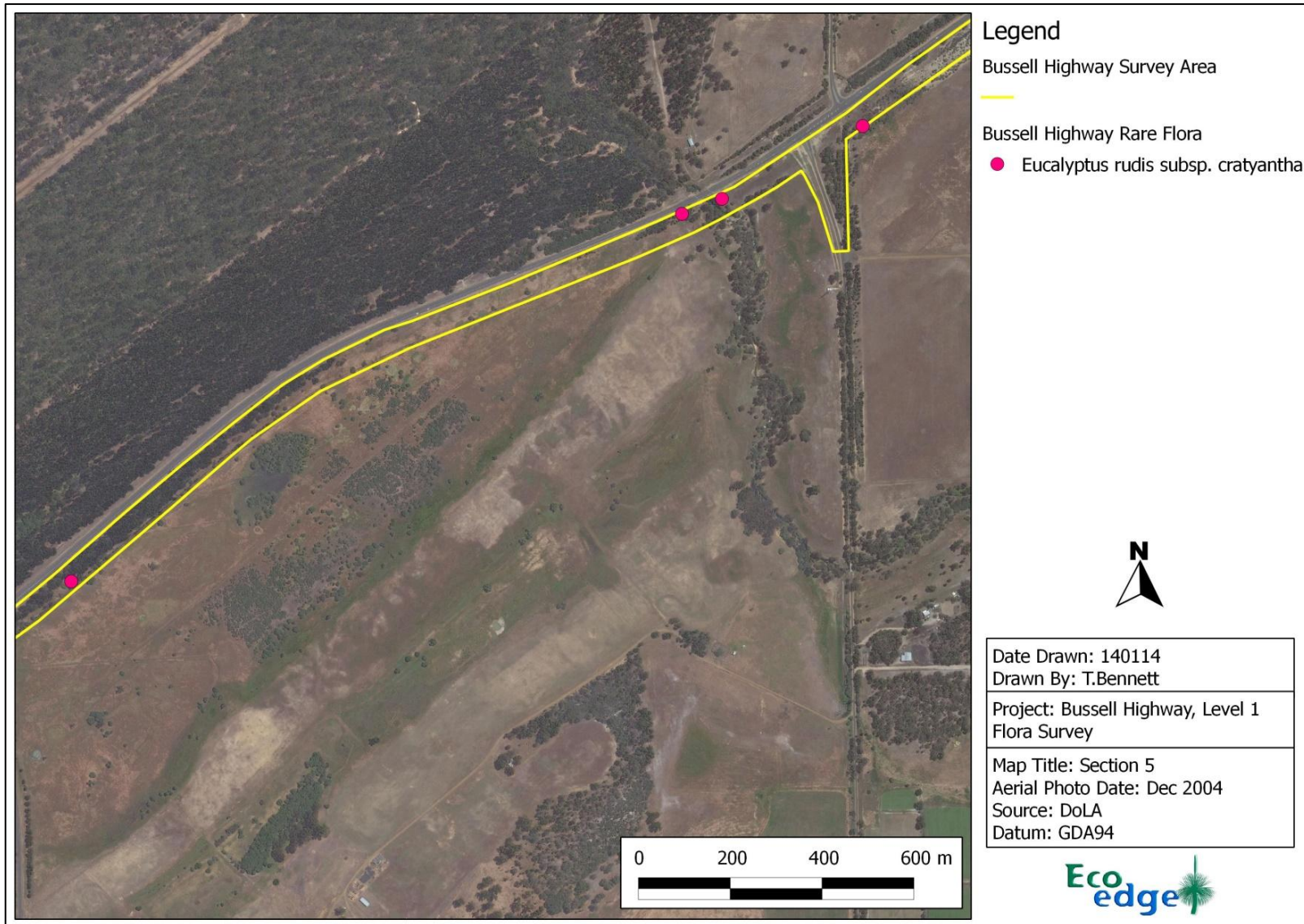


Figure 14. Priority flora locations within the Survey Area Section 5

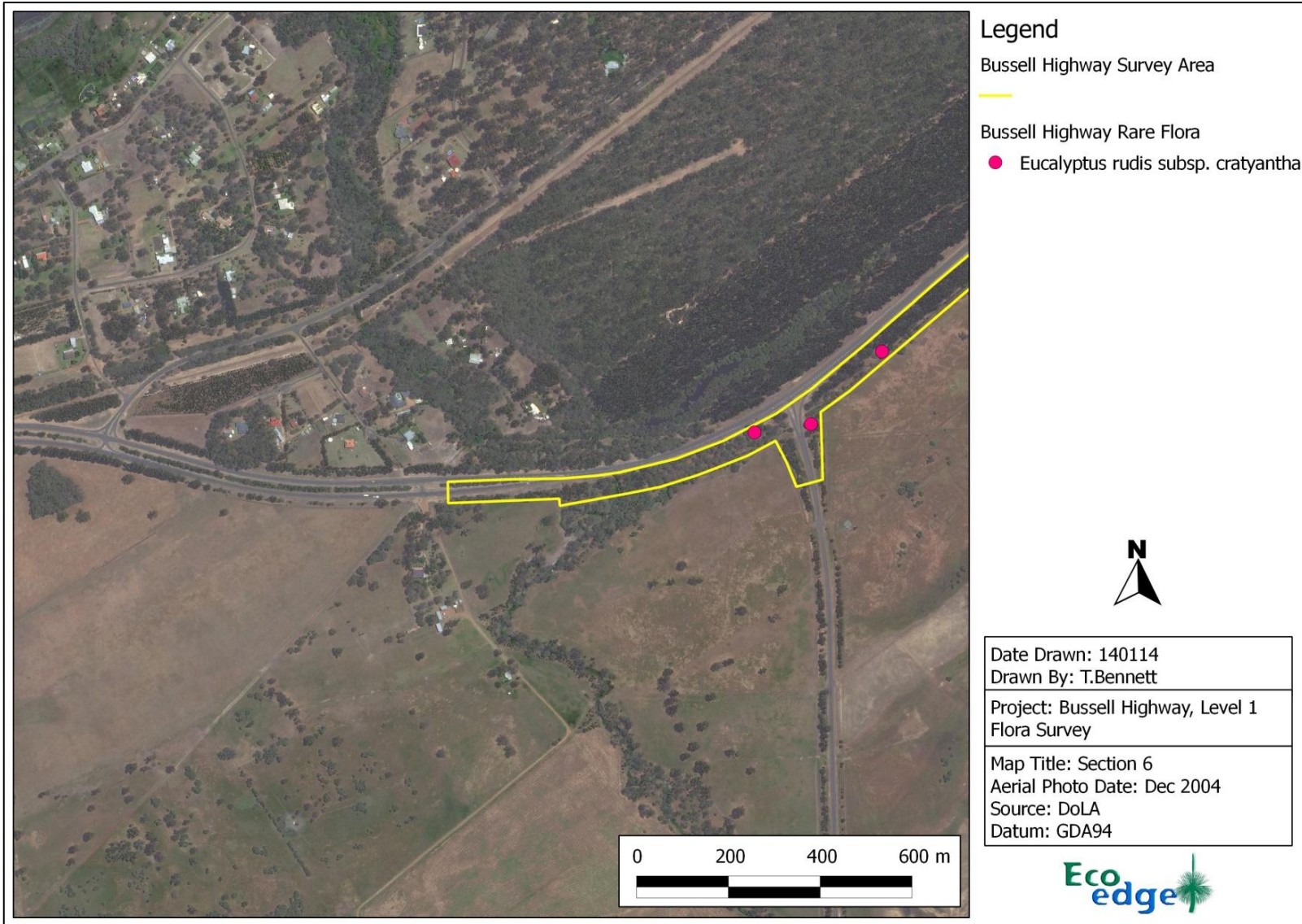


Figure 15. Priority flora locations within the Survey Area Section 6

Eucalyptus rudis subsp. *cratyantha* (**Figure 16**) is a tree up to 20 m high that is usually a riparian species inhabiting riverbanks, seasonal creeks, fringing lakes or swampy areas. It was once widespread on the southern Swan Coastal Plain, but has suffered much from clearing associated with agriculture and urban development. It is also highly susceptible to insect predation or pathogenic leaf diseases (Greening Australia, 2013). In the Survey Area, this taxon was found at 12 locations associated with riverbanks, streamlines and swampy areas.



Figure 16. *Eucalyptus rudis* subsp. *cratyantha* (P4)

Synaphea petiolaris subsp. *simplex* (**Figure 17**) is a tufted shrub up to 0.6 m high that is mainly confined to the southern Swan Coastal Plain south of Capel, but is found in scattered occurrences as far east as Collie and south to Nannup. Within the study area it was found as a small population of three plants in a small patch of bushland in very good condition just south of the Ruabon Road intersection.



Figure 17. *Synaphea petiolaris* subsp. *simplex* (P2)

Synaphea hians (P3) (**Figure 18**) is a prostrate or decumbent shrub, up to 0.6 m high and 1 m wide that is found within a zone stretching from Bowelling east of Collie and Lake Unicup east of Manjimup to the Capel-Busselton area (DPaW, 2013h). One population consisting of about 10 plants was found near the northern end of the Survey Area growing in Jarrah-Marri woodland on grey sand.



Figure 18. *Synaphea hians* (P3)

Verticordia attenuata (P3) (**Figure 19**) is a shrub up to 1 m high found growing in winter wet depressions on the southern Swan Coastal Plain south of Bunbury. Several hundred plants of this species were found growing within the Survey Area south of Ruabon Road.



Figure 19. *Verticordia attenuata* (P3).

4.2 Vegetation Units

Nine vegetation units were recognised within the Survey Area and are described below using a structural method based on a method derived from Aplin (1979) and Muir (1977). Maps showing the distribution of vegetation units is shown below (**Figures 20 to 25**), the total area of each of the vegetation units is presented in **Table 11**, and photographs of the vegetation units are presented in **Appendix 3**.

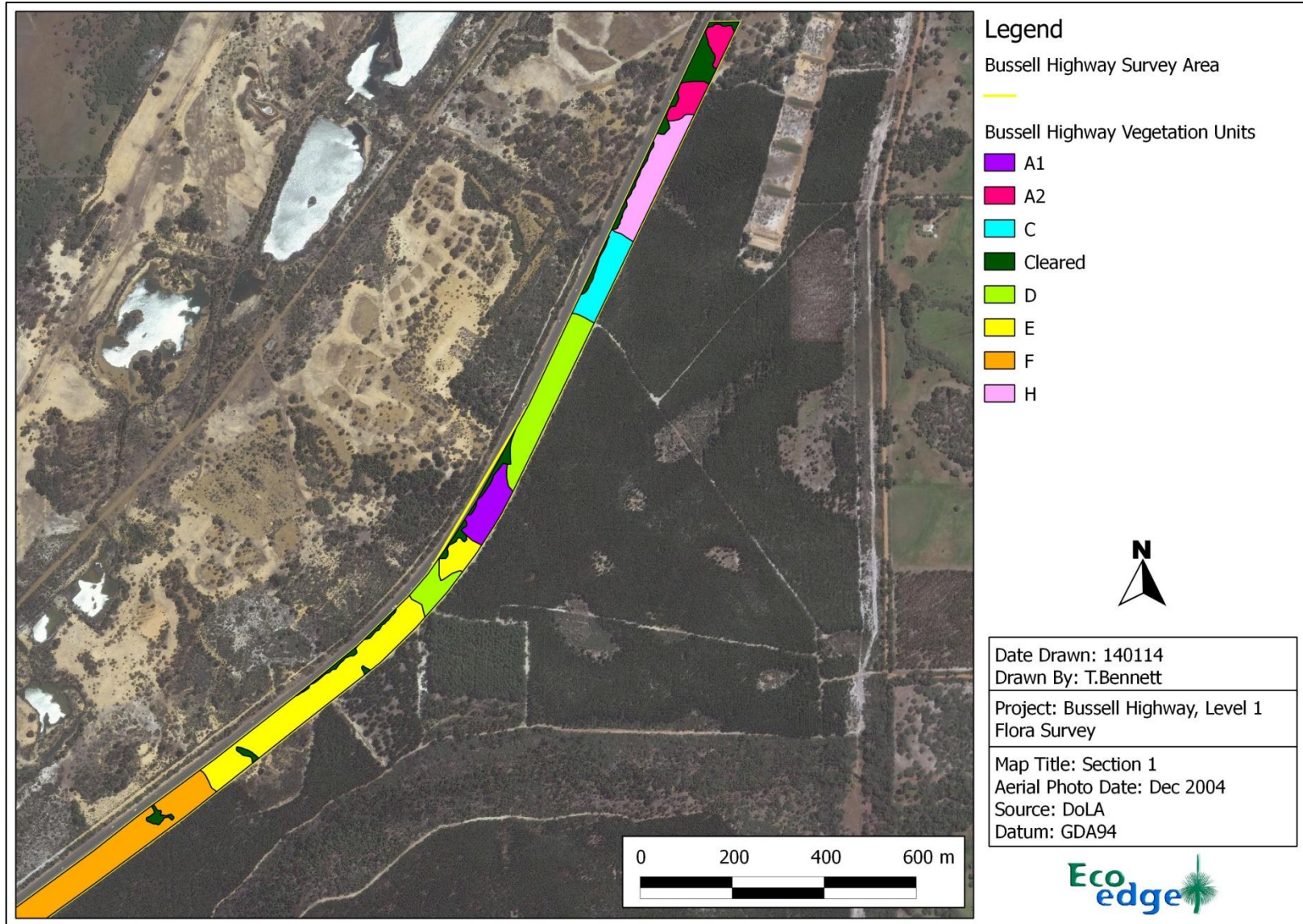


Figure 20. Vegetation Units of Section 1 of the Survey Area.

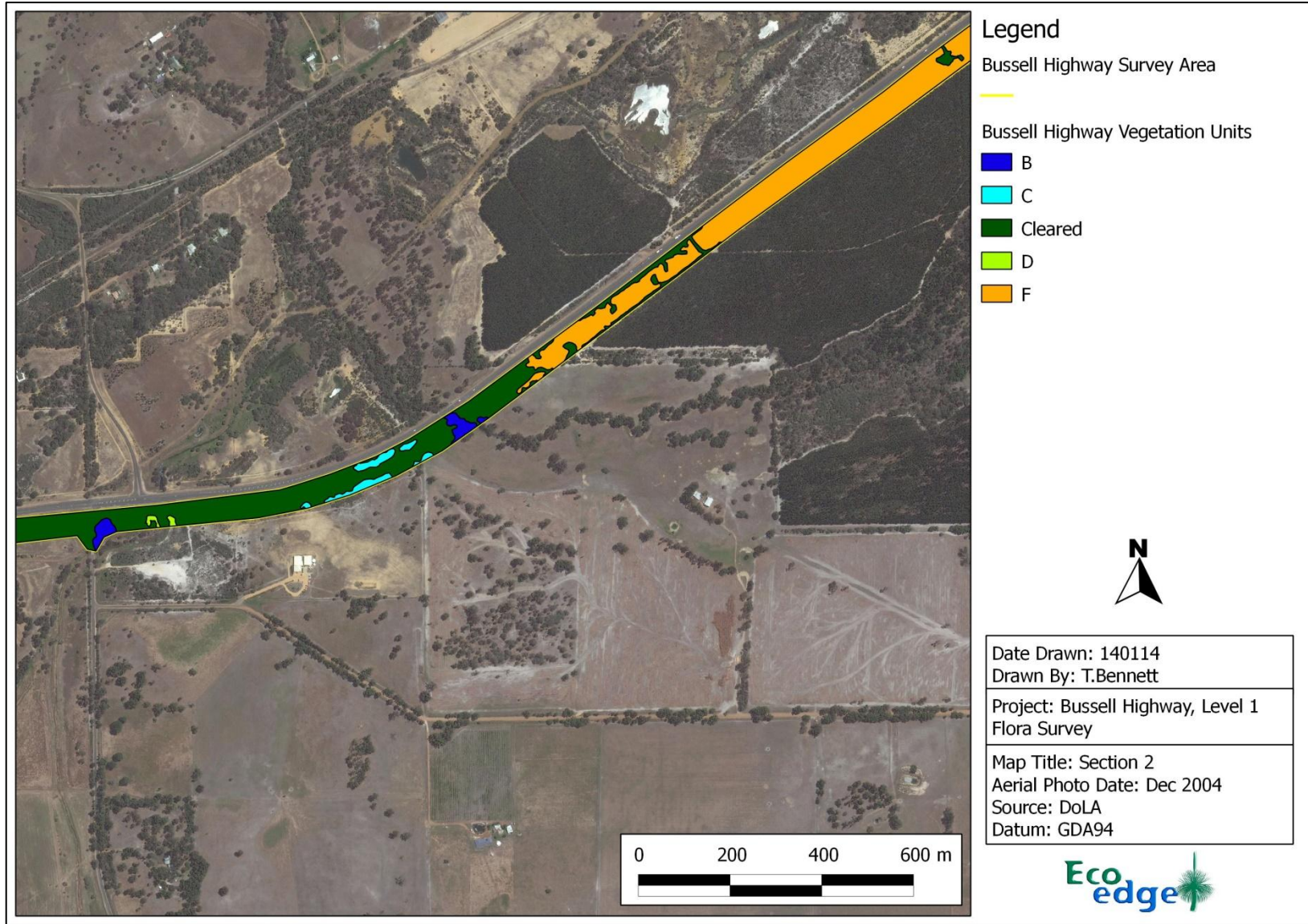


Figure 21. Vegetation Units of Section 2 of the Survey Area.

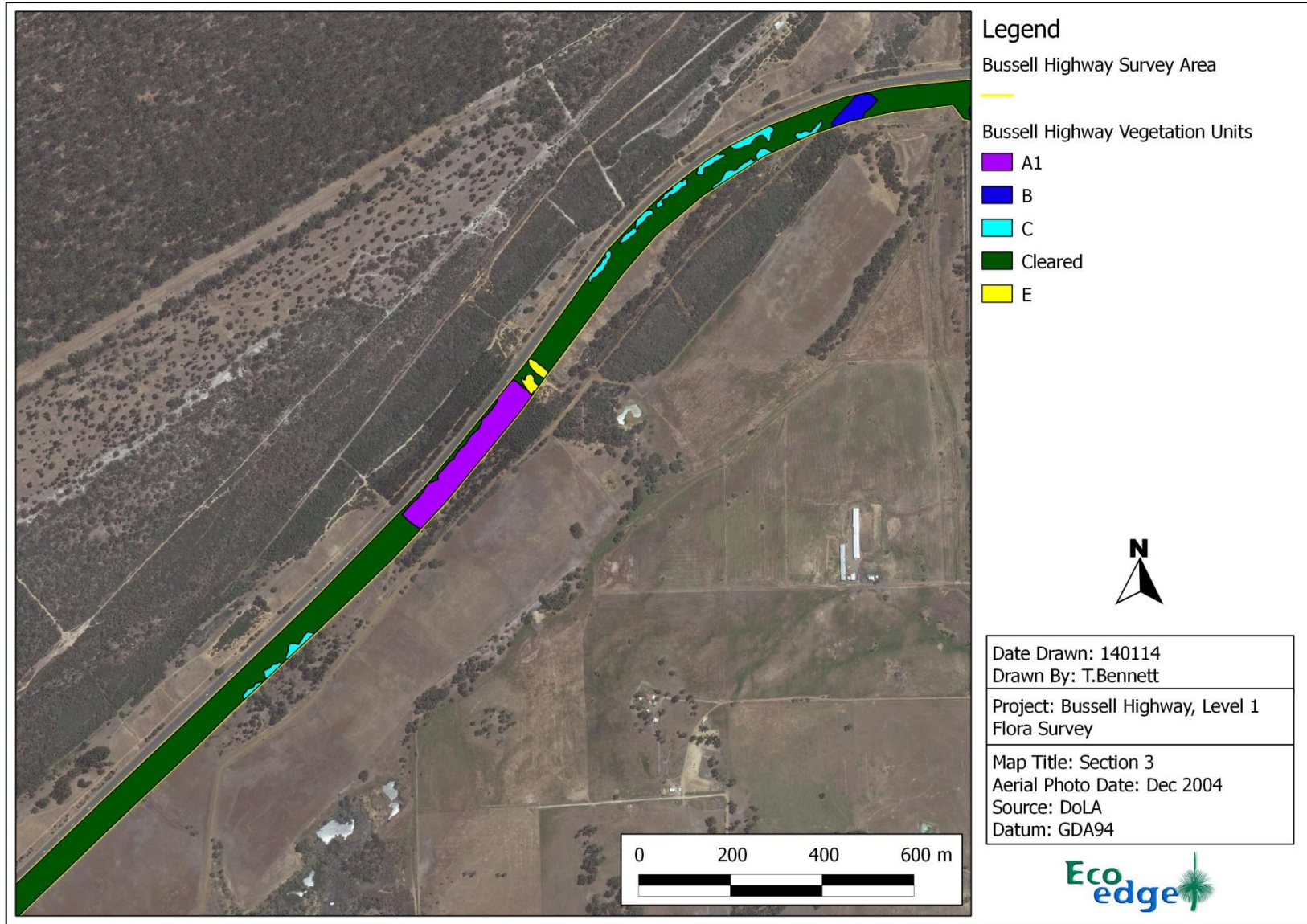


Figure 22. Vegetation Units of Section 3 of the Survey Area.

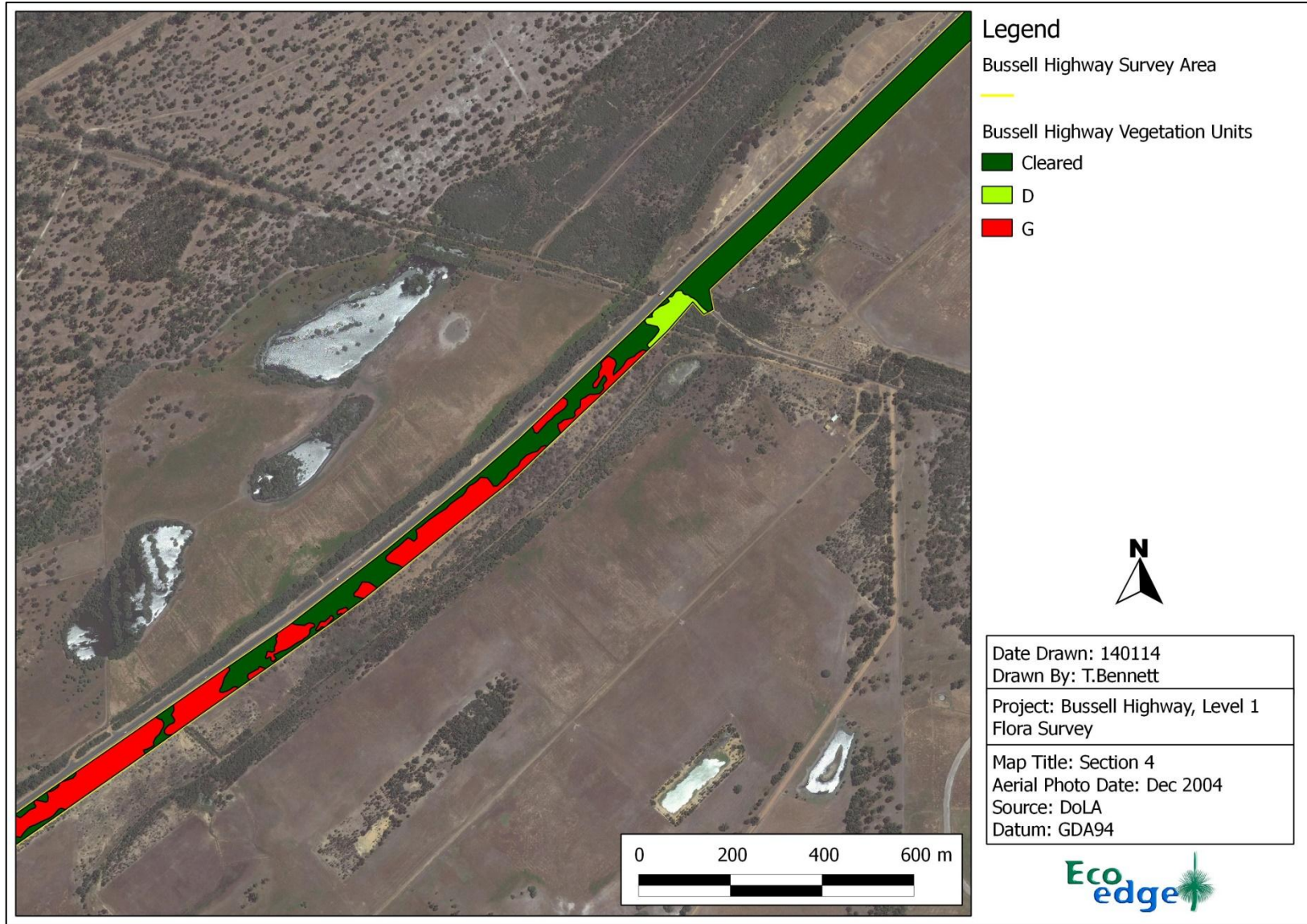


Figure 23. Vegetation Units of Section 4 of the Survey Area.

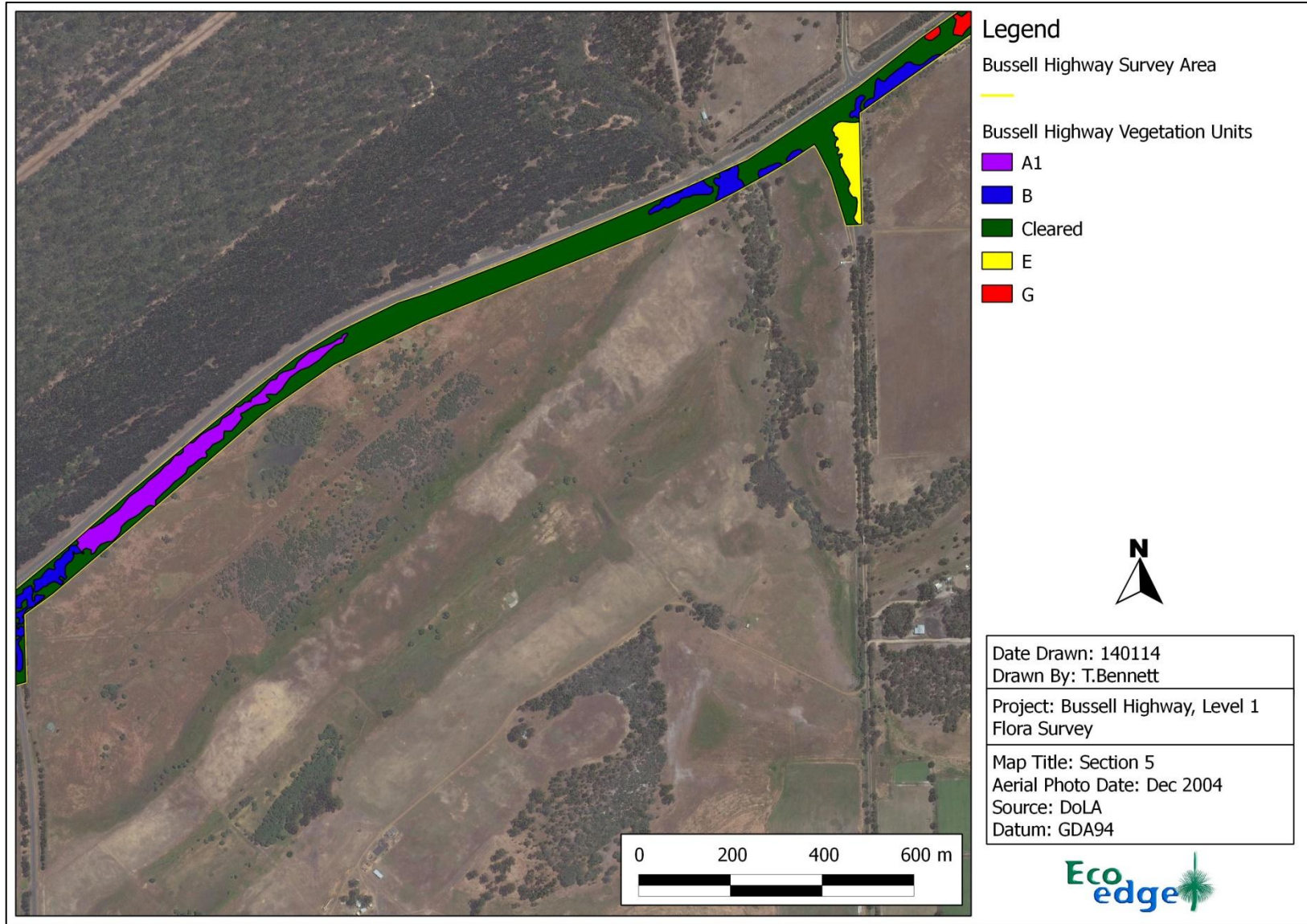


Figure 24. Vegetation Units of Section 5 of the Survey Area.

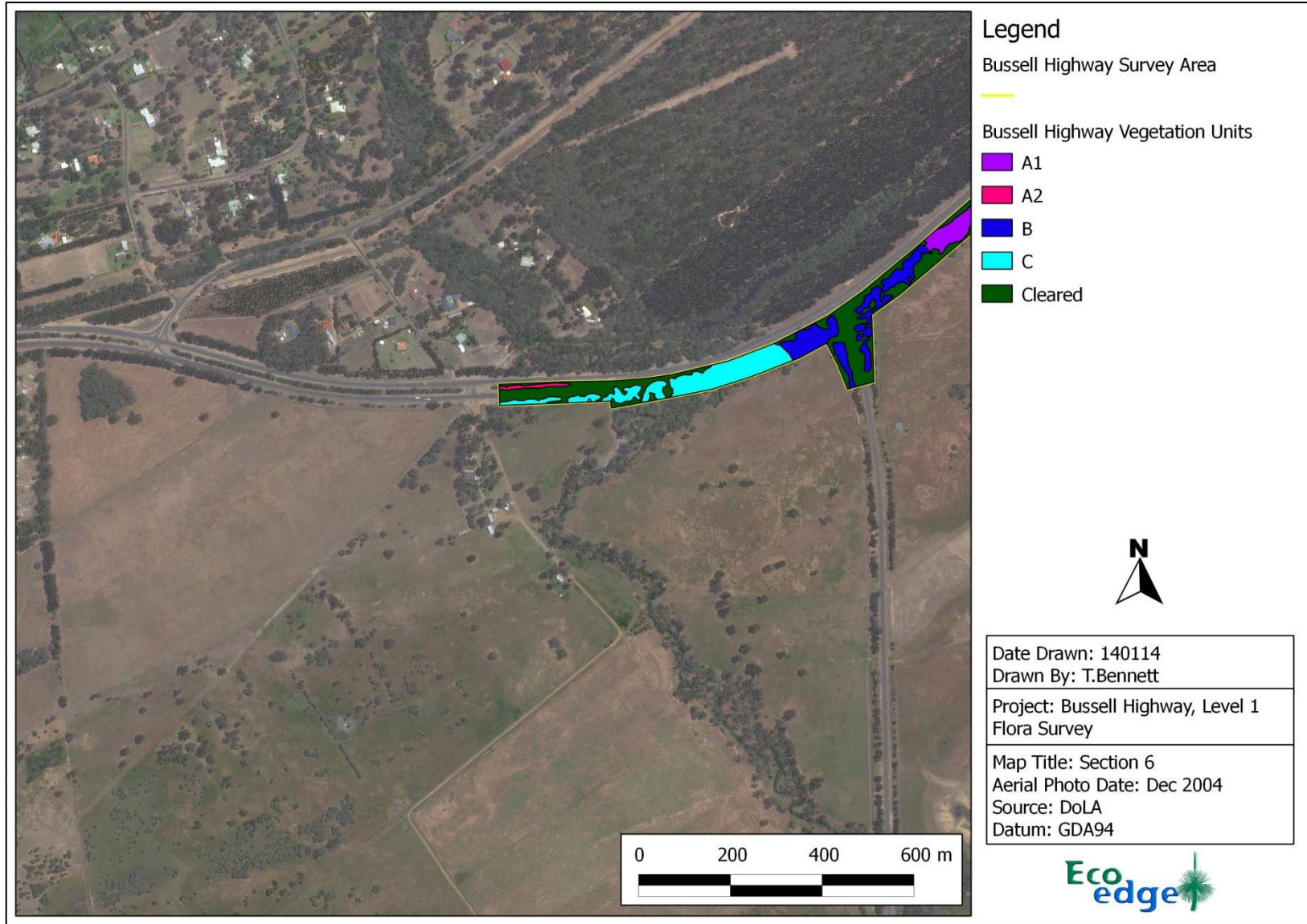


Figure 25. Vegetation Units of Section 6 of the Survey Area.

Vegetation Unit A1

Pine Plantation (**Pinus pinaster* with occasional **Asparagus asparagoides*, *Hibbertia cuneiformis*, **Zantedeschia aethiopica* scattered shrubs and herbs) – *Completely Degraded*

Vegetation Unit A2

**Eucalyptus* spp. plantings over introduced herbs and grasses – *Completely Degraded*

Vegetation Unit B

Eucalyptus rudis subsp. *cratyantha* woodland/open woodland over *Agonis flexuosa*, *Melaleuca preissii* open low woodland with occasional *Corymbia calophylla* and *M. raphiophylla* over *Acacia saligna*, *Astartea* sp., *Melaleuca viminea* open shrubland over introduced herbs and grasses including **Ehrharta calycina* on grey-brown sandy-loam or loam - *Degraded*

Vegetation Unit C

Agonis flexuosa low woodland/low open woodland with scattered *Eucalyptus gomphocephala* or **Pinus pinaster* over *Kunzea glabrescens*, (**Acacia longifolia*) shrubland/open shrubland over introduced herbs and grasses including **Lupinus angustifolius*, **Ehrharta calycina* and **E. longifolia* on grey-brown sand/sandy loam or yellow-grey sand. (*Eucalyptus cornuta* replaces *E. gomphocephala* west of Sue's Road turnoff) – *Degraded or Completely Degraded*.

Vegetation Unit D

Eucalyptus marginata subsp. *marginata*, *Corymbia calophylla* with scattered *Nuytsia floribunda* woodland over *Kunzea glabrescens* shrubland over *Gastrolobium praemorsum*, *Hibbertia hypericoides*, *Leucopogon parviflorus*, *Stirlingia latiflora*, *Xanthorrhoea brunonis* low shrubland over *Tetraria octandra* open sedgeland on grey-brown or yellow-grey sand. (*Eucalyptus rudis* subsp. *cratyantha* and *Banksia littoralis* and shrubs such as *Hakea varia* and *H. prostrata* may occur in damper areas) – *Good to Very Good*.

Vegetation Unit E

Corymbia calophylla woodland (sometimes with *Melaleuca raphiophylla*) over **Acacia* spp., *Hibbertia cuneiformis*, *Kunzea glabrescens*, (*Spyridium globulosum*) shrubland over introduced herbs and grasses including **Ehrharta calycina*, **Eragrostis curvula* and **Zantedeschia aethiopica* on grey-brown or yellow-brown sand – *Degraded to Good*.

Vegetation Unit F

**Acacia* spp., *Kunzea glabrescens* tall shrubland over *Adenanthos meisneri*, *Gastrolobium praemorsum*, (*Leucopogon conostephioides*) low shrubland over *Loxocarya cinerea* and introduced herbs and grasses on grey or yellow-brown sand. (Revegetated areas) – *Completely Degraded*.

Vegetation Unit G

Kunzea glabrescens (*Viminaria juncea*) tall shrubland over *Acacia saligna*, *Adenanthos meisneri*, *Jacksonia furcellata*, *Kunzea recurva*, *Melaleuca viminea*, *Verticordia attenuata*, (*Verticordia densiflora* subsp. *densiflora*) shrubland over *Conostylis aculeata*, *Patersonia occidentalis* open hermland and introduced herbs and grasses including on yellow-brown or yellow-grey sandy loams/sandy clay loams – *Degraded to Good*.

Vegetation Unit H

Melaleuca preissiana low open forest/low woodland over *Astartea leptophylla*, *A. scoparia*, *Melaleuca viminea*, *M. osullivanii*, (*Verticordia attenuata*) open heath/shrubland over *Baumea juncea* open sedgeland on grey sand over clay - *Degraded to Good*

Vegetation Unit	Area (ha)
A1	5.4
A2	0.5
B	3.3
C	4.2
D	3.1
E	4.7
F	6.4
G	5.2
H	1.4
Total Rem. Vegetation	34.3
Cleared	37.9
Total Survey Area	72.1

Table 11. Areas of each of the Vegetation Units.

4.3 Vegetation Condition

Only 11% of the Survey Area was rated as “Good” or “Very Good” condition – where the original vegetation structure is intact and native plant species predominate (**Figures 26 to 31**). More than half (58.3%) of the Survey Area is cleared or “Completely Degraded”, with little or no native vegetation remaining, and a further 9.9% is pine plantation or revegetated with a mixture of Western Australian and other Australian native species. The area and proportion of the total Survey Area for the various classes of vegetation in the Survey Area is shown in **Table 12**.

Class	Area (ha)	% Total
Completely Degraded	4.3	6.0
Degraded	15.1	20.0
Good	6.4	8.9
Very Good	1.5	2.1
Pine Plantation	2.0	2.8
Revegetated	5.1	7.1
Cleared	37.7	52.3
Total Survey Area	72.1	100.0

Table 12. Areas and percentage totals of each vegetation condition rating.

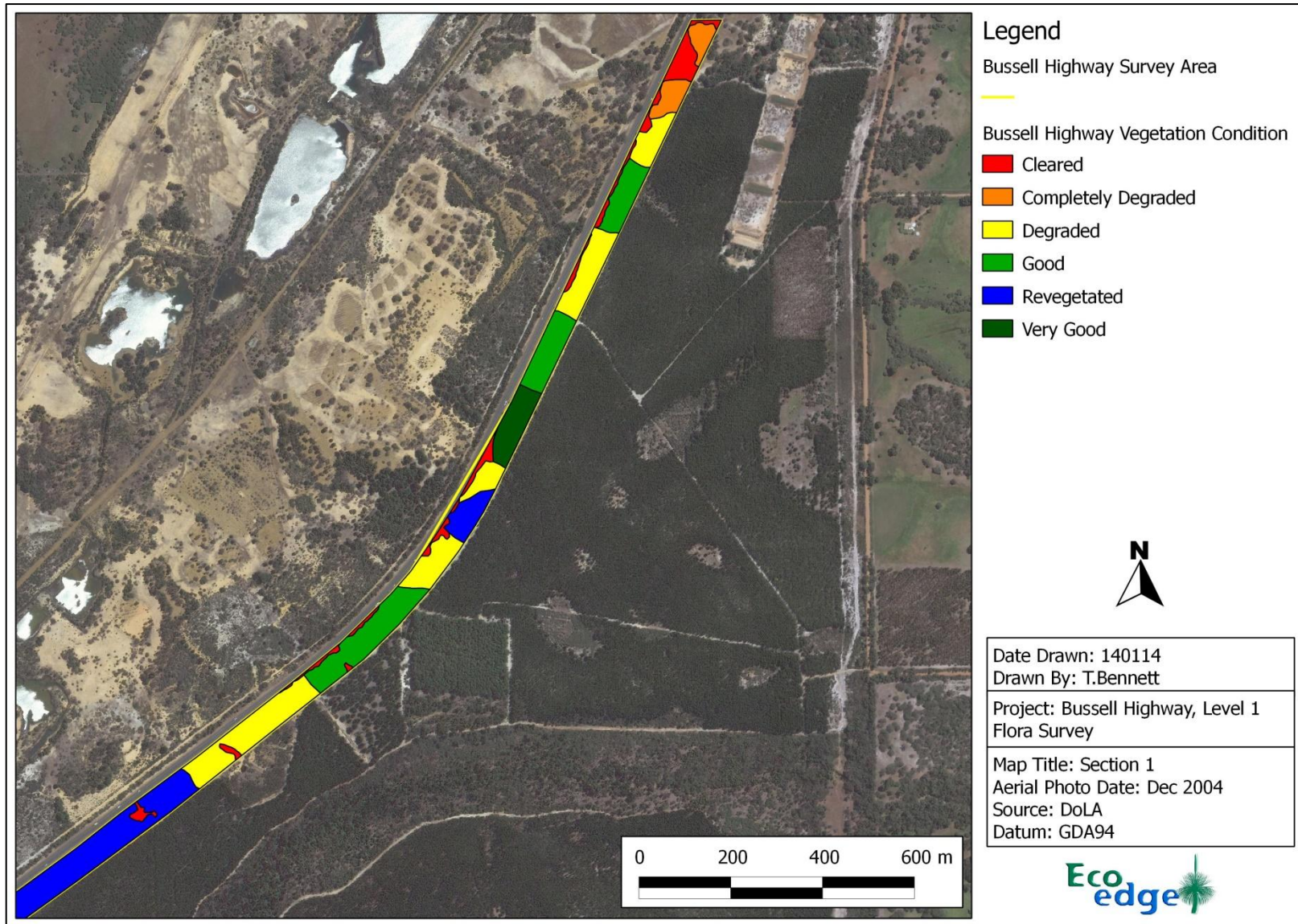


Figure 26. Vegetation condition of Section 1 of the Survey Area.

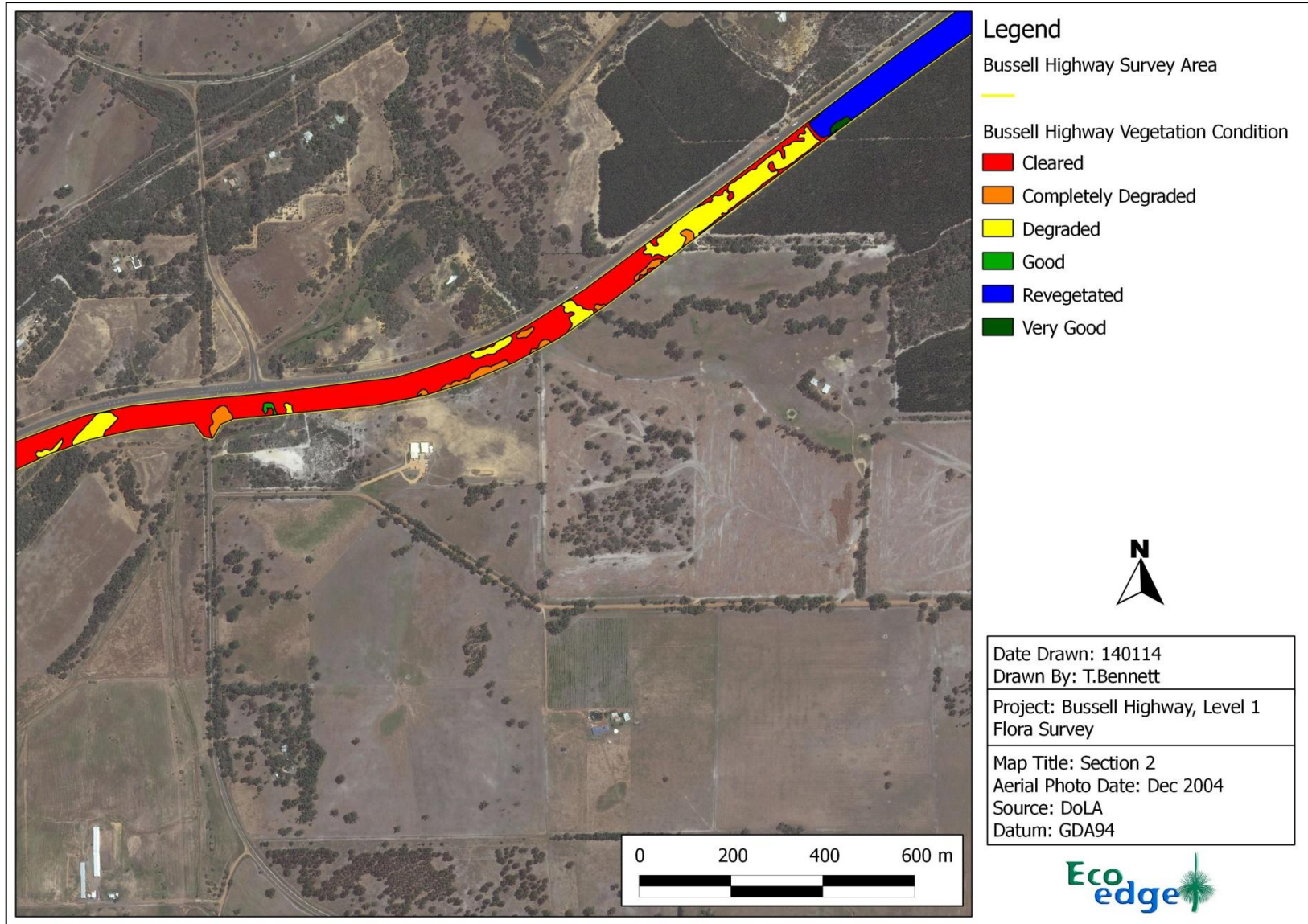


Figure 27. Vegetation condition of Section 2 of the Survey Area.

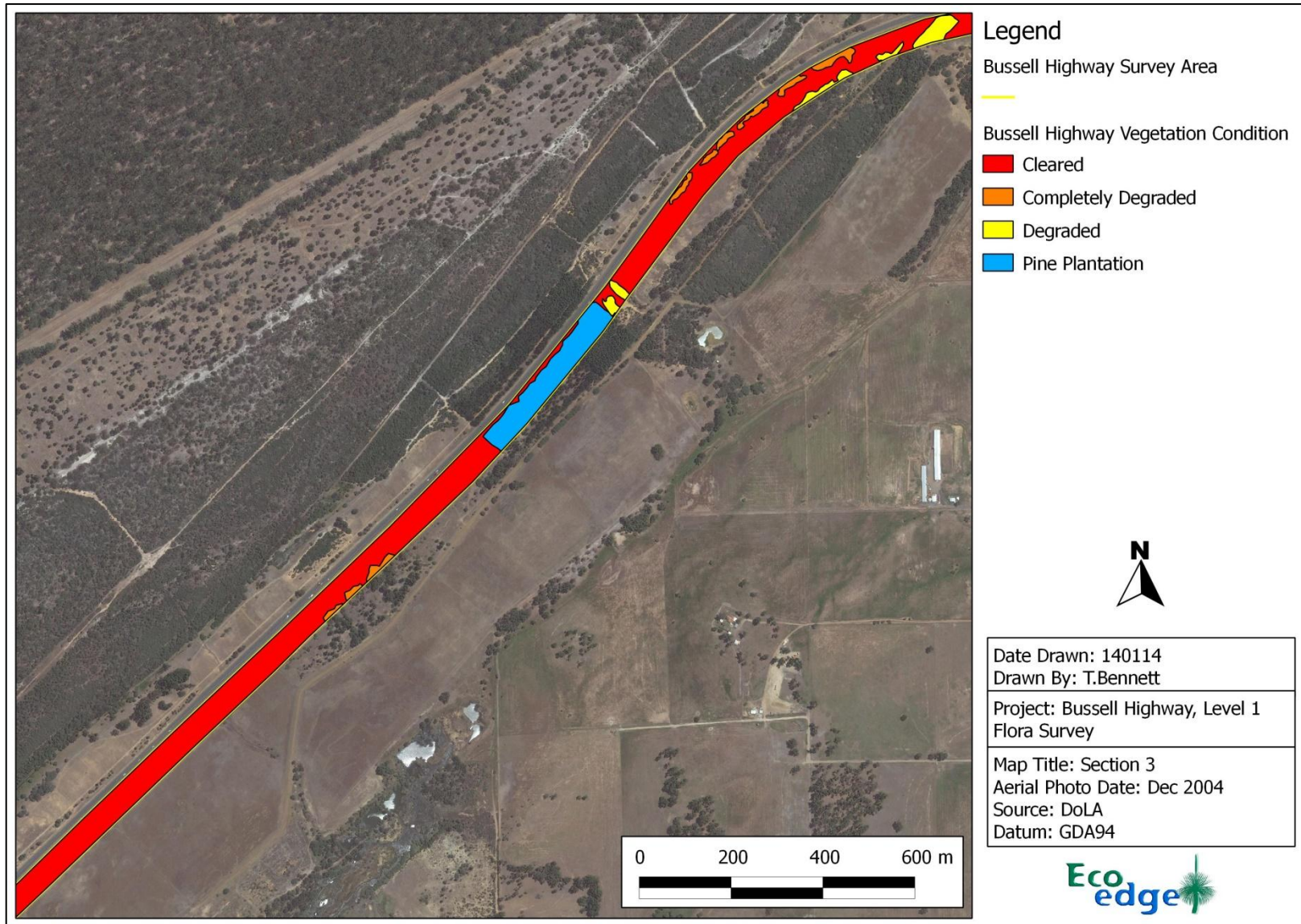


Figure 28. Vegetation condition of Section 3 of the Survey Area.

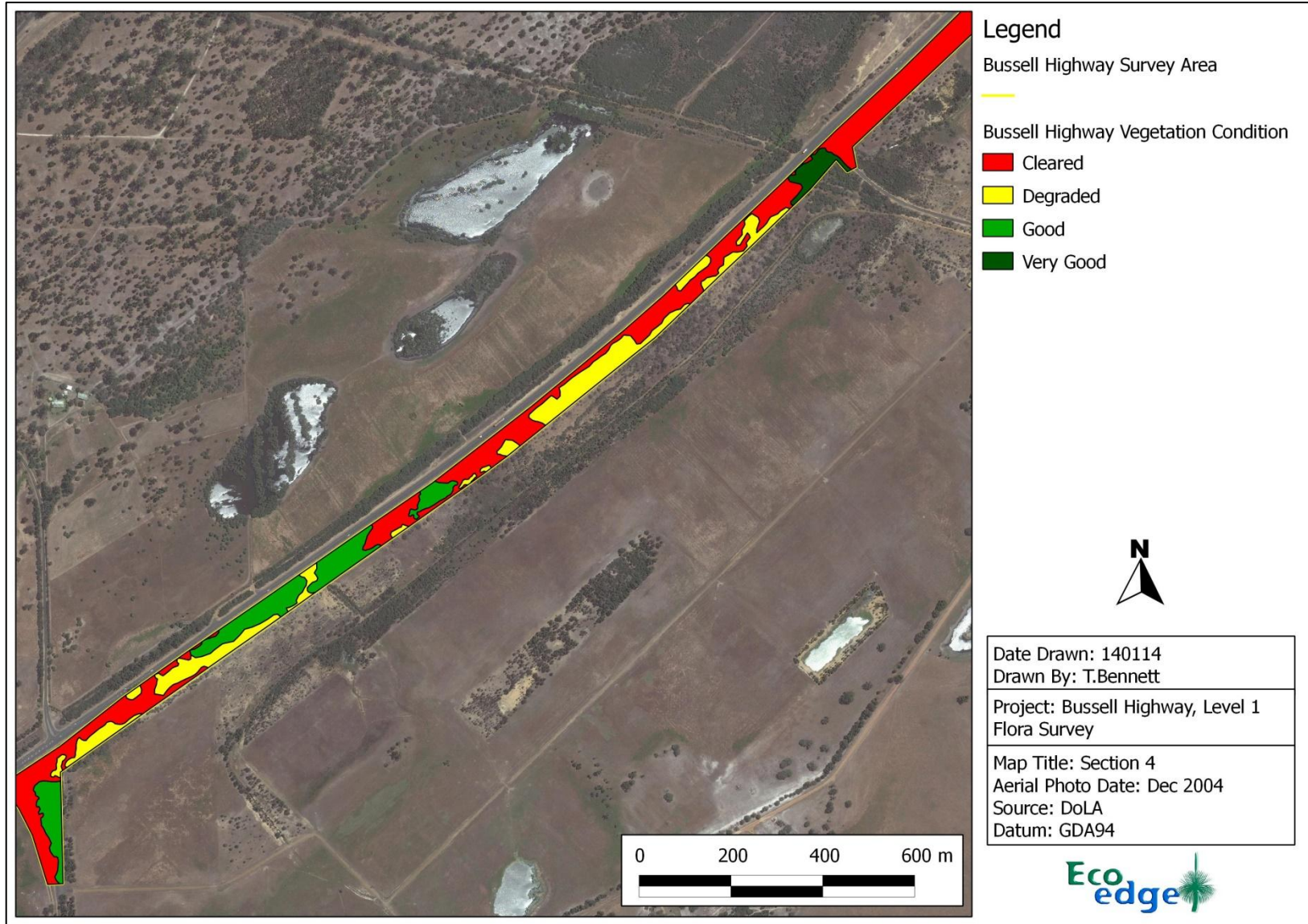


Figure 29. Vegetation condition of Section 4 of the Survey Area.

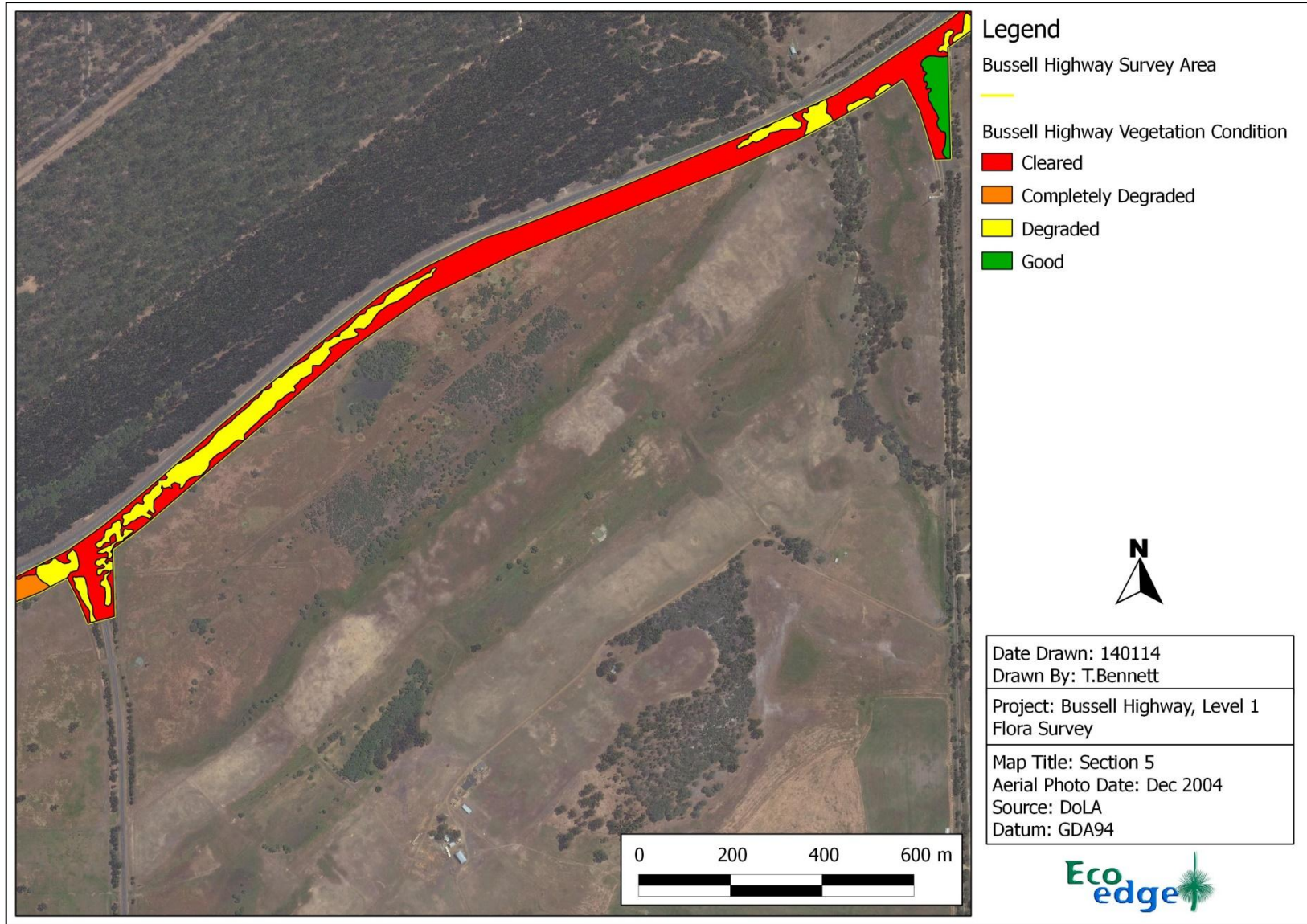


Figure 30. Vegetation condition of Section 5 of the Survey Area.

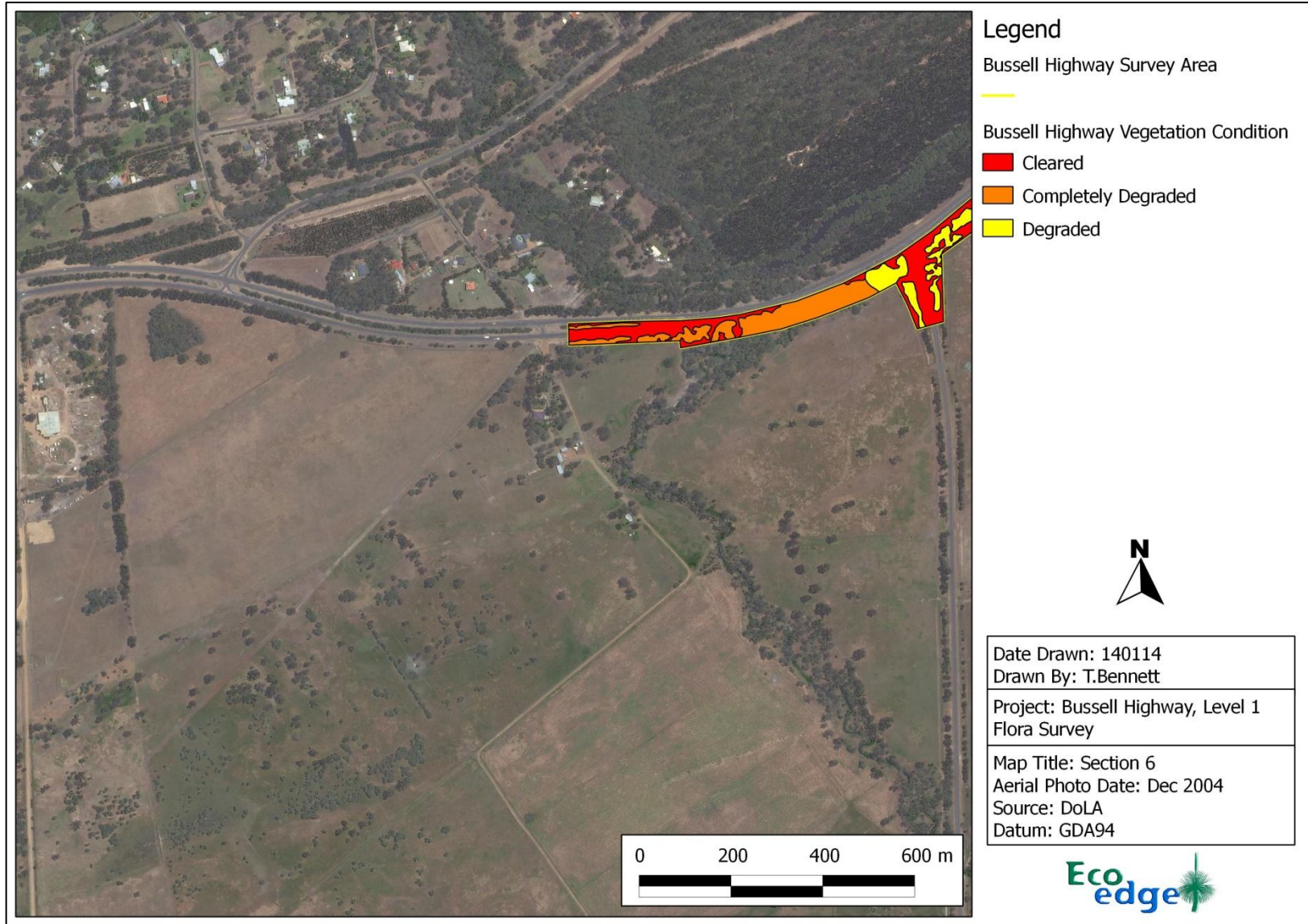


Figure 31. Vegetation condition of Section 6 of the Survey Area.

5 Discussion

5.1 Rare Flora

The populations of Priority flora in the Survey Area should be protected where possible because they are all under a degree of threat. The occurrence of *Synaphea petiolaris* subsp. *simplex*, in particular, should be protected both because it has the highest threat rating and because it occurs within an area of vegetation classified as “Very Good” condition. As noted above, this species is largely confined to the southernmost part of the Swan Coastal Plain, with many a large proportion of populations being situated on road and rail reserves. *Verticordia attenuata* is another taxon that is largely restricted to road and rail reserves on the southern Swan Coastal Plain and is therefore vulnerable to physical disturbance associated with road maintenance activities.

5.2 Vegetation Units

Nine vegetation units were recognised in the Survey Area (**Figures 20 to 25**), of which two consist almost solely of introduced species (Units A1 and A2). Another vegetation unit (F) represents the revegetated areas and also has a high proportion of introduced species and can be regarded as an artificial plant community. In light of this, Vegetation Units A1, A2 and F will not be considered further in this discussion.

5.3 Vegetation Unit B

Vegetation Unit B occurs in riverine areas on soils mapped as Abba (AbCKw, AbABvw soil phases), Spearwood (SpLD1 soil phase) or Bassendean (BsGCd2, Bs_B5 and BsX_MINE soil phases) soil landscape systems. It is usually in a Degraded condition, with the understorey dominated by introduced species, particularly the grass *Ehrharta calycina*. This unit represents an example of the “Riverine Sandy Soil Plant Communities” of the Busselton Plain (Webb *et al.*, 2009). No Floristic Community Types (FCTs) (Gibson *et al.*, 1994) (or Threatened Ecological Communities) have been recognised for these communities, and because of the almost complete lack of relatively intact occurrences, it is unlikely that any will be (Webb *et al.*, 2009).

5.4 Vegetation Unit C

Vegetation Unit C represents degraded examples of the Southern *Eucalyptus gomphocephala*, *Agonis flexuosa* woodlands (SWAFCT25) community on the Bassendean soil-landscape system (Bs_B1b, BsX_MINE soil phases), and “*Eucalyptus cornuta* and *Agonis flexuosa* Open Low Forest” on the Spearwood soil-landscape system (SpLD1 soil phase) at the southern end of the Survey Area (Webb *et al.*, 2009). All occurrences of this vegetation unit were classified as ‘Degraded’ or ‘Completely Degraded’. The Yate (*Eucalyptus cornuta*) dominated occurrence of this unit at the southern end of the Survey Area is amongst the only recorded occurrences of Yate on the Swan Coastal Plain. Yate dominated vegetation on the Swan Coastal Plain are listed as a Priority 1 ecological community (Webb *et al.*, 2009).

5.5 Vegetation Unit D

Vegetation Unit D is the most intact unit in the Survey Area, with most of it being in 'Good' to 'Very Good' condition. It occurs mainly on the Bassendean soil-landscape system (Bs_B1b, BsGCd2 soil phases), with a small, degraded example on soils mapped as Abba (AbABvw). Vegetation Unit D qualifies as an upland plant community of the Bassendean Dunes, however it does not match closely any of the three FCTs recorded on these soils (Webb *et al.*, 2009).

Within the Survey Area, Vegetation Unit D does not contain *Banksia attenuata* and so the unit does not qualify as either of the *Banksia* woodland communities (SWAFCT21a, SWAFCT21b). This species may have been removed from the community by *Phytophthora* dieback, to which it is highly susceptible. However, the generally good condition of the vegetation unit, plus the presence of other susceptible species within it makes this unlikely. Nevertheless, Vegetation Unit D does contain some taxa typical of SWAFCT21b (Southern *Banksia attenuata* woodlands), such as *Kunzea glabrescens*, *Hibbertia vaginata*, *Hypocalymma robustum* and *Stirlingia latifolia* (Gibson *et al.*, 1994).

Apart from the dominant tree species Jarrah and Marri (*Eucalyptus marginata* and *Corymbia calophylla*), Vegetation Unit D only contains a few species typical of the other identified FCT that occasionally occurs on Bassendean Dune soils (Southern *Corymbia calophylla* woodlands on heavy soils, SWAFCT01b) (Webb *et al.*, 2009). Instead, it appears to be an undescribed floristic community type that contains some of the taxa characteristic of Southern *Banksia attenuata* woodlands (SWAFCT21b), some wetland species in damper areas (e.g. *Banksia littoralis*, *Hakea varia*, *Meeboldina coangustata*) as well as several taxa characteristic of Quindalup Dune plant communities (e.g. *Hibbertia cuneiformis*, *Leucopogon parviflorus*, *Spyridium globulosum*).

Although it has been mapped as Vegetation Unit D, the small area of virtually intact woodland just south of the Ruabon Road intersection may in fact constitute a quite separate floristic community type. Although situated on soils mapped as part of the Bassendean system, it is very close to wetlands on Abba soils to the west and Spearwood Dune plant communities are located only 500 m away. Forty five plant taxa, most of them native, were recorded within this 0.5 ha area of woodland, including the Priority 2 taxon *Synaphea petiolaris* subsp. *simplex*. As well as Jarrah and Marri, there was *Eucalyptus rudis* subsp. *cratyantha*, *Melaleuca raphiophylla*, *Banksia littoralis* and *Banksia grandis* in the overstorey layer. Amongst the understorey species are *Acacia myrtifolia* and *A. alata* var. *alata*, which are uncommon on the Swan Coastal Plain.

Vegetation Unit D appears to be an undescribed 'interface' community, sharing some taxa with Abba, Bassendean and Spearwood plant communities and having representatives from upland and wetland communities. Because of its 'Very Good' vegetation condition, the

presence of a Priority two species and unusual combination of plant taxa, the area of woodland just south of the Ruabon Road intersection should be protected if practicable.

5.6 Vegetation Unit E

Vegetation Unit E occurs on Bassendean soils (Bs_B1b, BsGCd2 soil phases) and appears to be a degraded variant of Vegetation Unit D, with the introduced grasses **Ehrharta calycina* and **Eragrostis curvula* often dominating the understorey.

5.7 Vegetation Unit G

Structurally, this vegetation unit is a wet shrubland to open shrubland ranging in condition from 'Degraded' to 'Good'. It occurs along the boundary between the Bassendean (BsGCd2 soil phase) and Abba (AbCKw soil phase) soil-landscape systems but the soil (yellow-brown sandy clay loam to grey brown sandy loam) has more the characteristics of the AbCKw (Cokelup wet clayey flats) soil phase. Some of Vegetation Unit G occurs on land that was previously mined for mineral sands and these areas are probably the more degraded and less species-rich parts of the community.

Vegetation Unit G has some similarities to the "Shrublands on dry clay flats" (SWAFCT10a) and "Dense shrublands of clay flats" (SWAFCT09) floristic community types of Gibson *et al.* (1994) – both are threatened ecological communities. It appears that this unit represents the original vegetation of the Bassendean Dune orange sands which occur at the interface of the Bassendean Dunes with the Cokelup soils of the Abba soil-landscape system (Webb *et al.*, 2009) which has been extensively affected by mineral sands mining.

Sampling of this community using floristic quadrats followed by multivariate analysis may help to demonstrate the floristic affinities of this vegetation unit – however its level of degradation may make it difficult to obtain a definitive answer to the question.

Vegetation Unit G has conservation value both because it contains populations of the Priority 3 species *Verticordia attenuata* and because it represents, in parts, the original distinctive vegetation of a restricted soil type at the interface of the Bassendean and Abba soil-landscape systems.

5.8 Vegetation Unit H

This vegetation unit, which is structurally a tall open scrub to low open woodland in 'Degraded' to 'Good' condition, was found at one location at the northern end of the Survey Area on grey sand over clay mapped as Bassendean soil-landscape system (212Bs__B1b soil phase). Some of the area mapped as Vegetation Unit H was covered by standing water in October and appears to be receiving runoff from the Wonnerup Wetlands on the opposite side of the highway.

Vegetation Unit H is a wetland of the Bassendean soil-landscape system but it does not closely resemble either of the wetland floristic community types typical of this system

(SWAFCT12, SWAFCT13) nor does it resemble the *Melaleuca raphiophylla* Low Closed Forest with no perennial understorey species noted by Webb *et al.* (2009) to occur in the Bassendean Dunes. This unit appears to be an unrecognised floristic community type of the Bassendean Dune wetlands. It has conservation value because it is, in places, a relatively intact wetland in a landscape where many wetlands are highly modified by mining and agriculture, and because it contains the Priority 3 species *Verticordia attenuata*.

5.9 Environmentally Sensitive Areas (ESAs)

Environmentally sensitive areas are protected under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* and are selected for their environmental values at state or national levels (Government of Western Australia, 2013h). They include;

- Defined wetlands and riparian vegetation within 50m;
- Areas covered by Threatened Ecological Communities;
- Area of vegetation within 50m of Declared Rare Flora
- Bush Forever sites; and
- Declared World Heritage property sites.

The wetlands of much of the Swan Coastal Plain were mapped and classified by Hill *et al.* (1996) into three categories of significance (Conservation, Resource Enhancement and Multiple Use). About 26% of the Survey Area is classified as “Multiple Use” wetland; this category is described as: “Wetlands with few important ecological attributes and functions remaining” (Water and Rivers Commission (WRC), 2001). Multiple Use wetlands are not considered as ESAs. However, a small part of the Survey Area about 250 m west of the Hithergreen Road intersection falls within the 50 m ESA buffer around a “Conservation” category wetland. Part of the wetland vegetation associated with this ESA, although not mapped by Hill *et al.* (1996), extends into the Survey Area and was mapped as Vegetation Unit B (**Figure 20 to 25**).

Conservation category wetlands are regarded as supporting a high level of ecological attributes and functions. The WRC states that these are the highest priority wetlands and the management objective is:

Preservation of wetland attributes and functions through various mechanisms including:

- *reservation in national parks, crown reserves and State owned land,*
- *protection under Environmental Protection Policies, and*
- *wetland covenanting by landowners.*

These are the most valuable wetlands and the Commission will oppose any activity that may lead to further loss or degradation. No development.

As discussed in **Section 5.6** above, Vegetation Unit E has some similarities to two wetland Threatened Ecological Communities, however it appears to not be either of those communities but another floristic community type that was not sampled by Gibson *et al.* (1994) or in subsequent regional surveys.

As noted in **Section 4.1** no Declared Rare Flora were found within the Survey Area.

Therefore none of the Survey Area can be designated as an ESA on the basis of the presence of Threatened Ecological Communities or Declared Rare Flora. The Survey Area also does not contain any Bush Forever sites or Declared World Heritage property sites.

5.10 Conservation Status of Vegetation Complexes within the Survey Area

As discussed in **Section 1.5** above, the Survey Area is mapped as Southern River Complex, Abba (AF, Ad) and Ludlow (Lw) vegetation complexes (Hedde *et al.*, 1980, Mattiske and Havel, 1998, Molloy *et al.*, 2007). All of these complexes are poorly reserved, with less than 5% of the pre-European Area in formal and informal conservation reserves.

5.11 Recommendations

Because of its 'Very Good' vegetation condition, the presence of a Priority two species and unusual combination of plant taxa, the area of woodland just south of the Ruabon Road intersection (Vegetation Unit D) should be protected if practicable.

The populations of Priority flora in the Survey Area should be protected where possible because they are all under a degree of threat. The occurrence of *Synaphea petiolaris* subsp. *simplex*, in particular, should be protected both because it has the highest threat rating and because it occurs within an area of vegetation classified as "Very Good" condition.

The Yate (*Eucalyptus cornuta*) dominated occurrence of Vegetation Unit C at the southern end of the Survey Area is amongst the only recorded occurrences of Yate on the Swan Coastal Plain. Yate dominated vegetation on the Swan Coastal Plain are listed as a Priority 1 ecological community (Webb *et al.*, 2009). This occurrence should be protected if possible.

6 References

(Not necessarily cited)

Aplin, T.E.H. (1979). *The flora*. In: Environment and Science. Ed: B.J. O'Brien. University of WA Press, Perth.

Australian Government (2009), *Interim Biogeographic Regionalisation of Australia (IBRA) Version 6.1*, Department of the Environment, Water, Heritage and the Arts. Retrieved January 2011 from <http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html>

Bolland, M. (1998). *Soils of the Swan Coastal Plain*. Department of Agriculture and Food, Perth, Western Australia

Brown, A., Dixon, K., French, C. and Brockman, G. (2013). *Field Guide to the Orchids of Western Australia – The Definitive Guide to the Native Orchids of Western Australia*. Simon Nevill Publications.

Brown, A., Dundas, P., Dixon, K. and Hopper, S. (2008). *Orchids of Western Australia*. University of Western Australia Press.

Churchward H. M. & McArthur W.M. (1980), '*Landforms and Soils of the Darling System*' in *Atlas of Natural Resources, Darling System*, Western Australia. Government of Western Australia.

Commonwealth of Australia (2001) *National Objectives and Targets for Biodiversity Conservation 2001-2005*. Environment Australia, Department of Environment and Heritage, Canberra, Australian Capital Territory.

Conservation and Land Management (CALM) (1999) *Environmental Weed Strategy For Western Australia*. CALM. Perth, Western Australia.

Cropper, S.C. (1993). *Management of endangered plants*. CSIRO, Melbourne.

Department of Agriculture and Food (DAFWA). 2011. *Agriculture and Related Resources Protection Act 1976; Declared Plants*, January 2011. http://www.agric.wa.gov.au/PC_93088.html

Department of Conservation and Land Management. (CALM) (1999). *Environmental Weed Strategy for Western Australia*.

Department of Environment and Conservation (DEC) (2010a) *Definitions, categories and criteria for threatened and priority ecological communities* Department of Environment and Conservation, Perth, Western Australia

Department of Environment and Conservation (DEC) (2010b). *Max Version 20101028*. Department of Environment and Conservation

Department of Environment and Conservation (DEC) (2012b). *Species Database Management Software (Max), updated 7th June 2012*. Department of Environment and Conservation, Western Australian Herbarium.

Department of Parks and Wildlife (DPaW) (2013a). *Threatened ecological communities endorsed by the Minister for the Environment* (May 2013). <http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatened-ecological-communities>

Department of Parks and Wildlife (DPaW) (2013b). *Threatened and Priority Ecological Community Buffers in WA*. Extract from the DPaW Species and Communities Branch dated 1 February 2013.

Department of Parks and Wildlife (DPaW) (2013c). *Priority ecological communities list (September 2013)*. Department of Parks and Wildlife. <http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatened-ecological-communities>

Department of Parks and Wildlife (DPaW) (2013d). *Western Australian Flora Conservation Taxa*. <http://florabase.dpaw.wa.gov.au/conservationtaxa> or <http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/listing>

Department of Parks and Wildlife (DPaW) (2013e). *Extract from the Department's Threatened (Declared Rare) Flora database and the Western Australian Herbarium*. DPaW Species and Communities Branch dated 1 February 2013.

Department of Parks and Wildlife (DPaW) (2013f). *Naturemap*, Western Australian Herbarium. <http://naturemap.dec.wa.gov.au/default.aspx>

Department of Parks and Wildlife (DPaW) (2013g). *The WA Herbarium Census of WA Plants Database (WACENSUS: 'Max' update 24/09/2013)*.

Department of Parks and Wildlife (DPaW) (2013h). *Florabase*, Western Australian Herbarium. <http://florabase.dpaw.wa.gov.au/>

- Department of Parks and Wildlife (DPaW) (2013i). *Conservation Codes for Western Australian Flora and Fauna*. <http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/listing>.
- Department of Sustainability, Environment, Water, Population and Communities. (SEWPaC) (2013a). *Threatened ecological communities under the EPBC Act*. <http://www.environment.gov.au/biodiversity/threatened/communities.html> accessed 19 September 2013
- Department of Sustainability, Environment, Water, Population and Communities. (SEWPaC) (2013b). *Protected Matters Search Tool query*, generated 21 October 2013
- Department of Sustainability, Environment, Water, Population and Communities. (SEWPaC) (2013c). *Environment Protection and Biodiversity Conservation Act. Species Profile and Threats Database*. <http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl> accessed 19 September 2013
- Environment Australia (2001). *National objectives and targets for biodiversity conservation 2001–2005*. <http://www.environment.gov.au/resource/national-objectives-and-targets-biodiversity-conservation-2001%E2%80%932005>
- Environmental Protection Authority (2000). *Environmental Protection of Native Vegetation in Western Australia. EPA Position Statement No. 2*. EPA, Perth
- Environmental Protection Authority of WA (2004). *Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia, Guidance Statement No. 51*.
- Environmental Protection Authority (2006). *Level of Assessment for Proposals affecting Natural Area within the System 6 Region and Swan Coastal Plain Portion of the System 1 Region*. Guidance Statement No. 10, June 2006, Perth.
- Gibson, N., Keighery, B.J., Keighery, G.J., Burbidge, A.H. and Lyons, M.N. (1994). *A floristic survey of the southern Swan Coastal Plain: report to Heritage Council of W.A. and Australian Heritage Commission*. Department of Conservation and Land Management, Western Australia.
- Government of Western Australia (1950). *Wildlife Conservation Act 1950*. Perth, Western Australia
- Government of Western Australia (2010). *Wildlife Conservation Act 1950, Wildlife Conservation (Rare Flora) Notice 2010(2)*. Government Gazette, 17 August 2010.

- Government of Western Australia. (2011). *2011 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis*. WA Department of Environment and Conservation, Perth.
- Government of Western Australia. (2013a). *2012 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of October 2012*. WA Department of Environment and Conservation, Perth, <https://www2.landgate.wa.gov.au/web/guest/downloader>
- Government of Western Australia. (2013b). *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. http://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_1384_homepage.html
- Greening Australia. (2013). *Florabank: Eucalyptus rudis factsheet*. http://www.florabank.org.au/lucid/key/species%20navigator/media/html/Eucalyptus_rudis.htm
- Hanran-Smith (2002). *River Action Plan for the Sabina, Abba and Ludlow Rivers, Volume 2. Maps and Recommendations for Abba River (2002). Prepared for the Geographer Catchment Council –GeoCatch and the Vasse-Wonnerup and Conservation District Committee*.
- Havel, J.J. and Mattiske, E.M. (2000). *Vegetation mapping of south west forest regions of Western Australia*. CALMScience Division, Australia. Environment Australia, Pagination: 113 p.
- Hedde, E. M., Loneragan, O. W. & Havel, J. J. (1980). *Vegetation complexes of the Darling System, Western Australia. In: Atlas of Natural Resources, Darling System, Western Australia*. Department of Conservation and Environment, Perth, 37-72.
- Hill, A. L., Semeniuk, C. A., Semeniuk, V. and Del Marco, A. (1996). *Wetlands of the Swan Coastal Plain Volume 2B Wetland Mapping, Classification and Evaluation: Wetland Atlas*. Water and Rivers Commission and Department of Environmental Protection, Western Australia.
- Hoffman, N. and Brown, A. (2011). *Orchids of South – West Australia*. Noel Hoffman.
- IUCN (2013). *World Conservation Union (IUCN) protected area categories 2013*. http://www.iucn.org/about/work/programmes/gpap_home/gpap_quality/gpap_categories/
- Keighery, B. J. (1994). *Bushland Plant Survey: A guide to plant community survey for the community*. Wildflower Society of Western Australia (Inc.), Nedlands

- Keighery, G., Keighery, B. and Gibson, N. (1996b). *Floristics of reserves and bushland areas of the Whicher Scarp 1: flora and vegetation of Dardanup Forest Block*. Department of Environment and Conservation, Western Australia.
- Keighery, B.J., Keighery, G.J., Webb, A., Longman, V.M., Griffin E.A . (2008). *A floristic survey of the Whicher Scarp*. Department of Environment and Conservation, Perth. 272 p.
- Keighery, B. and Trudgen, M. (1992). *Remnant Vegetation on the alluvial soils of the eastern side of the Swan Coastal Plain*. Department of Environment and Conservation, Western Australia.
- Mattiske, E.M. and Havel, J.J., 1998. *Vegetation Complexes of the South-west Forest Region of Western Australia. Maps and report prepared as part of the Regional Forest Agreement*. Western Australia for the Department of Conservation and Land Management and Environment Australia. Western Australia.
- Mattiske Consulting and Havel. J.J. (2002). *Review of management options for poorly represented vegetation complexes*. Report to the Conservation Commission of Western Australia.
- McArthur, W.M. and Bettenay, E. (1960). *The development and distribution of the soils of the Swan Coastal Plain, Western Australia*. Soil Publication No 16, CSIRO, Melbourne.
- McArthur, W.M. and Bettenay, M. (1974). *The Development and distribution of the Soils of the Swan Coastal Plain, Western Australia*. CSIRO Soil Publication No. 16, (Second Edition).
- Molloy, S., O'Connor, T., Wood, J. and Wallrodt, S. (2007a). *Addendum for the South West Biodiversity Project Area*. Western Australian Local Government Association, West Perth, Western Australia
- Molloy, S., O'Connor, T., Wood, J. and Wallrodt, S. (2007b). *Reservation levels of vegetation complexes and systems with reserve status as at June 2006. Local Government Biodiversity Planning Guidelines: Addendum to the South West Biodiversity Project Area*, Western Australian Local Government Association, West Perth.
- Molloy, S., Wood, J., Hall, S., Wallrodt, S. and Whisson, G. (2009) *South West Regional Ecological Linkages Technical Report*, Western Australian Local Government Association (WALGA) and Department of Environment and Conservation (DEC), Perth, Western Australia
- Muir, B.G. (1977). *Biological Survey of the Western Australian Wheatbelt. Part II. Vegetation and habitat of Bendering Reserve*. Records of the West Australian Museum, Supplement No. 3.

Onshore Environmental Consultants Pty Ltd (2009). *Flora and Vegetation Survey, Location 7 (Wonnerup)*. Prepared for Bemax Resources incorporating Cable Sands (Bemax Resources).

Waters and Rivers Commission (WRC). (2001). Water and Rivers Commission Position Statement: Wetlands.

Webb, A, Keighery, B.J., Keighery, G.J., Longman, V. (2009). *The flora and vegetation of the Busselton Plain (Swan Coastal Plain): a report for the Department of Environment and Conservation as part of the Swan Bioplan Project*. Dept. of Environment and Conservation, Perth, Western Australia.

7 Appendix 1. Protected Matters Search Tool Report (attached)

8 Appendix 2. List of Vascular Flora Identified within the Survey Area

FAMILY	SPECIES NAME	COMMENT	NATURALISED	CONSV_CODE
Anarthriaceae	<i>Lyginia barbata</i>			
	<i>Lyginia imberbis</i>			
Apiaceae	<i>Xanthosia huegelii</i>			
Araceae	<i>Zantedeschia aethiopica</i>		*	
Araliaceae	<i>Trachymene pilosa</i>			
Asparagaceae	<i>Asparagus asparagoides</i>		*	
	<i>Lomandra suaveolens</i>			
	<i>Sowerbaea laxiflora</i>			
	<i>Thysanotus arenarius</i>			
	<i>Thysanotus manglesianus</i>			
	<i>Thysanotus tenellus</i>			
Asphodelaceae	<i>Trachyandra divaricata</i>		*	
Asteraceae	<i>Arctotheca calendula</i>		*	
	<i>Cotula coronopifolia</i>		*	
	<i>Cotula turbinata</i>		*	
	<i>Hypochaeris glabra</i>		*	
	<i>Lagenophora huegelii</i>			
	<i>Podotheca angustifolia</i>			
	<i>Rhodanthe citrina</i>			
	<i>Rhodanthe corymbosa</i>			
	<i>Siloxerus humifusus</i>			
	<i>Sonchus asper</i>		*	
	<i>Ursinia anthemoides</i>		*	
Brassicaceae	<i>Brassica napus</i>	?	*	
Campanulaceae	<i>Lobelia gibbosa</i>			
	<i>Wahlenbergia capensis</i>		*	
Caryophyllaceae	<i>Petrorhagia dubia</i>		*	
	<i>Silene gallica</i>		*	

FAMILY	SPECIES NAME	COMMENT	NATURALISED	CONSV_CODE
Casuarinaceae	<i>Allocasuarina humilis</i>			
	<i>Allocasuarina thuyoides</i>	Planted		
Celastraceae	<i>Stackhousia monogyna</i>			
	<i>Tripterococcus brunonis</i>			
Centrolepidaceae	<i>Aphelia cyperoides</i>			
	<i>Centrolepis aristata</i>			
Colchicaceae	<i>Burchardia congesta</i>			
Crassulaceae	<i>Crassula colorata</i>			
Cyperaceae	<i>Baumea juncea</i>			
	<i>Ficinia nodosa</i>			
	<i>Gahnia trifida</i>			
	<i>Lepidosperma longitudinale</i>			
	<i>Lepidosperma squamatum</i>			
	<i>Mesomelaena tetragona</i>			
	<i>Schoenoplectus pungens</i>			
	<i>Tetraria capillaris</i>			
	<i>Tetraria octandra</i>			
Dasypogonaceae	<i>Dasypogon bromeliifolius</i>			
Dennstaedtiaceae	<i>Pteridium esculentum</i>			
Dilleniaceae	<i>Hibbertia cuneiformis</i>			
	<i>Hibbertia hypericoides</i>			
	<i>Hibbertia racemosa</i>			
	<i>Hibbertia vaginata</i>			
Droseraceae	<i>Drosera erythrorhiza</i>			
	<i>Drosera glanduligera</i>			
	<i>Drosera menziesii</i>			
	<i>Drosera pallida</i>			
Elaeocarpaceae	<i>Platytheca galioides</i>			

FAMILY	SPECIES NAME	COMMENT	NATURALISED	CONSV_CODE
Elaeocarpaceae	<i>Tetratheca hirsuta</i>			
Ericaceae	<i>Leucopogon conostephioides</i>			
	<i>Leucopogon parviflorus</i>			
	<i>Leucopogon propinquus</i>			
Fabaceae	<i>Acacia alata</i>			
	<i>Acacia applanata</i>			
	<i>Acacia dealbata</i>		*	
	<i>Acacia extensa</i>			
	<i>Acacia huegelii</i>			
	<i>Acacia incurva</i>			
	<i>Acacia iteaphylla</i>		*	
	<i>Acacia longifolia</i>		*	
	<i>Acacia melanoxylon</i>		*	
	<i>Acacia myrtifolia</i>	?		
	<i>Acacia podalyriifolia</i>		*	
	<i>Acacia pulchella</i>			
	<i>Acacia saligna</i>			
	<i>Acacia stenoptera</i>			
	<i>Bossiaea eriocarpa</i>			
	<i>Bossiaea</i> sp. Waroona (B.J. Keighery & N. Gibson 229)			
	<i>Daviesia divaricata</i>			
	<i>Daviesia incrassata</i>			
	<i>Daviesia physodes</i>			
	<i>Dipogon lignosus</i>		*	
	<i>Eutaxia virgata</i>			
	<i>Gastrolobium praemorsum</i>			
	<i>Gompholobium tomentosum</i>			
	<i>Hardenbergia comptoniana</i>			

FAMILY	SPECIES NAME	COMMENT	NATURALISED	CONSV_CODE
Fabaceae	<i>Hovea trisperma</i>			
	<i>Jacksonia furcellata</i>			
	<i>Kennedia prostrata</i>			
	<i>Lotus subbiflorus</i>		*	
	<i>Lupinus cosentinii</i>		*	
	<i>Mirbelia dilatata</i>			
	<i>Ornithopus compressus</i>		*	
	<i>Trifolium arvense</i>		*	
	<i>Vicia sativa</i>		*	
	<i>Viminaria juncea</i>			
Geraniaceae	<i>Erodium botrys</i>		*	
	<i>Erodium cicutarium</i>		*	
Goodeniaceae	<i>Dampiera linearis</i>			
	<i>Goodenia pulchella</i> subsp. Coastal Plain B (L.W. Sage 2336)			
	<i>Scaevola calliptera</i>			
Haemodoraceae	<i>Anigozanthos manglesii</i>			
	<i>Anigozanthos viridis</i>			
	<i>Conostylis aculeata</i>			
	<i>Conostylis candicans</i>			
	<i>Conostylis serrulata</i>			
	<i>Haemodorum spicatum</i>			
Hemerocallidaceae	<i>Agrostocrinum hirsutum</i>			
	<i>Tricoryne elatior</i>			
Hypoxidaceae	<i>Hypoxis occidentalis</i>			
Iridaceae	<i>Gladiolus angustus</i>		*	
	<i>Patersonia occidentalis</i>			
	<i>Patersonia umbrosa</i>			
	<i>Watsonia meriana</i>		*	

FAMILY	SPECIES NAME	COMMENT	NATURALISED	CONSV_CODE
Juncaceae	<i>Juncus holoschoenus</i>			
	<i>Juncus microcephalus</i>		*	
	<i>Juncus pallidus</i>			
	<i>Juncus planifolius</i>			
Lamiaceae	<i>Hemiandra pungens</i>			
Lauraceae	<i>Cassytha racemosa</i>			
Lentibulariaceae	<i>Utricularia violacea</i>			
Loganiaceae	<i>Logania serpyllifolia</i> subsp. <i>angustifolia</i>			
	<i>Phyllangium paradoxum</i>			
Loranthaceae	<i>Nuytsia floribunda</i>			
Menyanthaceae	<i>Ornduffia</i> sp.			
Myrtaceae	<i>Agonis flexuosa</i>			
	<i>Astartea leptophylla</i>			
	<i>Astartea scoparia</i>	?		
	<i>Callistemon glaucus</i>	Planted		
	<i>Calothamnus quadrifidus</i>	Planted		
	<i>Corymbia calophylla</i>			
	<i>Darwinia vestita</i>	?		
	<i>Eremaea pauciflora</i>			
	<i>Eucalyptus cornuta</i>			
	<i>Eucalyptus gomphocephala</i>			
	<i>Eucalyptus marginata</i>			
	<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>			P4
	<i>Eucalyptus sideroxylon</i>	?	*	
	<i>Hypocalymma angustifolium</i>			
	<i>Hypocalymma robustum</i>			
	<i>Kunzea glabrescens</i>			
	<i>Kunzea micrantha</i>	Planted		

FAMILY	SPECIES NAME	COMMENT	NATURALISED	CONSV_CODE
Myrtaceae	<i>Kunzea recurva</i>			
	<i>Leptospermum laevigatum</i>		*	
	<i>Melaleuca huegelii</i>	Planted		
	<i>Melaleuca incana</i>			
	<i>Melaleuca osullivanii</i>	?		
	<i>Melaleuca preissiana</i>			
	<i>Melaleuca raphiophylla</i>			
	<i>Melaleuca teretifolia</i>			
	<i>Melaleuca thymoides</i>			
	<i>Melaleuca viminea</i>			
	<i>Taxandria linearifolia</i>			
	<i>Verticordia attenuata</i>			P3
	<i>Verticordia densiflora</i> var. <i>densiflora</i>			
Orchidaceae	<i>Caladenia attingens</i>			
	<i>Caladenia flava</i>			
	<i>Caladenia paludosa</i>			
	<i>Disa bracteata</i>		*	
	<i>Elythranthera brunonis</i>			
	<i>Elythranthera emarginata</i>			
	<i>Microtis alba</i>			
	<i>Microtis media</i>			
	<i>Pterostylis recurva</i>			
	<i>Pterostylis vittata</i>			
	<i>Pyrorchis nigricans</i>			
	<i>Thelymitra crinita</i>			
	<i>Thelymitra macrophylla</i>			
Orobanchaceae	<i>Orobanche minor</i>		*	
Oxalidaceae	<i>Oxalis pes-caprae</i>		*	

FAMILY	SPECIES NAME	COMMENT	NATURALISED	CONSV_CODE
Papaveraceae	<i>Fumaria muralis</i>		*	
Phyllanthaceae	<i>Phyllanthus calycinus</i>			
Pinaceae	<i>Pinus pinaster</i>		*	
Pittosporaceae	<i>Billardiera heterophylla</i>			
Plantaginaceae	<i>Plantago lanceolata</i>		*	
Poaceae	<i>Austrostipa compressa</i>			
	<i>Austrostipa semibarbata</i>			
	<i>Avena fatua</i>		*	
	<i>Briza maxima</i>		*	
	<i>Briza minor</i>		*	
	<i>Bromus diandrus</i>		*	
	<i>Bromus hordeaceus</i>		*	
Poaceae	<i>Cenchrus clandestinus</i>		*	
	<i>Ehrharta calycina</i>		*	
	<i>Eragrostis curvula</i>		*	
	<i>Holcus lanatus</i>		*	
	<i>Lagurus ovatus</i>		*	
	<i>Lolium multiflorum</i>		*	
	<i>Microlaena stipoides</i>			
	<i>Neurachne alopecuroidea</i>			
	<i>Rytidosperma occidentale</i>			
Polygalaceae	<i>Comesperma calymega</i>			
	<i>Acetosella vulgaris</i>		*	
	<i>Rumex crispus</i>		*	
Primulaceae	<i>Lysimachia arvensis</i>		*	
Proteaceae	<i>Adenanthos meisneri</i>			
	<i>Banksia attenuata</i>			
	<i>Banksia dallanneyi</i>			

FAMILY	SPECIES NAME	COMMENT	NATURALISED	CONSV_CODE
Proteaceae	<i>Banksia grandis</i>			
	<i>Banksia littoralis</i>			
	<i>Banksia menziesii</i>			
	<i>Banksia nivea</i> subsp. <i>uliginosa</i>	(?) Planted		
	<i>Grevillea diversifolia</i>			
	<i>Grevillea variifolia</i>			
	<i>Hakea prostrata</i>			
	<i>Hakea ruscifolia</i>			
	<i>Hakea varia</i>			
	<i>Persoonia longifolia</i>			
	<i>Petrophile linearis</i>			
	<i>Stirlingia latifolia</i>			
	<i>Synaphea floribunda</i>			
	<i>Synaphea hians</i>			P3
	<i>Synaphea petiolaris</i> subsp. <i>simplex</i>	?		P2
	<i>Xylomelum occidentale</i>			
Restionaceae	<i>Desmocladius fasciculatus</i>			
	<i>Desmocladius flexuosus</i>			
	<i>Hypolaena exsulca</i>			
	<i>Hypolaena pubescens</i>			
	<i>Loxocarya cinerea</i>			
	<i>Loxocarya cinerea</i>			
	<i>Meeboldina coangustata</i>			
	<i>Meeboldina roycei</i>			
Rhamnaceae	<i>Spyridium globulosum</i>			
Rutaceae	<i>Philothea spicata</i>			
Santalaceae	<i>Exocarpos odoratus</i>			
Solanaceae	<i>Solanum nigrum</i>		*	

FAMILY	SPECIES NAME	COMMENT	NATURALISED	CONSV_CODE
Stylidiaceae	<i>Levenhookia pusilla</i>			
	<i>Levenhookia stipitata</i>			
	<i>Stylidium brunonianum</i>			
	<i>Stylidium calcaratum</i>			
	<i>Stylidium ciliatum</i>			
	<i>Stylidium junceum</i>			
	<i>Stylidium repens</i>			
Thymelaeaceae	<i>Pimelea lanata</i>			
Typhaceae	<i>Typha domingensis</i>			
Xanthorrhoeaceae	<i>Xanthorrhoea brunonis</i>			
	<i>Xanthorrhoea gracilis</i>			
	<i>Xanthorrhoea preissii</i>			
Zamiaceae	<i>Macrozamia riedlei</i>			

9 Appendix 3. Photographs of Vegetation Units



Vegetation Unit A1

Pine Plantation (**Pinus pinaster* with occasional **Asparagus asparagoides*, *Hibbertia cuneiformis*, **Zantedeschia aethiopica* scattered shrubs and herbs)



Vegetation Unit A2

**Eucalyptus* spp. Plantings over introduced herbs and grasses.



Vegetation Unit B

Eucalyptus rudis subsp. *cratyantha* woodland/open woodland over *Agonis flexuosa*, *Melaleuca preissii* open low woodland with occasional *Corymbia calophylla* and *M. raphiophylla* over *Acacia saligna*, *Astartea* sp., *Melaleuca viminea* open shrubland over introduced herbs and grasses including **Ehrharta calycina* on grey-brown sandy-loam or loam.



Vegetation Unit C

Agonis flexuosa low woodland/low open woodland with scattered *Eucalyptus gomphocephala* or **Pinus pinaster* over *Kunzea glabrescens*, (**Acacia longifolia*) shrubland/open shrubland over introduced herbs and grasses including **Lupinus angustifolius*, **Ehrharta calycina* and **E. longifolia* on grey-brown sand/sandy loam or yellow-grey sand. (*Eucalyptus cornuta* replaces *E. gomphocephala* west of Sue's Road turnoff).



Vegetation Unit D

Eucalyptus marginata subsp. *marginata*, *Corymbia calophylla* with scattered *Nuytsia floribunda* woodland over *Kunzea glabrescens* shrubland over *Gastrolobium praemorsum*, *Hibbertia hypericoides*, *Leucopogon parviflorus*, *Stirlingia latiflora*, *Xanthorrhoea brunonis* low shrubland over *Tetraria octandra* open sedgeland on grey-brown or yellow-grey sand. (*Eucalyptus rudis* subsp. *cratyantha* and *Banksia littoralis* and shrubs such as *Hakea varia* and *H. prostrata* may occur in damper areas).



Vegetation Unit E

Corymbia calophylla woodland (sometimes with *Melaleuca raphiophylla*) over **Acacia* spp., *Hibbertia cuneiformis*, *Kunzea glabrescens*, (*Spyridium globulosum*) shrubland over introduced herbs and grasses including **Ehrharta calycina*, **Eragrostis curvula* and **Zantedeschia aethiopica* on grey-brown or yellow-brown sand.



Vegetation Unit F

**Acacia* spp., *Kunzea glabrescens* tall shrubland over *Adenanthos meisneri*, *Gastrolobium praemorsum*, (*Leucopogon conostephioides*) low shrubland over *Loxocarya cinerea* and introduced herbs and grasses on grey or yellow-brown sand. (Revegetated areas).



Vegetation Unit G

Kunzea glabrescens tall shrubland over *Acacia saligna*, *Adenanthos meisneri*, *Jacksonia furcellata*, *Kunzea recurva*, *Melaleuca viminea*, *Verticordia attenuata*, (*Verticordia densiflora* subsp. *densiflora*, *Viminaria juncea*) shrubland over *Conostylis aculeata*, *Patersonia occidentalis* open herbland and introduced herbs and grasses including on yellow-brown or yellow-grey sandy loams/sandy clay loams.



Vegetation Unit H

Melaleuca preissiana low open forest/low woodland over *Astartea scoparia*, *Melaleuca viminea*, *M. osullivanii* open heath/shrubland over *Baumea juncea* open sedgeland on grey sand over clay.