5.4 BANKSIA WOODLAND ASSESSMENT

Banksia Woodland is known to be supported by the study area, and therefore, an assessment was carried out to diagnose/characterise, map and quantify the extent of Banksia woodland TEC within and connected to the study area. Within areas of Banksia woodland within the study area and adjacent areas (for the purposes of "patch" mapping), vegetation condition was confirmed or determined and mapped in accordance with the adaptation of the Keighery (1994) and Trudgen (1988) condition scales (as per EPA 2016).

The Banksia woodland assessment methodology requires sampling of quadrats and analysis of this data to determine FCTs based on analysis against the Gibson *et al.* (1994) dataset. Areas of Banksia woodland within the study area were sampled from 36 pegged 10 m x 10 m quadrats.

FVC's tailored diagnostic tool has been developed in direct reference to the criteria listed in the Conservation Advice Threatened Species Scientific Committee (2016), which incorporates assessment of the following:

- IBRA region
- soil and landform systems
- overstorey layer (*Banksia* species)
- emergent or other tree layer (associated non-*Banksia* tree species)
- understorey/mid-ground sclerophyllous shrub layer species
- herbaceous ground layer species
- FCT
- continuity/connectedness
- condition.

The results of the field assessment and data analysis were used to determine the distribution of varying FCTs within mapped areas of Banksia woodland, which were also spatially mapped in terms of their condition. Spatial mapping of patches of Banksia woodland and the buffers around these was then carried out, by grouping Banksia woodland of adequate condition separated by less than 30 m.

5.5 DATA PROCESSING AND ANALYSIS

Flora identifications were undertaken by specialist taxonomist, Dr Udani Sirisena. Plant group specialist taxonomists were consulted where required for challenging identifications. Taxonomy and nomenclature follows current protocols of the WA Herbarium.

Field data collected on tablets within the mobile mapping software program, Mappt™ within customised data forms and spatial mapping shapefiles were downloaded for collation for the report.

Quadrat species lists, and flora identifications were entered into a customised Microsoft Access™ database called FloraData, which contains the WA flora inventory. The data was then able to be loaded into the PATN™ software (Belbin 2013) for floristic analysis.

Data was prepared for analysis including the grouping of some taxa to minimise or exclude ambiguity that could possibly be due to the identification of plants rather than a true difference in species composition. For example, removing infra-specific epithets and using only the specific epithet, considering uncertain species identification (indicated with '?') as the proper identification (e.g. *Drosera* ?*sewelliae* treated as *Drosera sewelliae*).

Data analysis carried out for flora quadrat data utilising PATN™ involves multivariate cluster analysis of species presence/absence. An association matrix of the Bray-Curtis coefficient was generated from the presence and absence site by species matrix using the software. The resultant dendrogram identified clusters of the quadrats which were then grouped into vegetation units and described at NVIS Level III and VI. Each local scale vegetation unit was then rationalised with regional vegetation associations as per Shepherd *et al.* (2002).

Grouping of site data and the characterisation and description to NVIS Level VI assisted with determination of floristic communities and potential TECs and PECs across the site. Rationalisation of recorded vegetation units with regional vegetation associations as documented in Shepherd *et al.* (2002) enabled an analysis of regional extent and representation, and therefore regional significance.

Vegetation datasets from recent and relevant studies in the surrounding region were analysed with collected field data to determine similarities between vegetation units recorded and enable an analysis of regional representation of the vegetation. The most recent and relevant dataset was that of Phoenix (2015) for the Muchea North and Chittering study area for the Great Northern Highway project.

The local and regional vegetation analysis again used multivariate cluster analysis of species presence/absence using PATN™ (Belbin 2013), with consolidated data from quadrats collected by FVC in 2017 and Phoenix (2015), providing a total of 117 sampling points. The resultant dendrogram was used to determine the similarity between the described vegetation units of the current survey and those from Phoenix (2015) to enable interpretation of the local distribution of vegetation units.

In order to understand the broader regional distribution of vegetation units within the study area, vegetation types recorded during the current FVC survey were matched with the vegetation associations of Shepherd *et al.* (2002), as well as the vegetation units described by Phoenix (2015). The resultant dendrogram was used to determine the similarity between the described vegetation units of the current survey plus those of Phoenix (2015) in comparison to the regional extent and distribution of the Shepherd *et al.* (2002) vegetation types.

5.6 STUDY LIMITATIONS

The limitations of the flora and vegetation assessment have been considered in accordance with the Technical Guidance (EPA 2016) and these are summarised in **Table 9**.

Table 9 Study Limitations

Aspect	Constraint?	Commentary
Availability of regional data	No	A number of studies have been previously completed within the local study area and wider region, reflected in the broad range of previous study reports reviewed and summarised in **Section 5.1**.
Scope (detail)	No	Detailed flora and vegetation assessments were carried out in accordance with EPA (2016). A collective total of 110 quadrats (inclusive of two relevés) have been sampled in the study area since October 2016. During the 2017 field assessments, field data was collected from a total of 89 pegged 10 m x 10 m quadrats. Survey effort was also invested in selective targeted surveys for Threatened and Priority flora, as well as separate intensive surveys dedicated to searching for two species of Threatened orchids; *Thelymitra stellata* and *Drakaea elastica*.
Experience of personnel	No	All of the personnel undertaking the field assessment, flora identifications, data analysis, vegetation mapping and reporting are experienced botanists, with specialist skills in their respective fields. All botanists have a minimum of eight and up to 19 years' experience. Field botanists are all experienced in undertaking surveys in the region, and in undertaking targeted significant flora surveys. Taxonomic identifications were undertaken by specifically trained taxonomists, including specialists in relevant groups, where required.
Survey effort/detail/ intensity	No	A total survey effort of 128 person-days was invested in the Level 2/detailed flora and vegetation assessments and the targeted Threatened and Priority Flora surveys across 2016 and 2017. These studies included the sampling of 117 quadrats across 12 vegetation units, with at least three quadrats per type. A total of 261 km of transects totalling approximately 250 ha of searched ground over 417 ha of 39 searched sites was included in the Targeted Threatened and Priority flora searches.
Seasonal timing and climatic conditions	Potentially somewhat	The field assessments were conducted during the full range of seasons, including spring surveys carried out during the optimal spring season, between October and November 2016 and between September and November 2017. Targeted surveys for significant flora were conducted during optimal flowering times for each target species, including the targeted *Thelymitra stellata* survey conducted in early November 2016 and 2017, and targeted *Drakaea elastica* surveys conducted during July 2017. The region experienced an unfavourable season with lower than expected rainfall during winter, with only 66.2 mm of rain in June 2017 and no rain between July and August 2017 (BoM 2018). No *Thelymitra stellata* individuals were observed from their known population near the study area during the surveillance surveys conducted across October and November 2017, as part of the targeted survey in November, possibly due to the little rainfall received by the region.
Access	Somewhat	The majority of the study area is easily accessible and being linear corridors, most areas are accessible at least on foot from nearby roads or properties. One significant sized area comprising 89.05 ha (2.60% of the study area), west of the railway line between Barn Road and Reichichi Road was unable to be accessed. A small pocket at the southern end and the northern portion of this area contains remnant native vegetation, which is considered likely to be representative of the Banksia Woodland TEC. This gap in data may be a constraint for the study and will limit the environmental impact assessment process. Application of the precautionary principle would assume that this area is equivalent to the Banksia Woodland TEC.

Aspect	Constraint?	Commentary
Mapping reliability	No	The mapping has been prepared at a scale based on mostly ground-truthed areas, with limited extrapolation given the good accessibility for most of the study area. Therefore, mapping reliability based on scale is considered high.
Disturbances	No	A large proportion (66.78%) of the total study area supports pasture with occasional trees or planted areas which include plantations and some small areas of rehabilitated vegetation. Only 23.78% of the study area was mapped to be in Good condition or better. However, significant areas were found to be in Very Good to Excellent and Excellent condition. The higher quality vegetation in a regional context of largely cleared vegetation is of greater significance in terms of conservation. Dieback infestations are apparent in some areas and weed invasion adjacent to pastoral areas are evident, however, within intact remnants, disturbance is mostly limited and is not considered to affect collected data.
Survey complete-ness	No	Most areas were easily accessible and there have been numerous surveys conducted in the study area over multiple seasons. The initial detailed flora and vegetation assessment was conducted in October 2016 with 46 quadrats and two releves across 13 vegetation communities. The second phase (autumn) detailed flora and vegetation assessment was conducted between March and August 2017 with 17 previously established quadrats re-sampled and an additional 13 new quadrats established. The third phase (spring) detailed flora and vegetation assessment was conducted between September and November 2017 with four previously established quadrats re-sampled and an additional 55 new quadrats established, of which 31 were regional quadrats. The spring 2017 assessment consolidated the vegetation into 12 separate units. Quadrat frequency provided at least three quadrats per vegetation unit.

6 RESULTS

6.1 FLORA

The desktop review determined that a total of 103 flora species of conservation significance have the potential to occur within the study area, based on previous records within or in the vicinity. A total of 11 Priority flora species were recorded within the study area during the range of field surveys conducted by FVC during 2016 and 2017. Seven species of Priority flora were recorded during spring 2016, two during autumn/winter 2017 and six during spring 2017. Three of these species were not able to be identified with certainty but are expected to be Priority flora (**Appendix A**, **Table 6**).

Six of the 103 species resulting from the desktop assessment have been determined to be 'likely' to occur in the study area, with 32 classified as 'may occur' and 55 considered 'unlikely' to occur based on the proximity of previous records, currency of data, and whether suitable habitat is provided in the study area. The remaining 10 species were recorded during the field assesments.

A collective total of 486 flora taxa from 207 genera and 59 families has been recorded throughout the study area between spring 2016 and spring 2017. During the field assessments in 2017 (autumn, winter and spring) there was a total of 416 taxa from 188 genera and 58 families recorded. The total includes 386 (93%) native and 30 (7%) introduced (weed) species. The dominant family species recorded were Fabaceae (51 (12.2%) species), Proteaceae (43 (10.3%) species) and Myrtaceae (41 (9.9%) species. The full list of vascular flora species recorded is presented in **Appendix B**, with the quadrats and vegetation units in which they were recorded presented in **Appendices C** and **D**, respectively.

None of the Threatened flora resulting for the desktop assessment (**Appendix A**) were recorded during the field assessments in 2017 and none of the recorded flora species are listed as Threatened under the WC Act or under the EPBC Act.

The 11 species listed as Priority flora which were recorded during the field studies, their conservation status and the survey areas, quadrats and vegetation units in which they occur are presented below in **Table 10** and the recorded locations (quadrats) are presented in the **Figure 11** series.

Two of the recorded flora species, *Jacksonia ? sericea* (P4) and *Synaphea* ?*flabelliformis* were found to be occurring outside their known range of distribution, based on Western Australian Herbarium records.

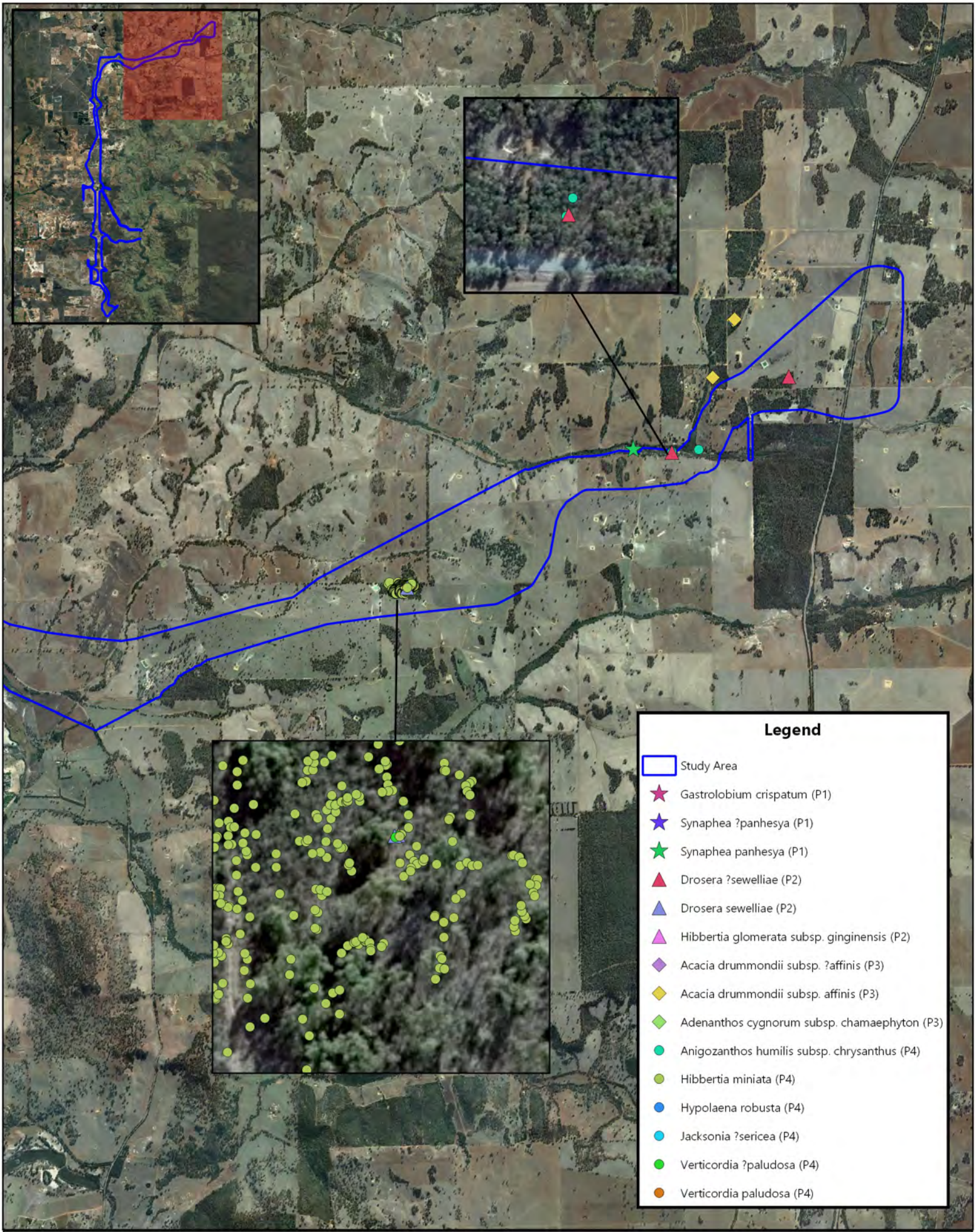
None of the recorded introduced (weed) species are listed WONS. One species, *Chondrilla juncea* (Skeleton weed) is listed as Declared Pest plant under the BAM Act across most of the State, including within the Shires of Chittering and Gingin, where it is listed under the category, 'C2' – Eradication.

Table 10 Recorded Priority Flora Locations

Species	WA Conservation Status	Recorded from Quadrat/s	Recorded within Vegetation Unit/s
*Gastrolobium ?crispatum**	P1	B40^	Vegetation unit does not occur in study area
Synaphea panhesya (with *Synaphea? panhesya**)	P1	B04.2, B12, B40^, B45.2	BaXpAn, EmXpHh, MvJspLs, ErXpBm
Drosera sewelliae (with *Drosera ?sewelliae**)	P2	B08, B16R, B18, B19, B27, B31, B04.2, B2.01^, B2.04^, B2.12, B2.13^, B2.14^, B2.22, B2.27^, B2.35^, B2.38^, B2.50, B28.2	EmBsHh, EmXpHh, EmXpAn, ErXpBm, EwBeNa, EwXpHh, EtBeAn, BaXpUa, BaXpAn
Hibbertia glomerata subsp. *ginginensis*	P2	B2.10^	EmXpHh
Acacia drummondii subsp. *affinis*	P3	B2.43, B2.44^	EwXpHh, ErXpBm, EmBsHh
Adenanthos cygnorum subsp. *chamaephyton*	P3	B38^, B39^, B40^	EmBsHh, ErXpBm, BaXpAn, BmKgHg (Quadrats outside study area)
Anigozanthos humilis subsp. *chrysanthus*	P4	B38^, B39^, B40^	PEwMrCo, EwBeNa (Quadrat outside study area)
Hibbertia miniata	P4	B28.2	EmBsHh, EmXpHh, EwXpHh, Pew,
Hypolaena robusta	P4	B2.17, B2.20^, B2.43, B2.50	BaXpAn, BaXpUa, EwXpHh
*Jacksonia ?sericea**	P4	C08	EtBeAn
Verticordia paludosa (with *Verticordia ?paludosa**)	P4	B28.2	EmBsHh, EtBeAn, EtEpAn

*from specimen collections unable to be identified with certainty due to lack of identifiable material

^ Denotes regional quadrats



0 0.5 1 1.5 2 km

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Figure 11a- Recorded Locations of Threatened and Priority Flora

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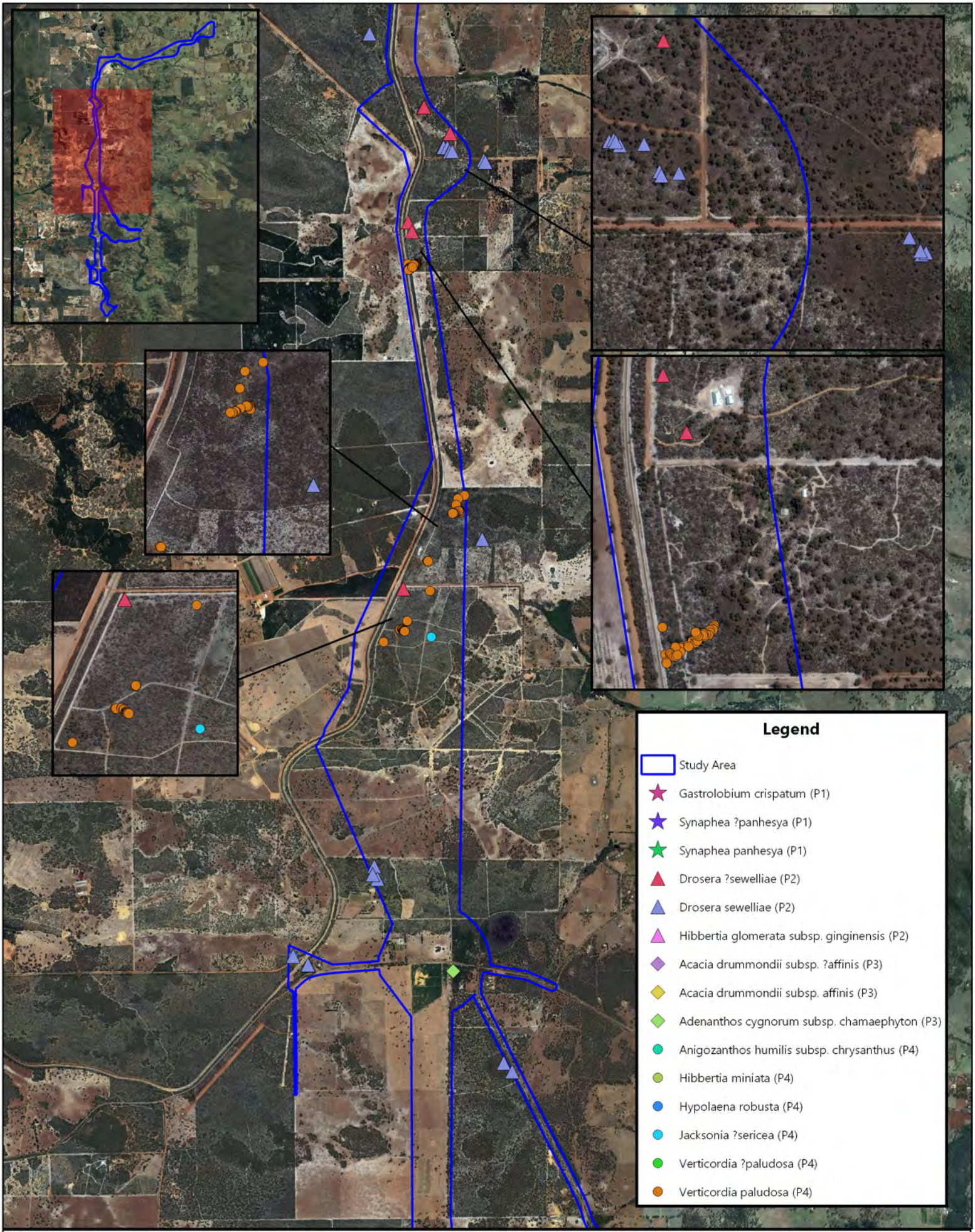

Figure 11b- Recorded Locations of Threatened and Priority Flora

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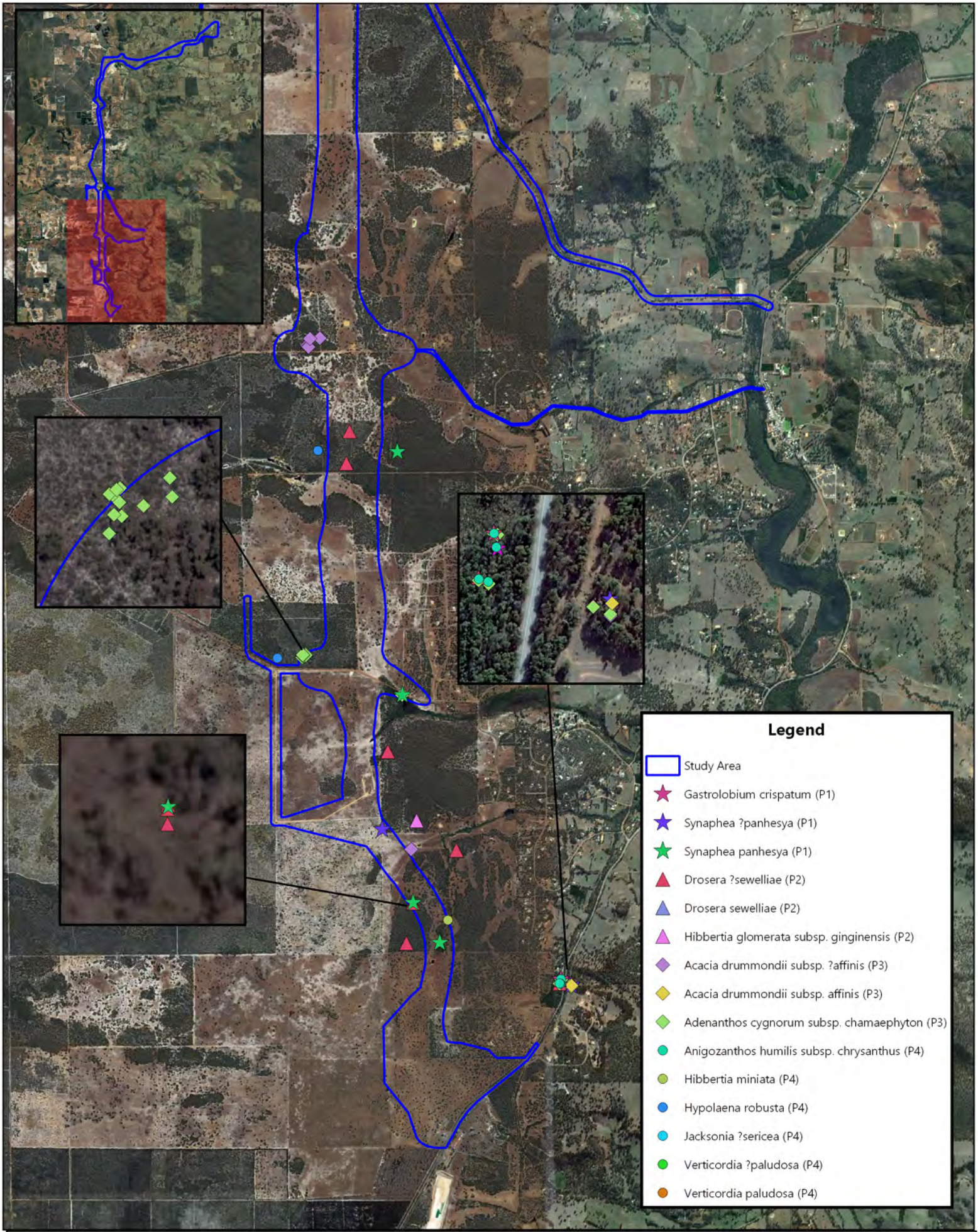

Figure 11c- Recorded Locations of Threatened and Priority Flora

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6.1.1 Threatened and Priority Flora

During the 2017 autumn and winter phase assessments, three Threatened flora and 17 Priority flora were targeted, based on suitable flowering times. Of these, seven Priority flora were targeted during the autumn phase assessment, and three Threatened flora and 13 Priority flora were targeted during the winter phase. During the 2017 spring assessment, 14 Threatened flora and 28 Priority flora were targeted. The flora targeted during each phase are summarised in **Appendix A** and their previously recorded locations in proximity to the study area is presented in **Figure 7**.

A collective total of 11 Priority flora species have been recorded by FVC within the study area and surrounds since spring 2016. Of these, two species were only recorded during the 2016 studies, namely *Gastrolobium* ?*crispatum* (P1) and *Anigozanthos humilis* subsp. *chrysanthus* (P4).

During the autumn and winter phase assessments, two Priority were recorded from four confirmed locations. *Verticordia paludosa* (P4) was recorded during the autumn phase assessment at three confirmed locations. One additional collection of a *Verticordia* species was recorded during autumn and initial taxonomic identification indicated that it is possibly *Verticordia paludosa*, however, it was not possible to definitively confirm this identification due to a lack of flowering material. *Adenanthos cygnorum* subsp. *chamaephyton* (P3) was recorded from one location north of Teatree road, where most of the population occurs outside the study area (**Figure 11**).

During the spring phase assessment, six Priority flora were recorded, *Drosera sewelliae* (including *Drosera ?sewelliae*), *Hibbertia glomerata* subsp. *ginginensis*, *Acacia drummondii* subsp. *affinis* (including *Acacia drummondii* subsp. ?*affinis*), *Hibbertia miniata, Hypolaena robusta* and *Jacksonia ?sericea* from various locations, as presented spatially in **Figure 11**.

Based on the results from collective field assessments conducted between 2016 and 2017, there has been 1,967 individuals of Priority flora recorded within the study area. The population numbers are summarised in **Table 11**.

Table 11 Priority Flora Population Numbers

Species	Total number of individuals recorded
Gastrolobium ?crispatum (P1)	1
Synaphea panhesya (P1) (including *Synaphea ?panhesya*)	5
Drosera sewelliae (P2) (including *Drosera* ?*sewelliae*)	206
Hibbertia glomerata subsp. *ginginensis* (P2)	1
Acacia drummondii subsp. *affinis* (P3) (including *Acacia drummondii* subsp. ?*affinis*)	55
Adenanthos cygnorum subsp. *chamaephyton* (P3)	35
Anigozanthos humilis subsp. *chrysanthus* (P4)	8
Hibbertia miniata (P4)	1,493
Hypolaena robusta (P4)	3
Jacksonia ?*sericea* (P4)	1
Verticordia paludosa (P4) (including *Verticordia* ?*paludosa*)	159
TOTAL	**1,967**

A total of 261 km of transects totalling approximately 250 ha of searched ground over 417 ha of 39 searched sites was included in the Targeted Threatened and Priority Flora searches. Particular attention was given to the presence or potential presence of *Thelymitra stellata* during the 2016 targeted searches, and to both *Thelymitra stellata* and *Drakaea elastica* during the 2017 targeted search program. Despite the intensive surveys which focused on areas of optimal habitat, no individuals of either Threatened orchid were recorded.

6.2 VEGETATION UNITS

The vegetation of the study area found to be in 'Good' or better condition was defined from a total of 89 quadrats sampled across 2017 (**Figure 9**). Floristic analysis of the quadrat data using multivariate cluster analysis of species presence/absence in PATN™ was carried out for both spring 2016 and all 2017 qudrat data. The 2017 data analysis resulted in the dendrogram presented below in **Figure 12**.

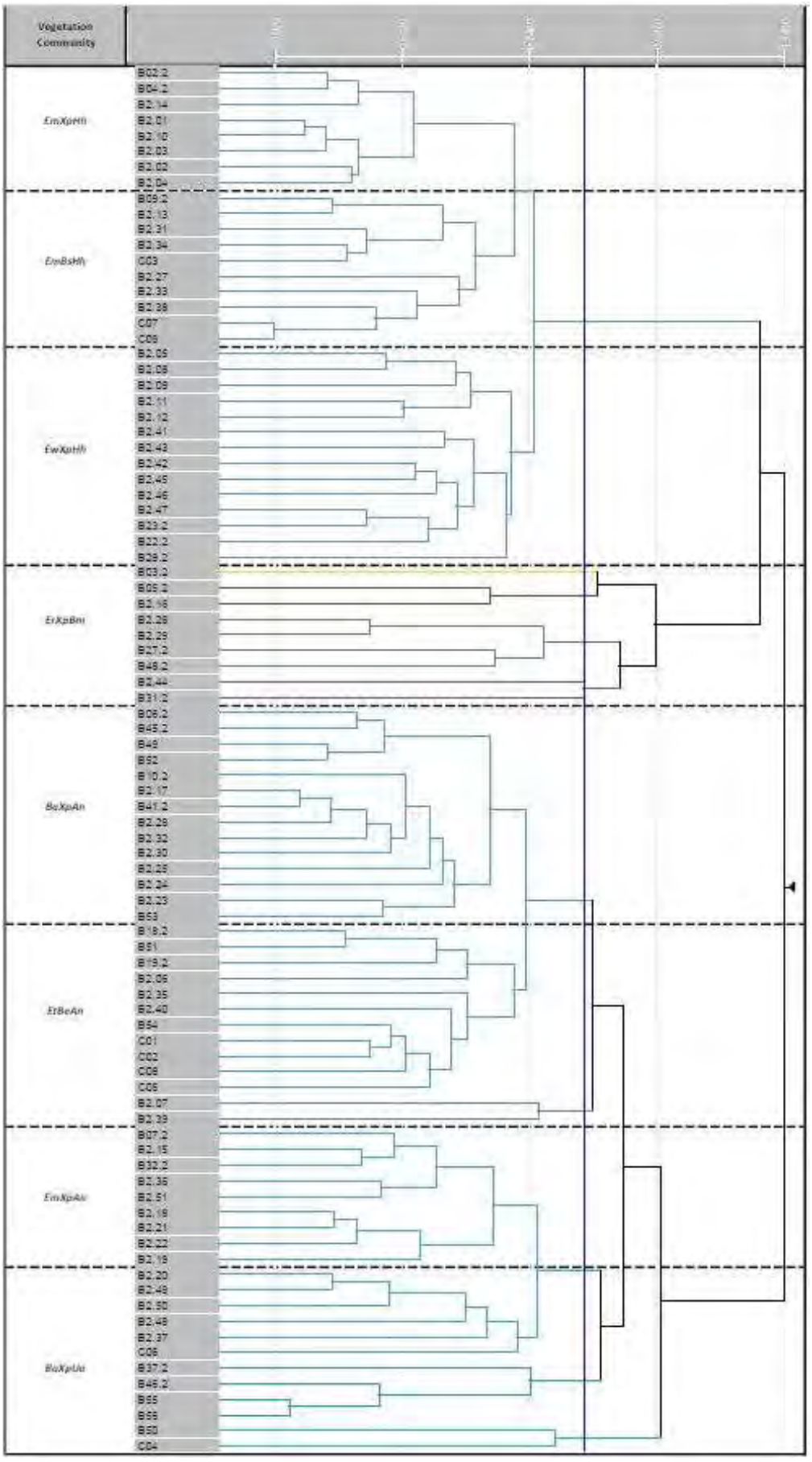

Figure 12 **Quadrat Cluster Analysis Dendrogram**

The clusters of quadrats resulting from the 2017 results dendrogram produced seven separate vegetation units, and the cluster analysis and site data from 2016 results (FVC 2017) augmented this to provide a total of 12 vegetation units for the final vegetation mapping.

Recorded quadrat data was then used to describe each unit to NVIS Levels III and VI. In a broad sense, the vegetation units comprise Eucalypt woodlands (Jarrah, Marri, Wandoo and Flooded Gum), Banksia Woodlands and Melaleuca woodlands and shrublands.

Clusters resulting from the PATN analysis as evident in the dendrogram, and the vegetation units described for each cluster, and the results of the 2017 PATN analysis in comparison to that resulting from the 2016 PATN anlsysis, were verified by field botanists. This was done by considering tangible site characteristics such as dominant flora species, total species composition and vegetation structure (community type; e.g. woodland, shrubland). In a limited number of cases, this verification overruled the results of the PATN analysis. Such instances include the persistence of four vegetation units (BmKgHg, EtEpAn, EwBeNa and MvJspLs) resulting from the 2016 study, although the 2017 dendrogram did not result in discrete clusters for these units.

Incorporation of PATN analysis results, combined with the verifications described above resulted in the 12 vegetation units recorded, described and mapped within the study area, as summarised in **Table 12**. The structure and floristic composition of each quadrat is detailed in **Appendix C** and the species composition of each of the quadrats/sites and intact vegetation units is provided in **Appendices C** and **D**, respectively. The spatial extent of the various vegetation units is presented in the **Figure 13** series.

Table 12 Summary of Recorded Vegetation Units

Vegetation Unit and Description	Representative Quadrats	Corresponding Shepherd *et.al.* Code	Equivalent Phoenix Quadrat/s
BaXpAn *Banksia* spp. sparse woodland *Banksia attenuata*, *Banksia menziesii* and *Eucalyptus todtiana* low sparse woodland over *Xanthorrhoea preissii* mid isolated to sparse shrubs over *Bossiaea eriocarpa, Gompholobium tomentosum* and *Petrophile linearis* low isolated shrubs over *Alexgeorgea nitens* and *Lyginia imberbis* sparse sedgeland **Average species richness: 42.2 ± 3.45**	B11, B49, B06.2, B10.2, B2.17^, B2.23^, B2.24^, B2.25, B2.28^, B2.30, B2.32, B41.2, B45.2, B52^, B53^	1027 and/or 949	MNP2013 and/or MNP2002
BaXpUa *Banksia attenuata* sparse woodland *Banksia attenuata* low sparse woodland (with occasional *Banksia menziesii*) over *Xanthorrhoea preissii* mid isolated shrubs over *Bossiaea eriocarpa, Hibbertia hypericoides* and *Petrophile linearis* low isolated shrubs over *Ursinia anthemoides*, *Conostylis aculeata* and *Hypochaeris glabra* isolated herbs **Average species richness: 31.25 ± 3.72**	B55, C04, C06, B2.20^, B2.37, B2.48, B2.49, B2.50	949	MNP2002
BmKgHg *Kunzea glabrescens* shrubland *Banksia menziesii* low sparse to open woodland over *Kunzea glabrescens* and *Xanthorrhoea preissii* mid shrubland over *Hypochaeris glabra* and *Drosera erythrorhiza* isolated herbs **Average species richness: 14 ± 1.00**	B14, B37.2, B50	Regionally not represented, locally distributed vegetation unit	NA
EmBsHh *Eucalyptus marginata* and *Banksia sessilis* sparse woodland *Eucalyptus marginata* and *Corymbia calophylla* low sparse woodland over *Banksia sessilis* and *Xanthorrhoea preissii* tall to mid sparse shrubland over *Hibbertia hypericoides* and *Bossiaea eriocarpa* low isolated to sparse shrubland over *Hypochaeris glabra* and *Ursinia anthemoides* isolated herbs **Average species richness: 37 ± 2.22**	B08, C03, C07, C09, B09.2, B15R, B2.13^, B2.27^, B2.31, B2.33, B2.38^, B28.2, B2.34^	1019	MNP2012

Vegetation Unit and Description	Representative Quadrats	Corresponding Shepherd *et.al.* Code	Equivalent Phoenix Quadrat/s
EmXpAn *Eucalyptus marginata* sparse woodland *Eucalyptus marginata* (and *Banksia attenuata)* low sparse woodland over *Xanthorrhoea preissii* mid sparse shrubland over *Bossiaea eriocarpa Hibbertia hypericoides* and *Petrophile linearis* low isolated to sparse shrubland over *Alexgeorgea nitens* and *Lomandra* spp. isolated sedges **Average species richness: 38.6 ± 2.97**	B07.2, B2.15^, B2.18^, B2.19, B2.21^, B2.22, B2.36, B2.51, B32.2	1027	MNP2013
EmXpHh *Eucalyptus marginata* sparse woodland *Eucalyptus marginata* and *Corymbia calophylla* low sparse woodland over *Xanthorrhoea preissii* mid sparse shrubland over *Hibbertia hypericoides*, *Bossiaea eriocarpa* and *Banksia dallanneyi* low isolated shrubs over *Conostylis setosa*, *Xanthosia* sp. and *Philotheca spicata* isolated herbs **Average species richness: 38 ± 1.95**	B02.2, B04.2, B2.01, B2.02^, B2.03, B2.04, B2.10^, B2.14^	1019	MNP2012
ErXpBm# *Eucalyptus rudis* and *Melaleuca preissiana* sparse woodland *Eucalyptus rudis, Melaleuca preissiana* and *Corymbia calophylla* low sparse woodland over *Xanthorrhoea preissii* and *Jacksonia furcellata* mid isolated shrubs over *Hypocalymma angustifolium* low shrubland over *Lepidosperma tenue* isolated sedges and *Briza* spp. sparse grassland **Average species richness: 21.7 ± 3.56**	B25, B26, B33, B34, B36, B43, B47, B27.2, B48.2, B05.2, B2.16^, B2.26^, B2.29, B2.44^	973 or 1009 (1009 is restricted Bassendean landform near rivers which is slightly away from the study area)	Not represented
EtBeAn *Eucalyptus todtiana* sparse woodland *Eucalyptus todtiana, Banksia attenuata* and *Banksia menziesii* low sparse woodland over *Bossiaea eriocarpa, Hibbertia hypericoides* and *Petrophile linearis* low isolated shrubs over *Alexgeorgea nitens, Lyginia imberbis* and *Mesomelaena pseudostygia* sparse sedgeland **Average species richness: 37.3 ± 3.04**	B15, B16R, B17, B18.2, B19.2, B2.06^, B2.07^, B2.35^, B2.39^, B2.40^, B51, B54, C01, C02, C05, C08	949	MNP2002

Vegetation Unit and Description	Representative Quadrats	Corresponding Shepherd *et.al.* Code	Equivalent Phoenix Quadrat/s
EtEpAn *Eucalyptus todtiana* sparse woodland *Eucalyptus todtiana* and *Banksia* spp. low sparse woodland over *Adenanthos cygnorum* tall sparse shrubland over *Eremaea pauciflora* and *Stirlingia latifolia* mid sparse to isolated shrubland over *Bossiaea eriocarpa* and *Conostephium pendulum* low isolated shrubs over *Austrostipa hemipogon* and *Briza maxima* grasses and *Alexgeorgea nitens* sedges **Average species richness: 24.50 ± 0.70**	B42, B46.2, B56	949	MNP2002
EwBeNa *Eucalyptus wandoo* and *Casuarina obesa* sparse woodland *Eucalyptus wandoo* and *Casuarina obesa* mid to low sparse woodland over *Bossiaea eriocarpa* and *Gastrolobium calycinum* and *Hakea lissocarpha* low isolated shrubs over *Neurachne alopecuroidea* and *Lepidosperma tenue* isolated grasses and sedges **Average species richness: 33 ± 5.50**	B31.2, B29^, B30^	1018	Not represented
EwXpHh *Eucalyptus wandoo* sparse woodland *Eucalyptus wandoo* mid sparse woodland over *Xanthorrhoea preissii* mid isolated shrubs over *Hibbertia hypericoides*, *Bossiaea eriocarpa* and *Banksia dallanneyi* low isolated shrubs over *Conostylis setosa*, *Hypochaeris glabra* and *Drosera* spp. isolated herbs **Average species richness: 39.9 ± 2.15**	B21, B24, B22.2, B23.2, B2.05^, B2.08^, B2.09, B2.11^, B2.12, B2.41^, B2.42^, B2.43^, B2.45, B2.46^, B2.47	4	MNP2014
MvJspLs *Melaleuca viminea* shrubland *Melaleuca viminea* tall shrubland over *Juncus* spp. and *Isolepis* spp. sparse sedgeland and *Cotula coronopifolia, Lotus* spp. and *Utricularia multifida* isolated herbs **Average species richness: 8.00 ± 1.00**	B20, B35, B03.2	37	M1.31

incorporates vegetation units from FVC (2017) (MpJfLf, ErHaBr, ErXpLt)

originally described from FVC (2017)

^ regional quadrats (outside study area)

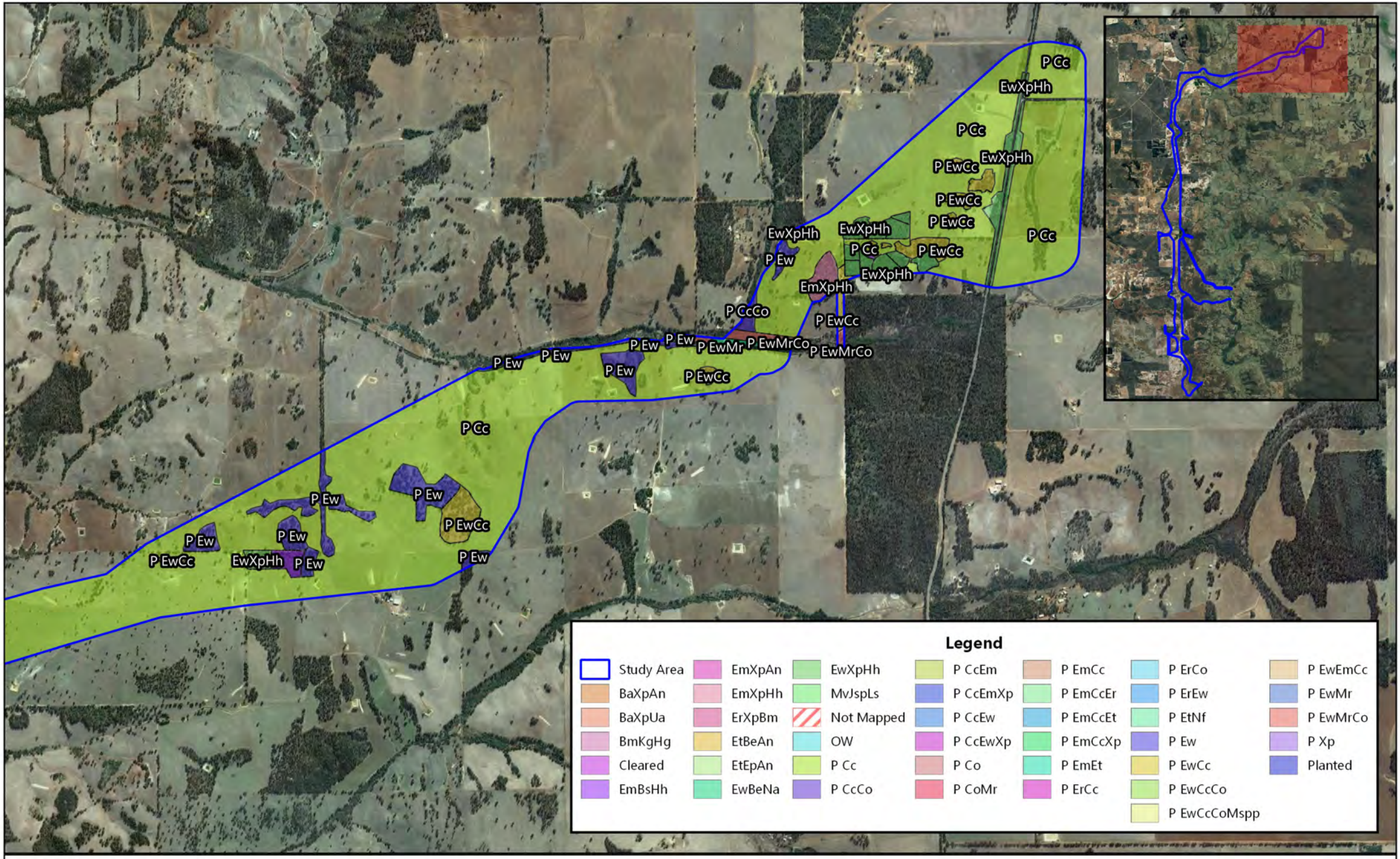

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Figure 13a - Vegetation Units of the Study Area

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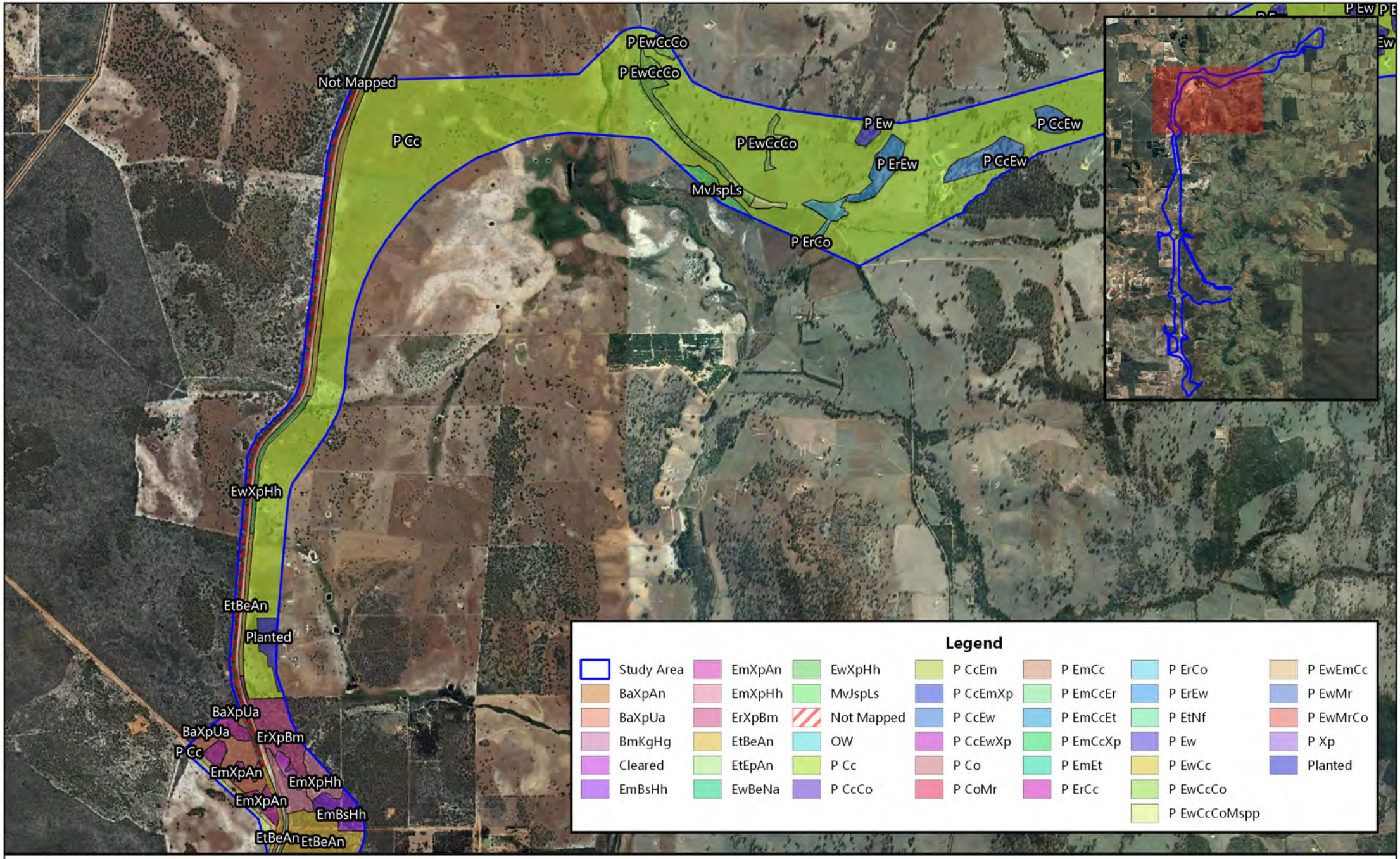

Figure 13b - Vegetation Units of the Study Area

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ASJV17001 08 March 2018

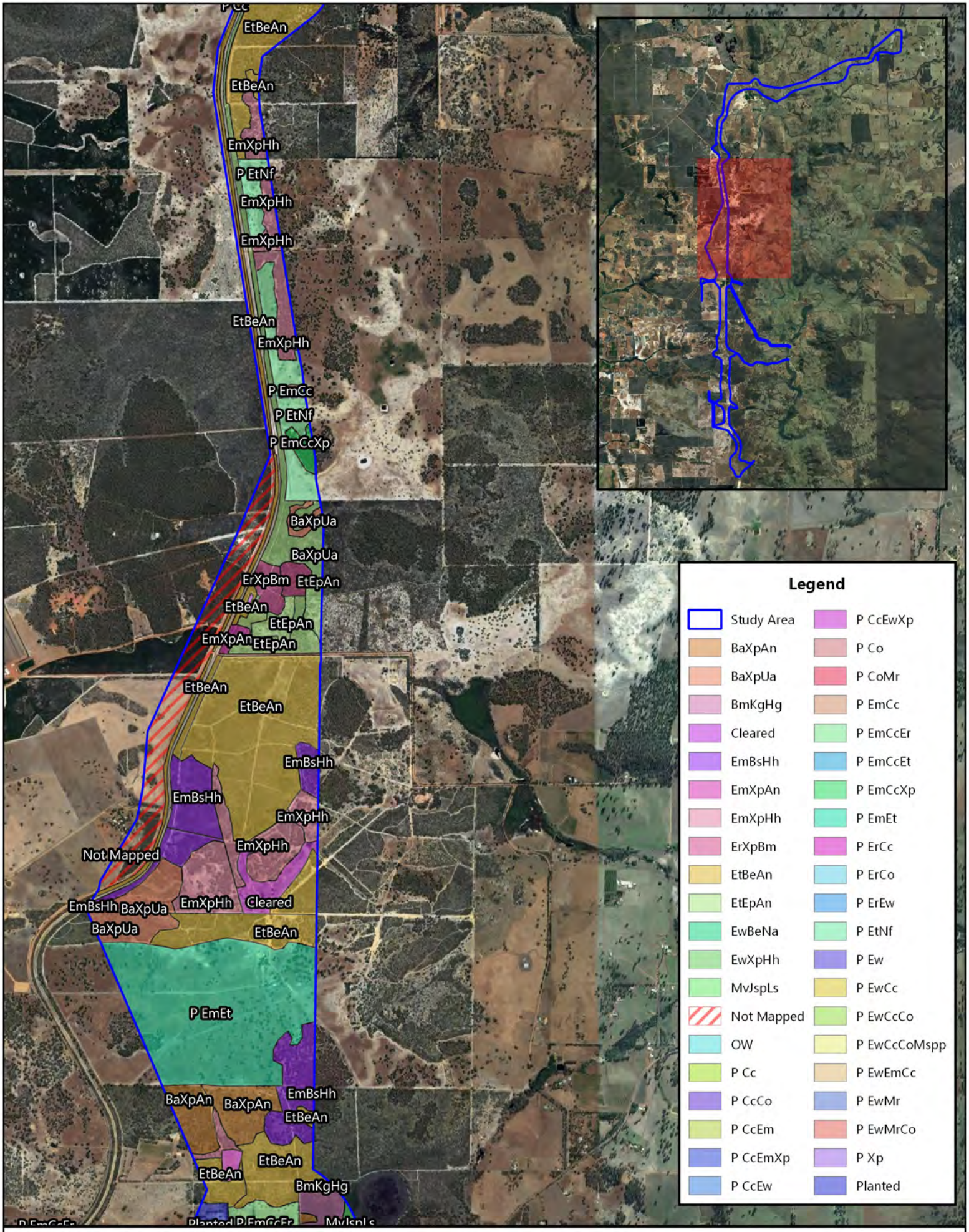

Figure 13c - Vegetation Units of the Study Area

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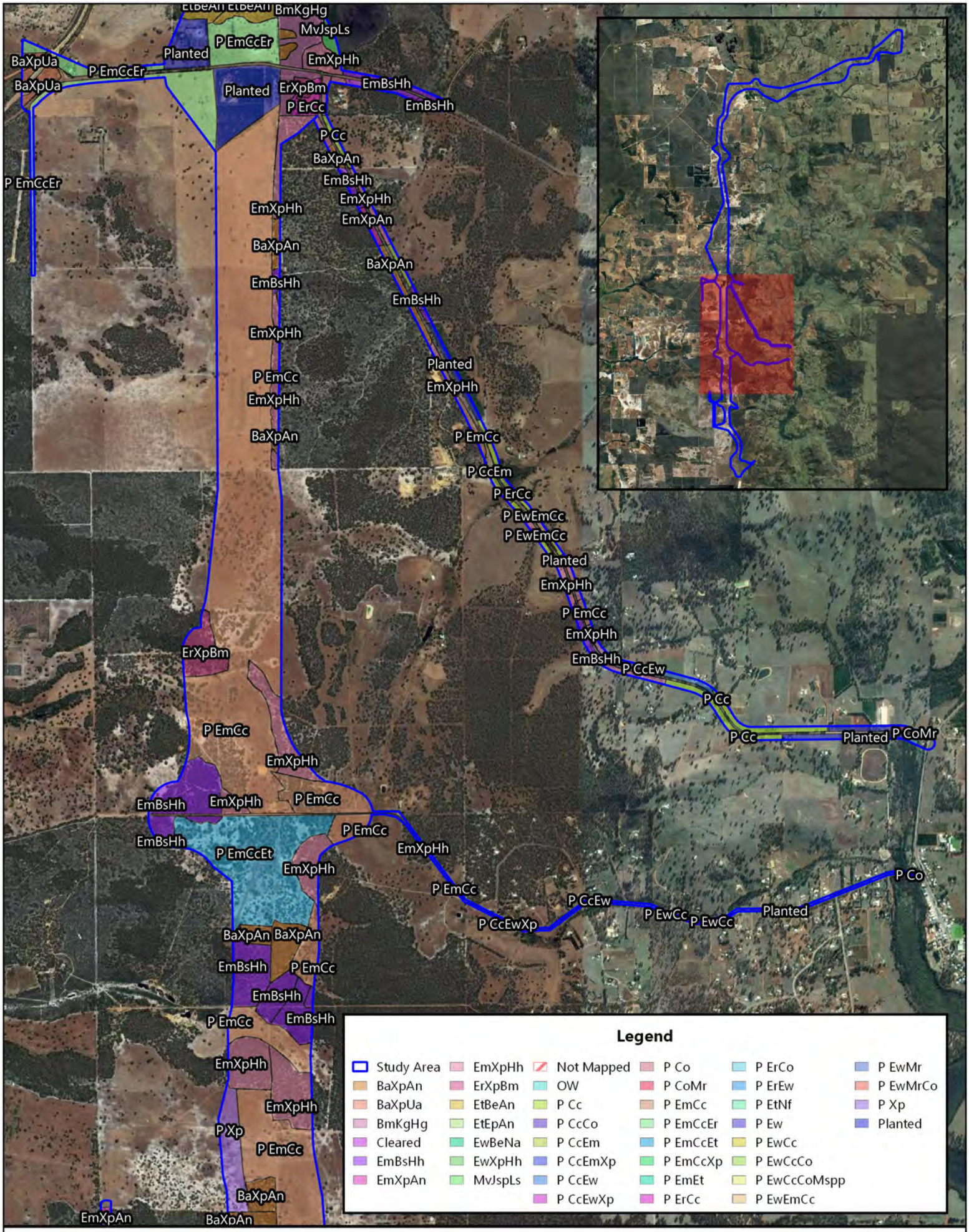

Figure 13d - Vegetation Units of the Study Area

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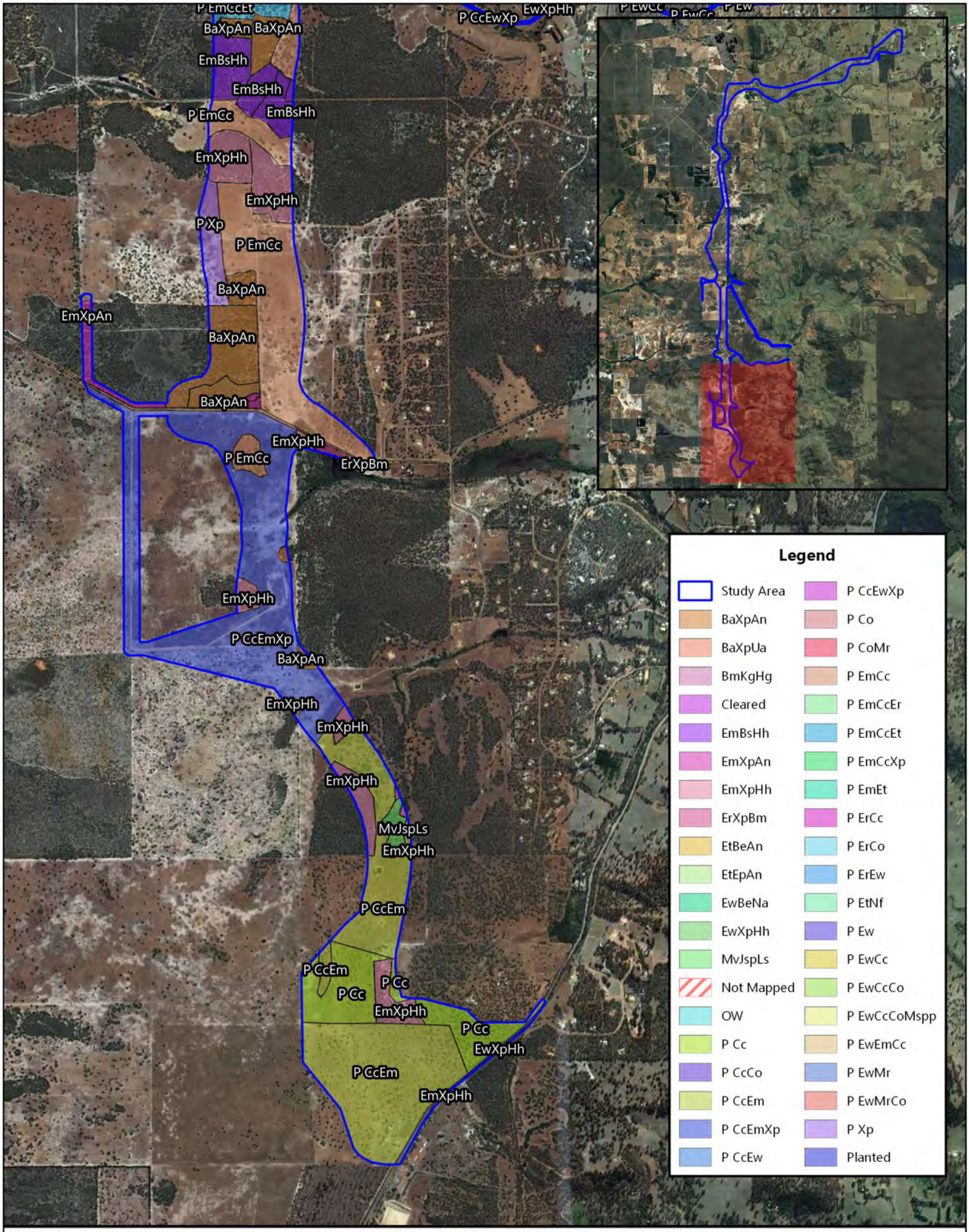


0 0.25 0.5 0.75 1 km

GDA 94 / MGA Zone 50

N

Figure 13e - Vegetation Units of the Study Area

FOCUSED VISION consulting

A large proportion of the study area comprises of cleared land/pasture, mostly cleared or degraded areas, usually supporting native trees in varying densities. Where native understorey is completely lacking or almost so, and the ground cover is entirely pasture grasses and/or other weeds, areas have been mapped as 'Pasture' (P) communities. In the vegetation mapping, such areas are designated a 'P' before letter codes for the genus and species of the trees present in that area of pasture. For example, an area of pasture or completely degraded understorey with Marri (*Corymbia calophylla*) is coded 'P Cc'. A number of areas were found to support multiple tree species and therefore, the mapping codes indicate this also. The species of trees as present in the pasture communities of the study area are listed in **Table 13**.

Table 13 Codes for Tree Species Present in Pasture Communities

Code	Species
Cc	*Corymbia calophylla*
CcCo	*Corymbia calophylla, Casuarina obesa*
CcEm	*Corymbia calophylla, Eucalyptus marginata*
CcEmXp	*Corymbia calophylla, Eucalyptus marginata, Xanthorrhoea preissii*
CcEw	*Corymbia calophylla, Eucalyptus wandoo*
Co	*Casuarina obesa*
CoMr	*Casuarina obesa, Melaleuca rhaphiophylla*
EmCc	*Eucalyptus marginata, Corymbia calophylla*
EmCcEr	*Eucalyptus marginata, Corymbia calophylla, Eucalyptus rudis*
EmCcEt	*Eucalyptus marginata, Corymbia calophylla, Eucalyptus todtiana*
EmCcXp	*Eucalyptus marginata, Corymbia calophylla, Xanthorrhoea preissii*
EmEt	*Eucalyptus marginata, Eucalyptus todtiana*
ErCc	*Eucalyptus rudis, Corymbia calophylla*
ErCo	*Eucalyptus rudis, Casuarina obesa*
ErEw	*Eucalyptus rudis, Eucalyptus wandoo*
EtNf	*Eucalyptus todtiana, Nuytsia floribunda*
Ew	*Eucalyptus wandoo*
EwCc	*Eucalyptus wandoo, Corymbia calophylla*
EwCcCo	*Eucalyptus wandoo, Corymbia calophylla, Casuarina obesa*
EwCcCoMspp	*Eucalyptus wandoo, Corymbia calophylla, Casuarina obesa. Melaleuca* spp.
EwEmCc	*Eucalyptus wandoo, Eucalyptus marginata, Corymbia calophylla*
EwMr	*Eucalyptus wandoo, Melaleuca rhaphiophylla*
EwMrCo	*Eucalyptus wandoo, Melaleuca rhaphiophylla, Casuarina obesa*
Xp	*Xanthorrhoea preissii*

Most of the vegetation units recorded relatively high average species richness values (with at least 20-30 taxa per quadrat). The most floristically diverse vegetation units were BaXpAn (*Banksia* spp. sparse woodland), EwXpHh (*Eucalyptus wandoo* sparse woodland) and EmXpAn (*Eucalyptus marginata* sparse woodland), recording average species richness values of 42.2, 39.9 and 38.6 taxa, respectively. The

lowest average species richness of 8.0 species was recorded from the vegetation unit MvJspLs (*Melaleuca viminea* shrubland), a wetland vegetation type.

The total area occupied by each of the intact vegetation units, the combined degraded 'pasture' communities, planted areas and other areas such as those completely cleared and supporting open water, within each of the survey areas is presented in **Table 14**.

Table 14 Areas of Varying Vegetation

Vegetation Unit	Area (ha)	Proportion of Total Study Area (%)
BaXpAn	94.88	2.77
BaXpUa	47.77	1.40
BmKgHg	16.90	0.49
EmBsHh	133.59	3.90
EmXpAn	22.93	0.67
EmXpHh	204.18	5.97
ErXpBm	41.43	1.21
EtBeAn	253.79	7.42
EtEpAn	56.45	1.65
EwBeNa	2.29	0.07
EwXpHh	36.43	1.06
MvJspLs	11.77	0.34
Not Mapped	88.71	2.59
Open Water	0.02	0
Pasture	2,237.56	65.38
Planted	47.94	1.40
Cleared	19.75	0.58
Total	**3,316.39**	**96.90**

NB: Roads not included in area calculation

6.3 VEGETATION CONDITION

The vegetation of the study area was found to range from 'Completely Degraded' (CD) to 'Excellent' (Ex), with most areas found to be in 'Degraded to Completely Degraded' (D-CD) condition. The spatial extent of the varying vegetation condition across the study area is presented in the **Figure 14** series, and the areas of each condition category are presented in **Table 15**.

Table 15 Areas of Varying Vegetation Condition

Qualitative Vegetation Condition Rating	Total Area (ha)	Proportion of Total Study Area (%)
Pristine (P)	0	0
Excellent (Ex)	107.5	3.14
Very Good to Excellent (VG-Ex)	224.06	6.55
Very Good (VG)	228.17	6.67
Good to Very Good (G-VG)	184.35	5.39
Good (G)	69.80	2.04
Degraded to Good (D-G)	68.28	2.00
Degraded (D)	48.02	1.40
Degraded to Completely Degraded (D-CD)	2,229.81	65.16
Completely Degraded (CD)	67.69	1.98
Not Mapped	88.71	2.59
Total	**3,316.39**	**96.92**

A large proportion of the study area (65.16%, 2,229.81 ha) is in 'Degraded to Completely Degraded' condition and is represented by cleared pasture with occasional trees or stands of trees, usually native Eucalypts. The presence and condition of native understorey is a key factor in determining vegetation condition and therefore most areas of pasture supporting native trees but with no understorey, even if in relatively dense proportions, are classified as 'Degraded to Completely Degraded'. Such pasture areas dominate the study area and the general landscape of the region.

A total of 813.88 ha (23.79%) of the study area was recorded to be in 'Good' condition or better, with 107.5 ha (3.14%) in 'Excellent' condition, but 2,502.51 ha (73.13%) in poorer than 'Good' condition.

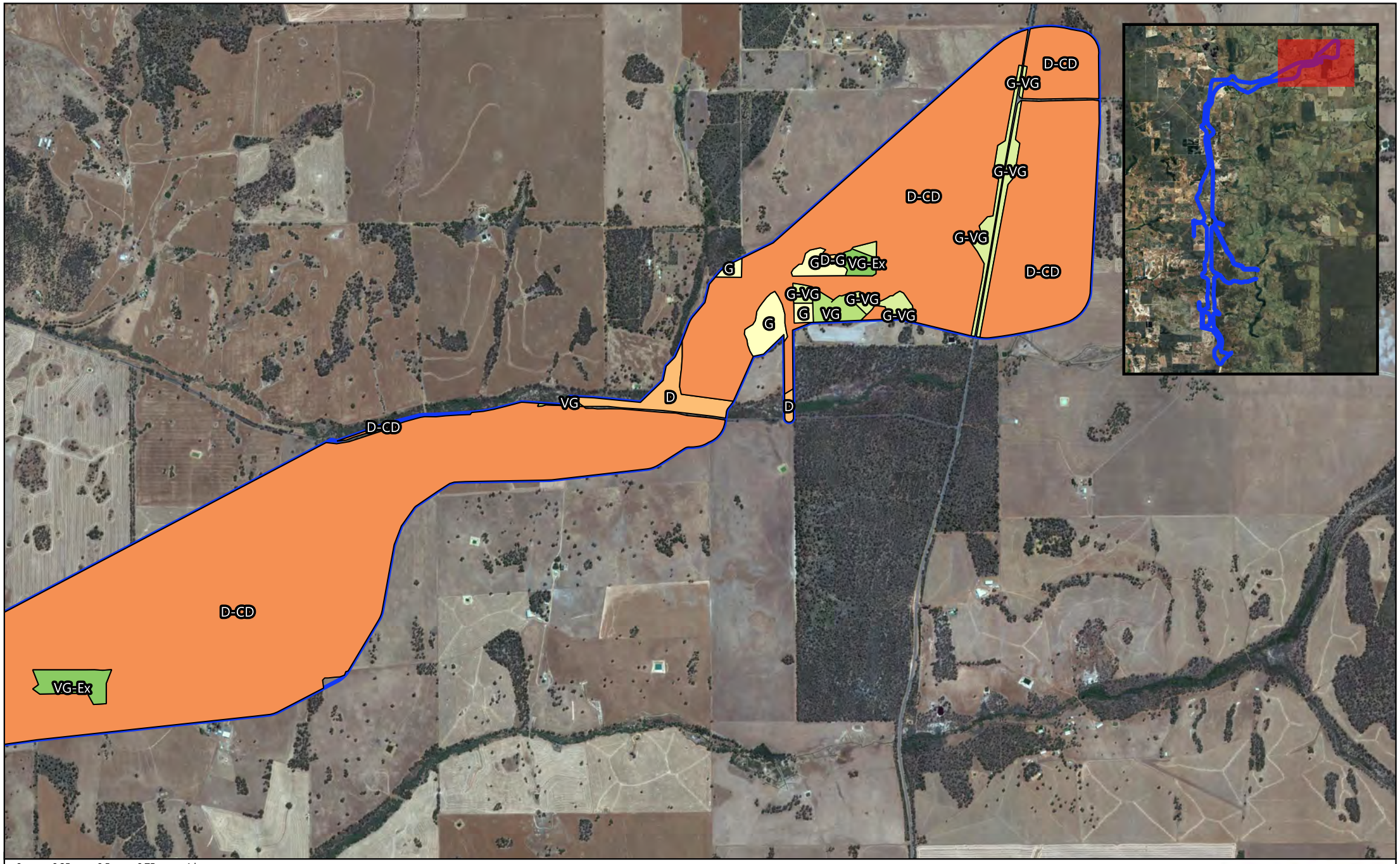
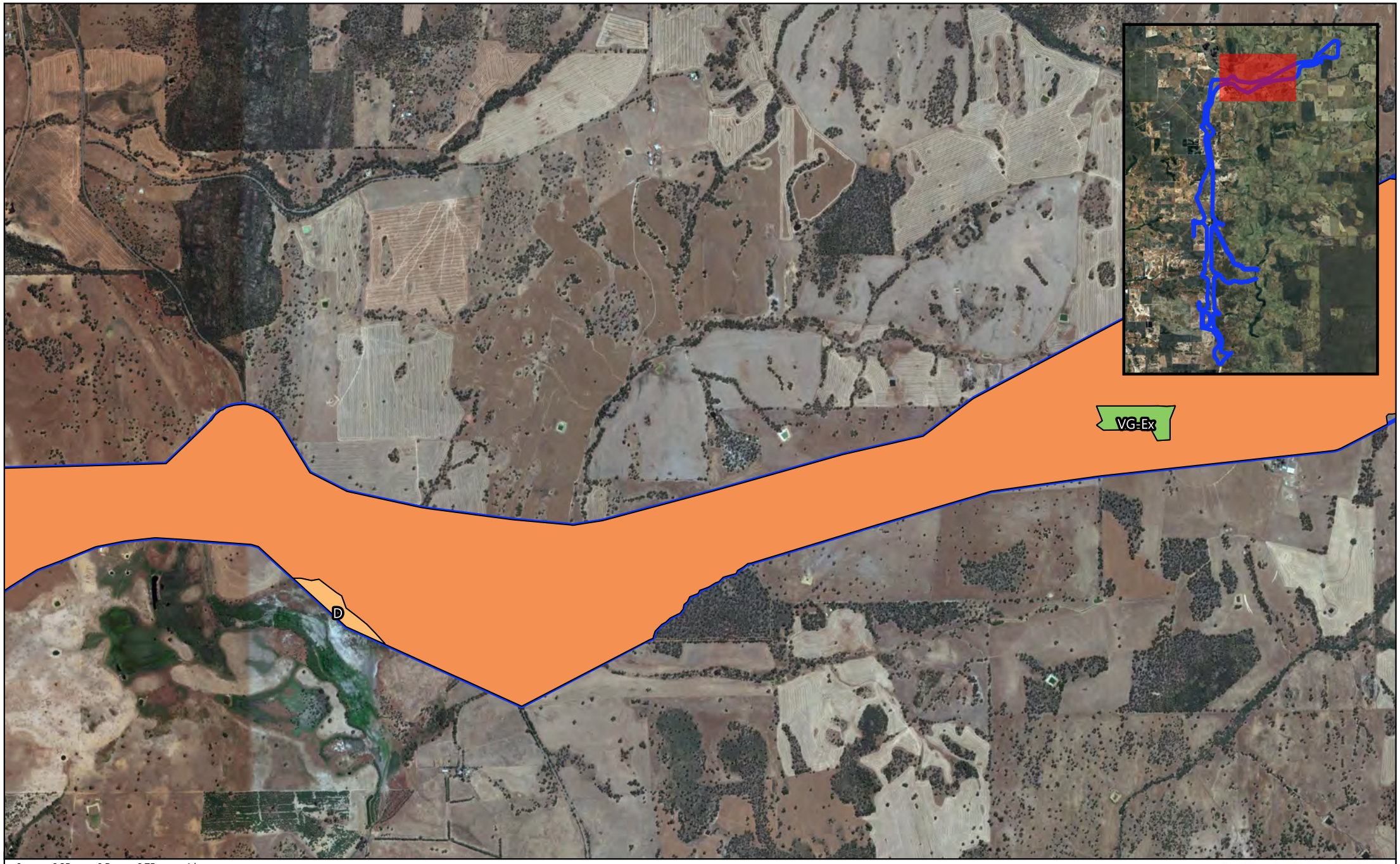


Figure 14a - Vegetation Condition of the Study Area

FOCUSED VISION consulting



0 0.25 0.5 0.75 1 km

GDA 94 / MGA Zone 50

N

Legend

Study Area | D-CD | D-G | G-VG | VG-Ex | NA

CD | D | G | VG | Ex

Figure 14b - Vegetation Condition of the Study Area

FOCUSED VISION consulting

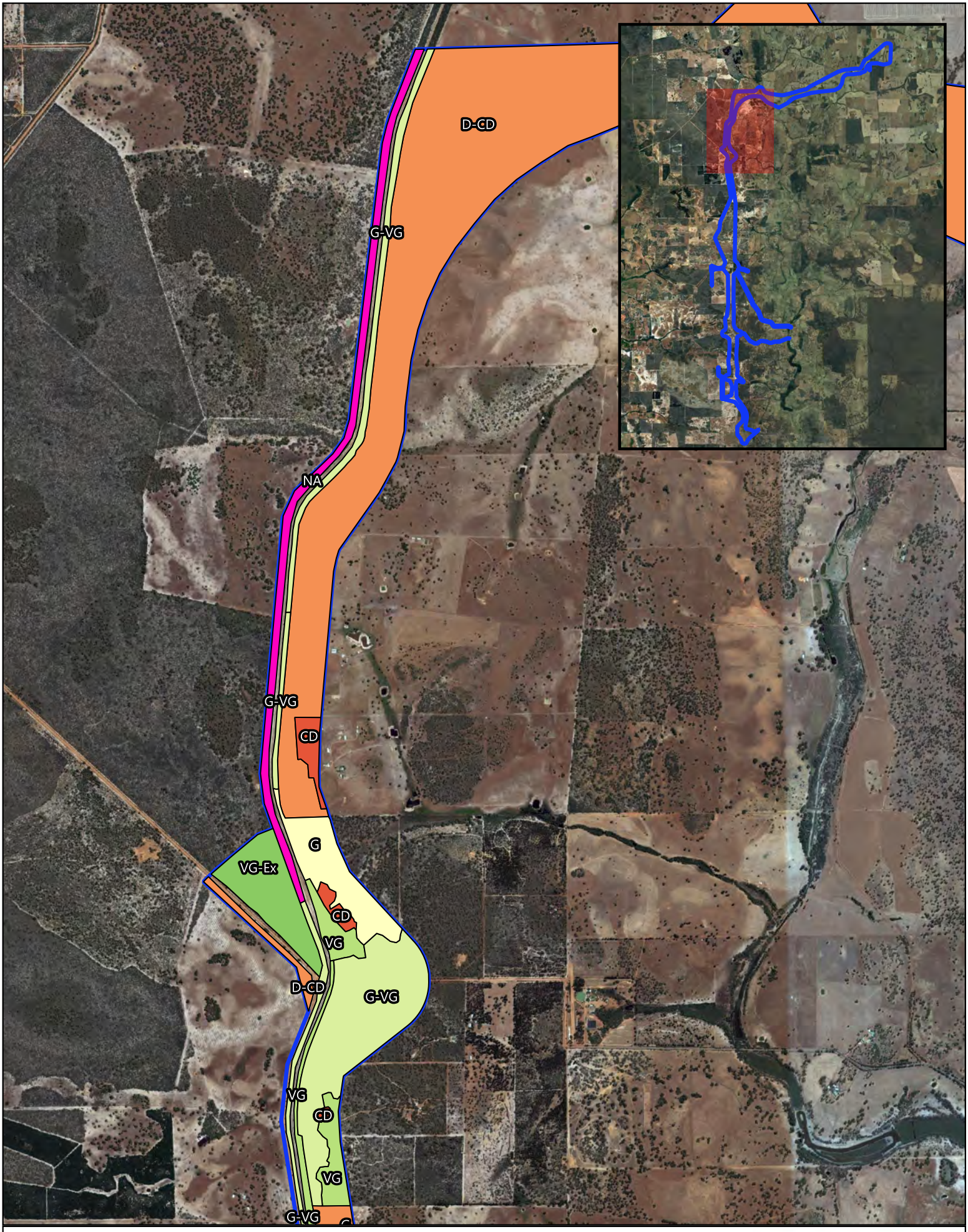


Figure 14c - Vegetation Condition of the Study Area

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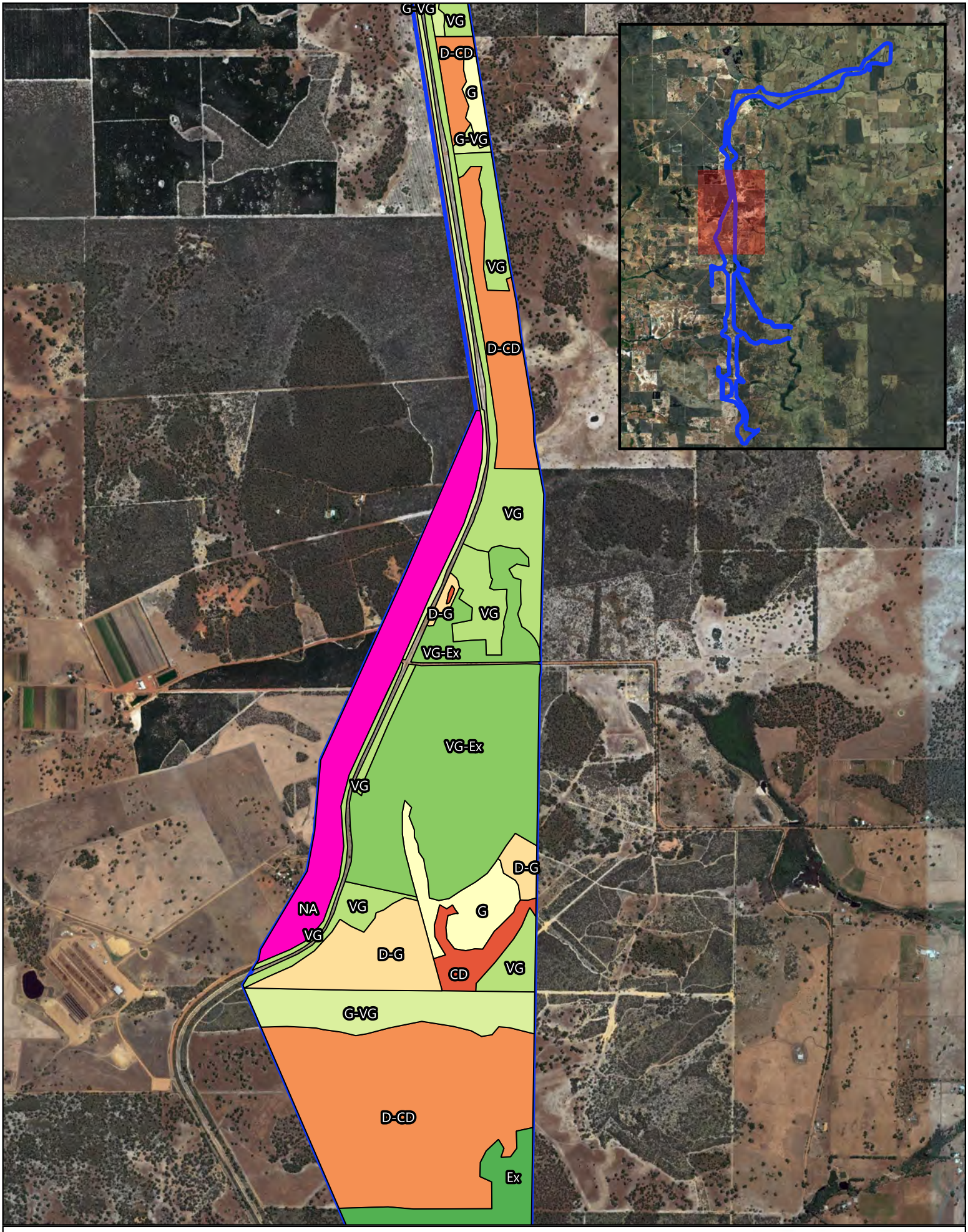

0 250 500 750 1000 m

GDA 94 / MGA Zone 50

N

Legend

Study Area, CD, D-CD, D, D-G, G, G-VG, VG, VG-Ex, Ex, NA

Figure 14d - Vegetation Condition of the Study Area

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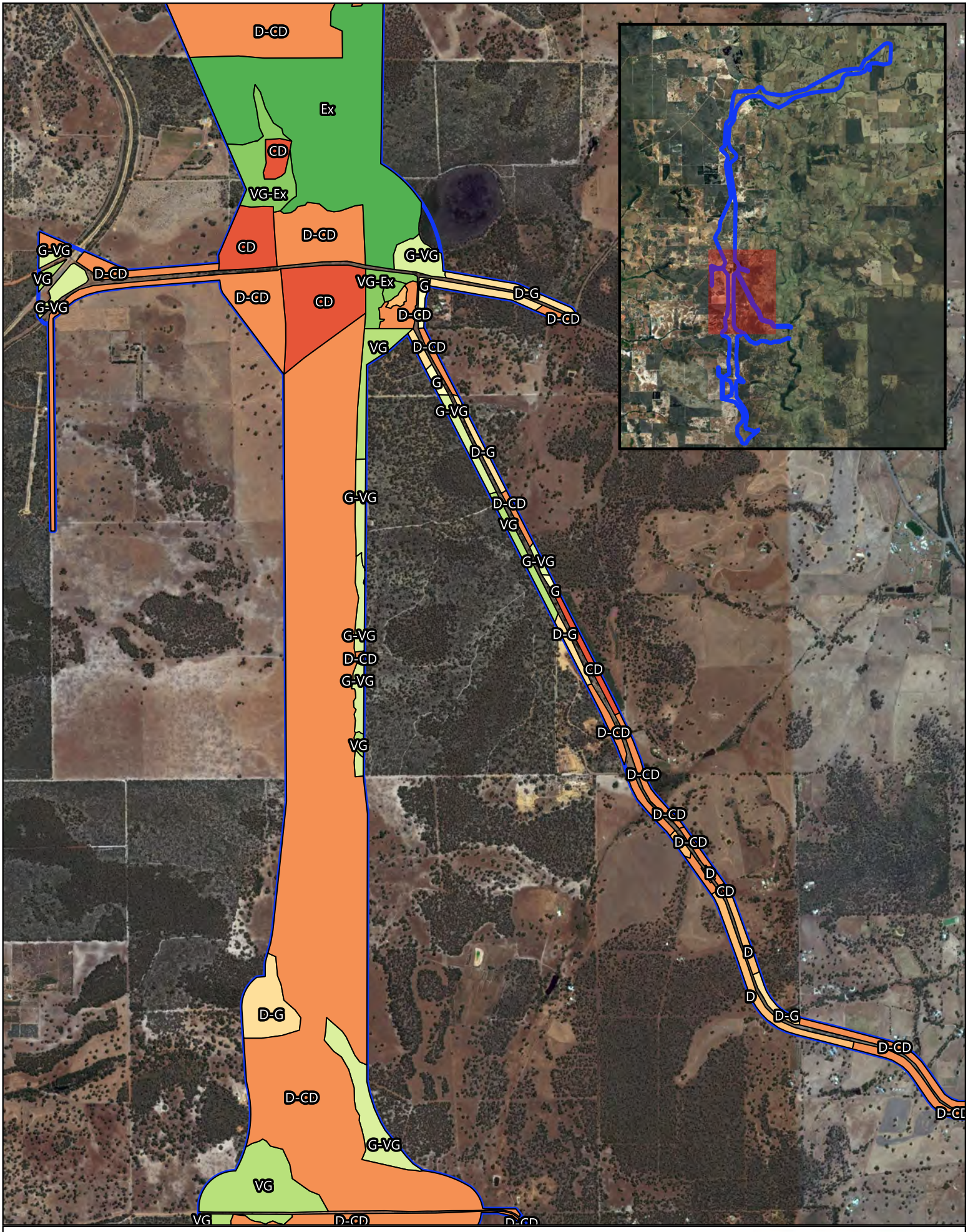


Figure 14e - Vegetation Condition of the Study Area

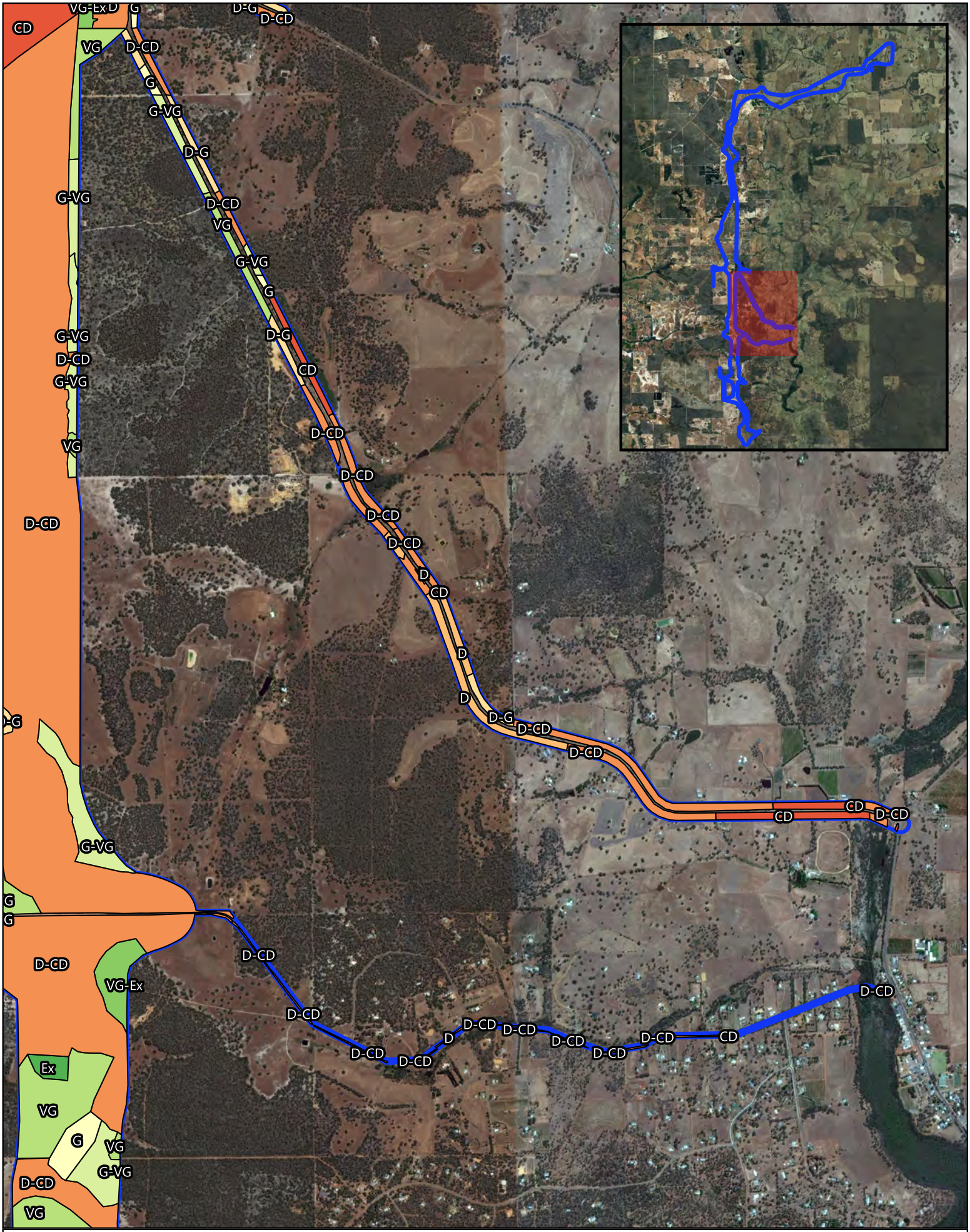


Figure 14f - Vegetation Condition of the Study Area

FOCUSED VISION consulting

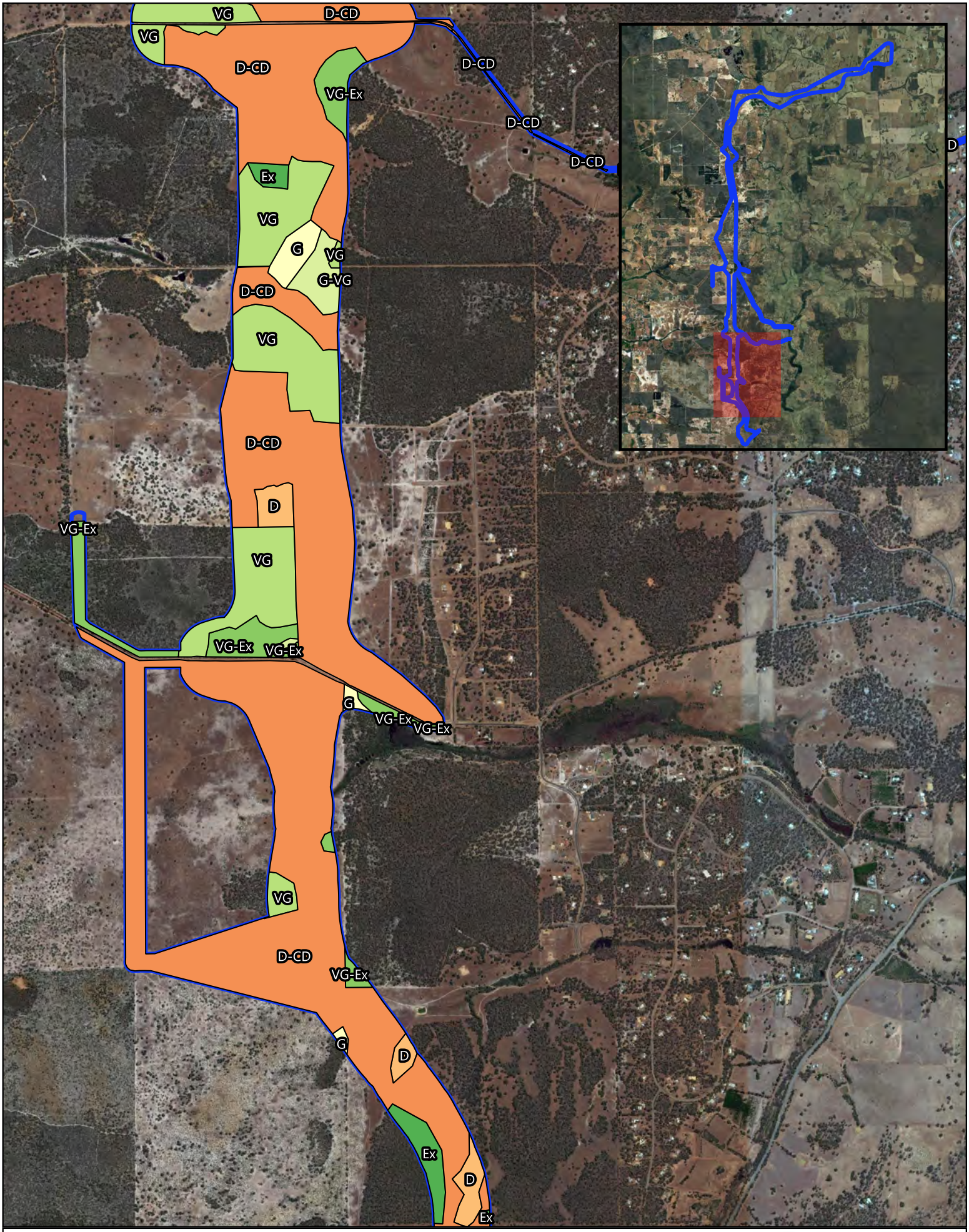
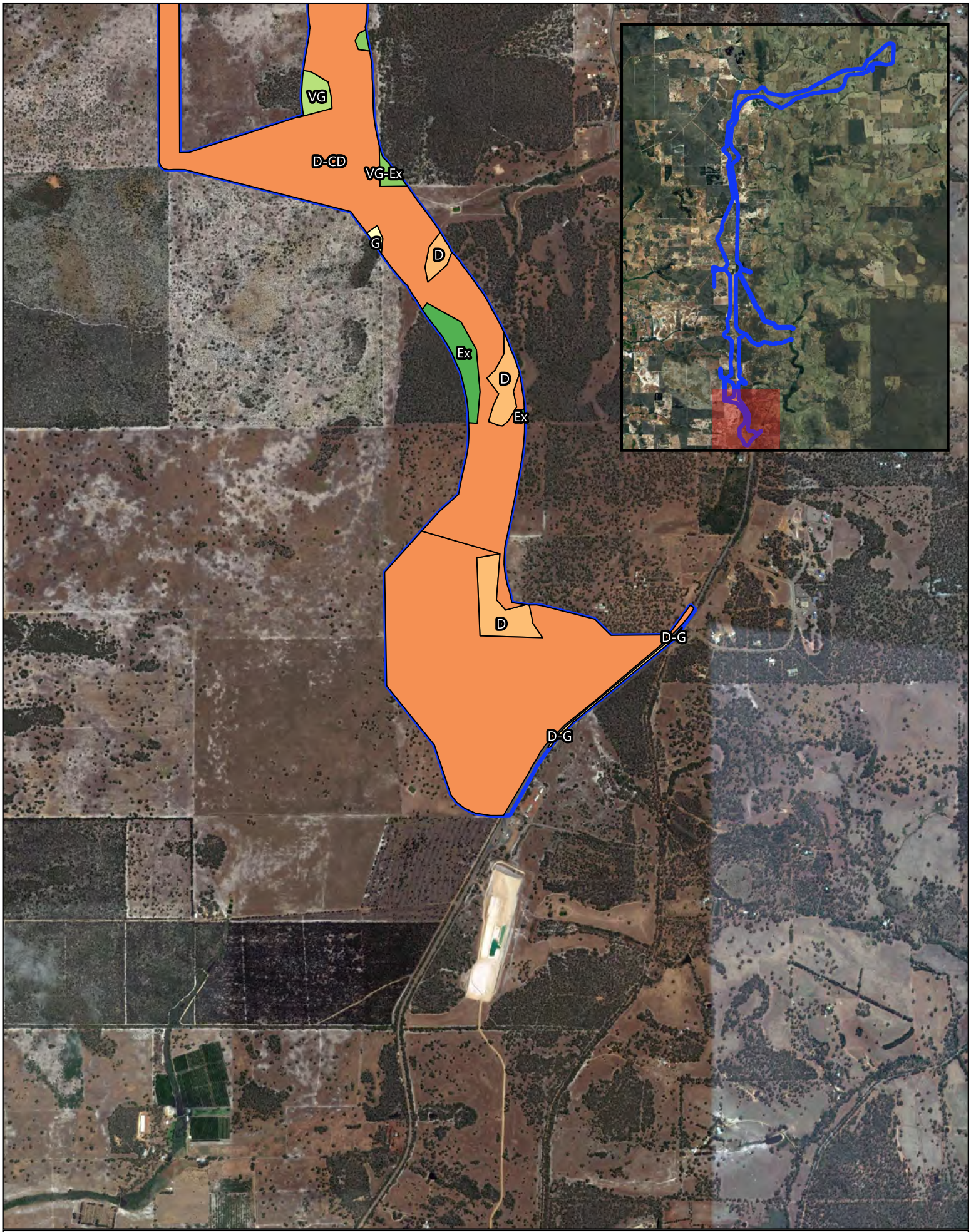


Figure 14g - Vegetation Condition of the Study Area



0 250 500 750 1000 m

GDA 94 / MGA Zone 50

N

Legend

Study Area
CD
D-CD
D
D-G
G
G-VG
VG
VG-Ex
Ex
NA

Figure 14h - Vegetation Condition of the Study Area

FOCUSED VISION consulting

7 DISCUSSION

7.1 FLORA

The 486 flora taxa from 207 genera and 59 families that have been recorded throughout the study area between spring 2016 and spring 2017 is considered relatively high species diversity and is reflective of the diversity of landform types, geology/soils and vegetation types across the study area, where two botanical and IBRA regions are traversed and where the scarp and Dandaragan Plateau of the Northern Jarrah Forest transitions to the deep sands of the Swan Coastal Plain. A collective total of 110 quadrats and two releves have been sampled in the study area since October 2016. During the 2017 field assessments, a total of 89 quadrats were sampled to characterise biological values and address additional areas encompassed within the revised corridor.

The desktop review identified the potential for 103 flora species of conservation significance to occur within the study area. A collective total of 11 Priority flora have been recorded within the study area and surrounds since spring 2016 (**Table 10**). Five species, *Gastrolobium* ?*crispatum, Synaphea* ?*panhesya, Drosera* ?*sewelliae, Jacksonia* ?*sericea* and *Verticordia* ?*paludosa* are uncertain in their identification to species level, due to inadequate or sterile material for identification purposes. However, all collections are considered to likely be the queried Priority flora, and two collections identified as *Synaphea panhesya* and *Drosera sewellia*e were also made.

All of the Priority flora recorded within the study area (**Table 9**), with the exception of *Jacksonia* ?*sericea* (P4) resulted from the desktop assessment (**Appendix A**). Of the 103 species of conservation significance resulting from the desktop assessment, six were considered 'likely' to occur within the study area, 32 'may occur' and 55 are considered 'unlikely' to occur. Of the potential 92 flora species of conservation significance not recorded within the study area (**Appendix A)** 38 are listed as Threatened, with 36 of these listed as Nationally (EPBC) significant. Of these 36 Commonwealth listed species, 28 are considered 'unlikely' to occur, eight 'may occur'. None were recorded, nor were any of the Threatened flora species considered 'likely' to occur based on the proximity of previous records, currency of data and whether or not suitable habitat is present in the study area. This includes Threatened orchid species, *Thelymitra stellata* and *Drakaea elastica,* neither of which were recorded, despite significant search effort being invested in the field program. Although suitable habitat for both species of Threatened orchids exists within the study area, the proximity of a known population of *Thelymitra stellata* is somewhat removed from the study area, with other records much greater distances away; and an historic population of *Drakaea elastica* was not able to be located, despite intensive searching in the location which is now found to be significantly degraded.

The searches for all Threatened and Priority flora conducted, including for the Threatened orchid species targeted, were carried out via intensive targeted surveys within a series of parallel transects, that systematically searched areas of optimal or potential habitat. The surveys encompassed more than 261 km of walked transect lines covering approximately 250 ha of searched ground (assumes an average visibility of 5 m either side of walked centrelines), within more than 417 ha of designated search areas.

The timing of the targeted *Thelymitra stellata* surveys which were carried out between 1-2 November 2017 was considered suitable for the identification of the species. However, verification of the flowering status of a known *Thelymitra stellata* population in a location in Chittering, nearby to the study area which was carried out during October, and at the commencement and conclusion of the

targeted surveys did not result in any individuals observed in flower. Additionally, emergent *Thelymitra* leaves recorded within the known population area during September and October were later found (once flowering) to be other *Theylmitra* species. The lack of observable plants may be attributed to the unfavourable season experienced by the region, with lower than expected rainfall.

Two species, *Jacksonia ?sericea* (P4) and *Synaphea* ? *flabelliformis* were found to be occurring outside their known range based on distributions from the Western Australian Herbarium records.

Jacksonia sericea is a spreading to prostrate shrub growing in woodland on grey or yellow to brown sand over limestone (Malcom 2012). This species is considered to have a restricted range and has only been previously recorded within woodlands within the Perth Metropolitan area between Wanneroo and Manduarah (Malcolm 2012).

Synaphea flabelliformis is a tufted shrub to 0.4 m high and occurs on sandy clay, white or grey sand over laterite (DBCA 2018a). Its current extent occurs between Beverley and West Arthur, with an isolated occurence at Ravensthorpe.

Significance is not limited to species covered by State and Commonwealth legislation and also includes species of local significance and species showing significant range extensions or at the edge of their known range.

Although extensive targeted surveys were conducted throughout the study area over multiple seasons, it is possible that the distribution and abundance of the Priority flora recorded within the study area is more vast and abundant than the assessments would suggest. This could be attributed to factors such as the unfavourable season the region experienced in 2017 with lower than expected rainfall during winter, with only 66.2 mm of rain in June 2017 and no rain between July and August 2017 (BoM, 2018). No *Thelymitra stellata* individuals were observed from their known population on Blue Plains Road, nearby the study area during 2017, perhaps due to the low rainfall received by the region.

Chondrilla juncea (Skeleton weed) is listed as category 'C2' Declared Pest plant under the BAM Act across most of the State, including within the Shires of Chittering and Gingin. Skeleton weed can drastically reduce crop yields by competing for moisture and nutrients (mainly nitrogen) (Department of Primary Industries and Regional Development's Agriculture and Food (DPIRD) 2018). The category, 'C2' – Eradication, requires landholders to undertake a range of search and control measures for Skeleton weed, specifically:

- eradicate infestations; destroy plants and prevent propagation each year, until no plants remain
- prevent the spread of seed or plant parts
- undertake searches during summer
- undertake control activities during winter.

The timing of the field survey was considered optimal for the majority of flora, with only 22 of the 416 recorded taxa unable to be identified with certainty to species or infra-species level, and the majority of those, relatively certain in their identification. The multiple phase and multi-season assessment is also considered to have recorded the floristic values of the study area in optimal detail, compared to a single or even two-phase assessment.

7.2 VEGETATION

7.2.1 TECs and PECs

The State-listed TEC and two PECs of the study area, as revealed by the DBCA database search results are:

- SCP 20a – *Banksia attenuata* woodlands over species rich dense shrublands' (EN TEC)
- 'Banksia Woodlands of the Gingin area restricted to soils dominated by yellow to orange sands' (P2 PEC)
- SCP 23b – Northern Swan Coastal Plain *Banksia attenuata – Banksia menziesii* woodlands' (P3 PEC).

All three of these ecological community types are also classified as likely to be equivalent to the Commonwealth listed Banksia Woodland TEC.

The Banksia Woodlands of the Gingin area ecological community (P2) or its buffer (DPaW 2016) is known to occur north of Mooliabeenee Road and along Teatree Road. At these locations, the PEC intersects with FVC vegetation units BaXpAn, EmBsHh, EmXpAn, EmXpHh, ErXpBm, EtBeAn and BmKgHg (**Figure 8**). Three of these units (BaXpAn, EmXpAn and EtBeAn) are considered to be equivalent to 'Banksia Woodlands of the Gingin area restricted to soils dominated by yellow to orange sands' (P2 PEC) (**Figure 13**). The remaining five are not considered to be equivalent to the PEC.

One significant sized area comprising 89.05 ha or 2.60% of the study site, occurring west of the railway line between Barn Road and Reichichi Road was not accessable for the detailed survey and therefore, vegetation within this area was not able to be confirmed. A small pocket at the southern end and the northern portion of this area contains remnant native vegetation, which is considered likely to be representative of the Banksia Woodland TEC, due to its close proximity to confimed Banksia Woodland TEC on the eastern side of Barn Road. A very pronounced occurrence of sudden yellow to orange sands is also evident immediately north of Barn Road, where vegetation unit EtBeAn has been mapped.

Based on species composition and other characteristics of the Banksia Woodland TEC, five vegetation units BaXpAn, BaXpUa, EmXpAn, EtBeAn and EtEpAn are considered to be a likely representation of the Commonwealth-listed TEC. The total area of the Banksia Woodland TEC within the study area is 476 ha, consisting of occurrences of the aforementioned vegetation units.

7.2.2 Banksia Woodlands Threatened Ecological Community

7.2.2.1 Banksia Woodland Characterisation

The Conservation Advice (Threatened Species Scientific Committee 2016) states that Banksia Woodland TEC "typically occurs on well drained, low nutrient soil on sandplain landforms, particularly deep Bassendean and Spearwood sands and occasionally on Quindalup sands", and that the community "is also common on sandy colluvium and aeolian sands of the Ridge Hill Shelf, Whicher Scarp and Dandaragan Plateau; and may also occur in other limited scenarios".

The PATN™ analysis resulted in quadrats clustering with eachother based on common combinations of flora species recorded (**Figure 12**). This analysis determined which of the vegetation units each quadrat represents, including five Banksia Woodland units represented by 54 quadrats.

One of the tools used to characterise the Banksia woodland vegetation as representative of the TEC was a checklist developed based on the Conservation Advice (Threatened Species Scientific Committee

2016). The checklist includes the key characteristics of the TEC, including botanical region, soil and landform types and required or typical species for each stratum.

All 2017 sampled quadrats containing at least one of the characteristic tree Banksia species, plus all quadrats that have clustered with Banksia woodland vegetation units (**Figure 12**) for the final vegetation mapping presented in this report (whether or not they recorded relevant Banksia tree species), totalling 54 quadrats, have been included in an analysis against the checklist, as presented in **Table 16**.

The combined PATN™ analysis and assessment against the checklist determined that 36 of the quadrats are confirmed to represent the Banksia Woodland TEC, with a further 13 considered likely to represent the TEC, based only on PATN™ analysis.

Table 16 Key Characteristic Analysis of Recorded Quadrats for Banksia Woodland TEC Diagnosis

Key Character (see key)	B06.2	B07.2	B10.2	B11	B14	B15	B16R	B17	B18.2	B19.2	B2.06	B2.07	B2.15	B2.17	B2.18	B2.19	B2.20	B2.21	B2.22	B2.23	B2.24	B2.25	B2.28	B2.30	B2.32	B2.35	B2.36
a).	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
b).	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
c).	+	+	+		+		+		+	+		+	+	+			+					+	+	+	+	+	+
d).		+											+		+	+	+	+	+		+						
e).	+		+			+	+			+	+	+		+								+	+	+			
f).	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
g).	+	+	+	+			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Confirmed/Likely	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Key Character (see key)	**B2.37**	**B2.39**	**B2.40**	**B2.48**	**B2.49**	**B2.50**	**B2.51**	**B32.2**	**B37.2**	**B41.2**	**B42**	**B45.2**	**B46.2**	**B49**	**B50**	**B51**	**B52**	**B53**	**B54**	**B55**	**B56**	**C01**	**C02**	**C04**	**C05**	**C06**	**C08**
a).	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
b).	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
c).			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+
d).	+			+				+						+													
e).			+			+				+	+	+	+	+			+	+	+					+	+		+
f).	+		+	+	+	+	+	+		+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+
g).	+	+	+		+	+	+	+		+	+	+	+	+		+	+	+	+	+	+	+	+		+	+	+
Confirmed/Likley	+	+	+	+	+	+	+	+		+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+

KEY

a) Swan Coastal Plain or Jarrah Forest location

b) Soils and landform either deep Bassendean, Spearwood or occasionally Quindalup sands, sandy colluvium, Aeolian sands of the Ridge Hill Shelf or Whicher Scarp

c) Distinctive upper sclerophyllous layer dominated by *Banksia attenuata, Banksia menziesii, Banksia ilicifolia* or *Banksia prionotes*

d) With (although can be without) an emergent tree layer of *Corymbia calophylla, Eucalyptus marginata* or *Eucalyptus gomphocephala*

e) With (although can be without) other trees including *Eucalyptus todtiana, Nuytsia floribunda, Allocasuarina fraseriana, Callitris arenaria, Callitris pyramidalis* or *Xylomelum occidentale*

f) Understorey/mid-ground sclerophyllous shrub layer including mostly Asteraceae, Dilleniaceae, Droseraceae, Ericaceae, Fabaceae, Haemodoraceae, Iridaceae, Myrtaceae, Orchidaceae, Proteaceae, Restionaceae

g) Herbaceous ground layer including mostly Apiaceae, Asteraceae, Cyperaceae, Haemodoraceae, Poaceae, Restionaceae, Stylidiaceae

Confirmed (based on PATN™ analysis and checklist); **Likley** (based on PATN™ only)

7.2.2.2 Banksia Woodland FCTs

Floristic analysis of recorded quadrat data was carried out against the Gibson *et al.* (1994) and Keighery (2012) datasets using multivariate cluster analysis of species presence/absence using PATN™ software. The resulting dendrogram is presented in **Figure 15**. This analysis was based on the fact that five of the vegetation units present within the study area, BaXpAn, BaXpUa, EmXpAn, EtBeAn and EtEpAn, are representative of the Banksia Woodland TEC.

The analysis determined that all of the units cluster with and therefore likely represent 'FCT SCP09 *Banksia attenuata* woodlands over dense low shrublands', which is considered to be representative of the Banksia Woodland TEC. An affinity to FCT 23c 'North-eastern *Banksia attenuata – Banksia menziesii* woodlands' is also evident, except for quadrat B50, which clusters away from the rest of the Banksia woodland quadrats and forms a cluster with some FCT 21c 'Low lying *Banksia attenuata* woodlands or shrublands' quadrats. Although quadrat B50 has *Banksia attenuata* and *Banksia menziesii* present in its upper sclerophyllous layer, it is heavily dominated by dense *Kunzea micrantha* up to 6 m in height and is therefore not considered to be a representation of a Banksia dominated woodland, nor is it considered representative of the TEC.

The resulting dendrogram from the PATN™ analysis is presented in **Figure 15** with the full cluster analysis presented in **Appendix E**.

7.2.2.3 Banksia Woodland Mapping

The areas of Banksia woodland across the study area have been mapped based on data from 36 quadrats confirmed to support the Banksia Woodland TEC (**Table 16**), with data collected during field assessments conducted between 2016 and 2017. The extent of Banksia woodland across the study area is presented in **Figure 16**.

7.2.2.4 Banksia Woodland Patches and Condition Thresholds

Each area of mapped Banksia woodland has been grouped with other relevant areas of Banksia woodland connected to those areas within the stiudy area, to form patches, in accordance with the methodologies and requirements described in the Conservation Advice (Threatened Species Scientific Committee 2016). These methodologies specify that areas of Banksia woodland may be variable in their condition within their patch but that condition thresholds provide guidance as to whether or not a patch as a whole retains sufficient conservation values to be considered a Matter of National Environmental Significance (MNES) as defined under the EPBC Act. Patches that do not meet the minimum condition thresholds are excluded from full national protection, so that efforts are focused on the most valuable elements of the ecological community (Threatened Species Scientific Committee 2016).

In summary, areas of Banksia woodland that are in 'Degraded' condition are unlikely to be able to be conserved, so are excluded from patches and classification as the TEC altogether. Areas of Banksia woodland in 'Degraded' or worse condition are not considered to be a MNES unless they are connected to or closely located to (separated by less than a 30 m gap, with gaps being cleared areas, infrastructure, areas of another vegetation type, or any other interruption) other areas of applicable Banksia woodland. That is, isolated and degraded areas of Banksia woodland would not be incorporated into nearby patches and, given the low likelihood of sustainable conservation, would not be focused on for protection. Based on the above logic there are Banksia woodland patches totalling approximately 18,142 ha present in the region, that are connected to areas of Banksia woodland classified as the TEC within the study area, as shown in **Figure 17**.

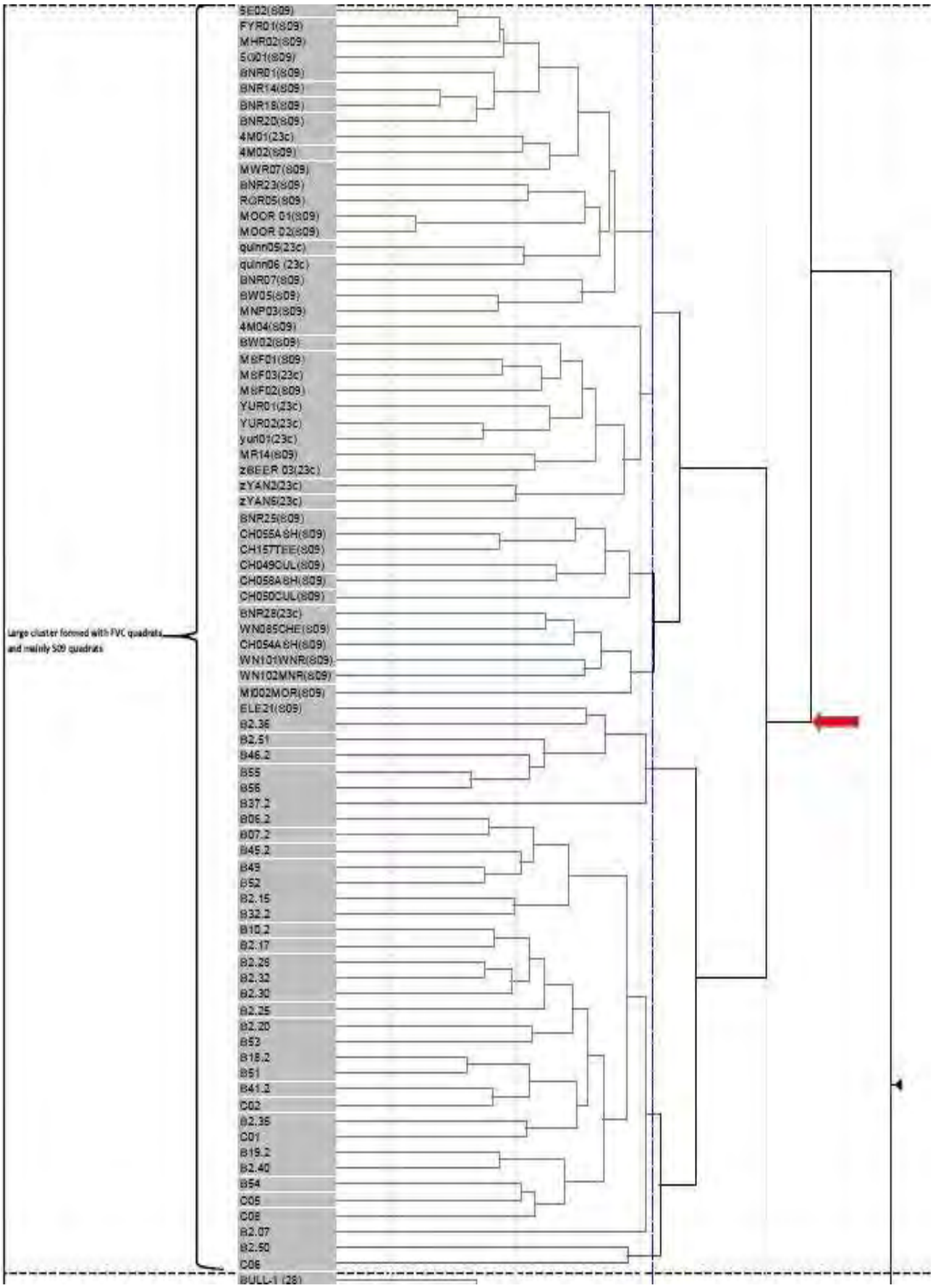
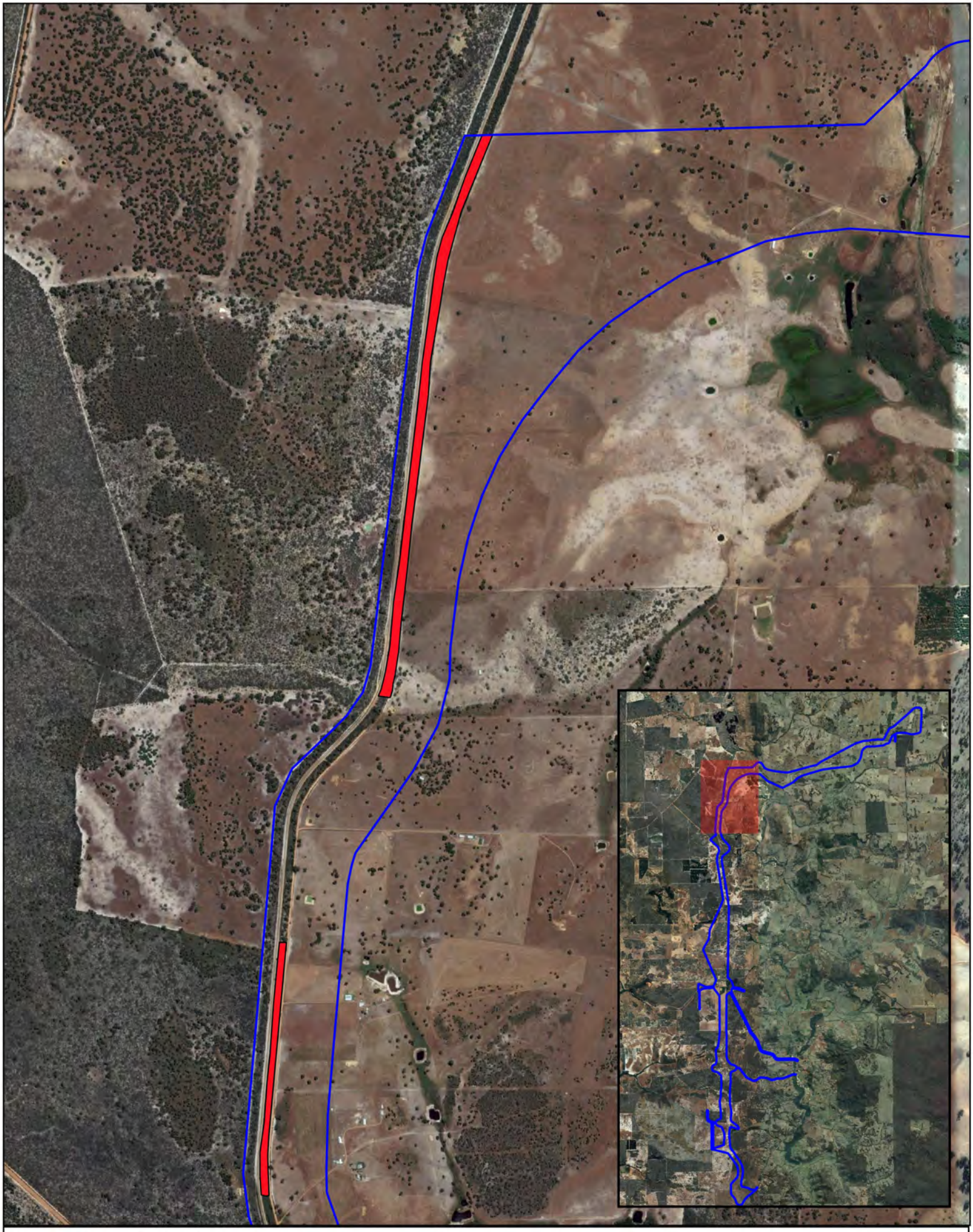


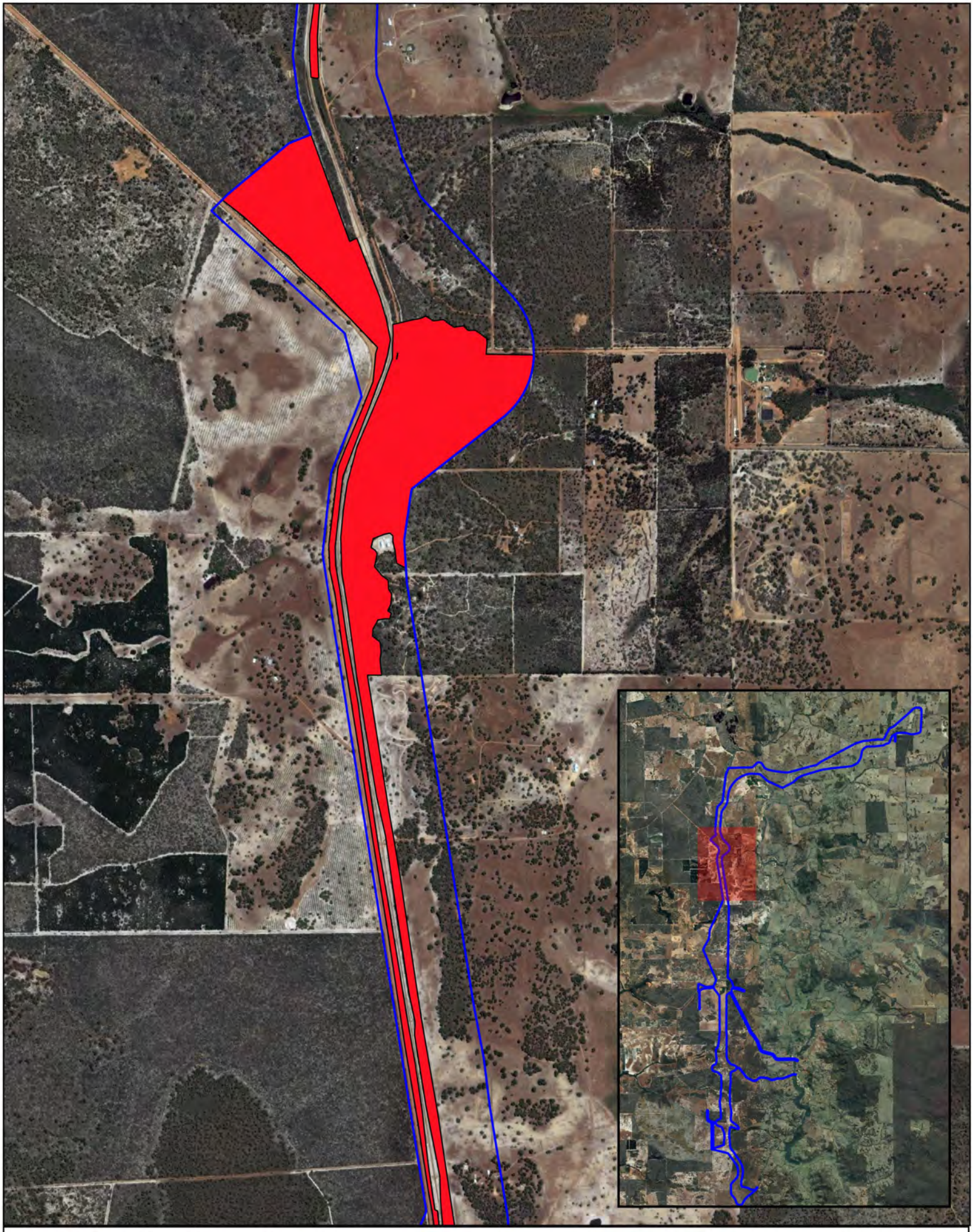
Figure 15 **Banksia Woodland Cluster Analysis**



GDA 94 / MGA Zone 50

Figure 16a - Banksia Woodland Extent

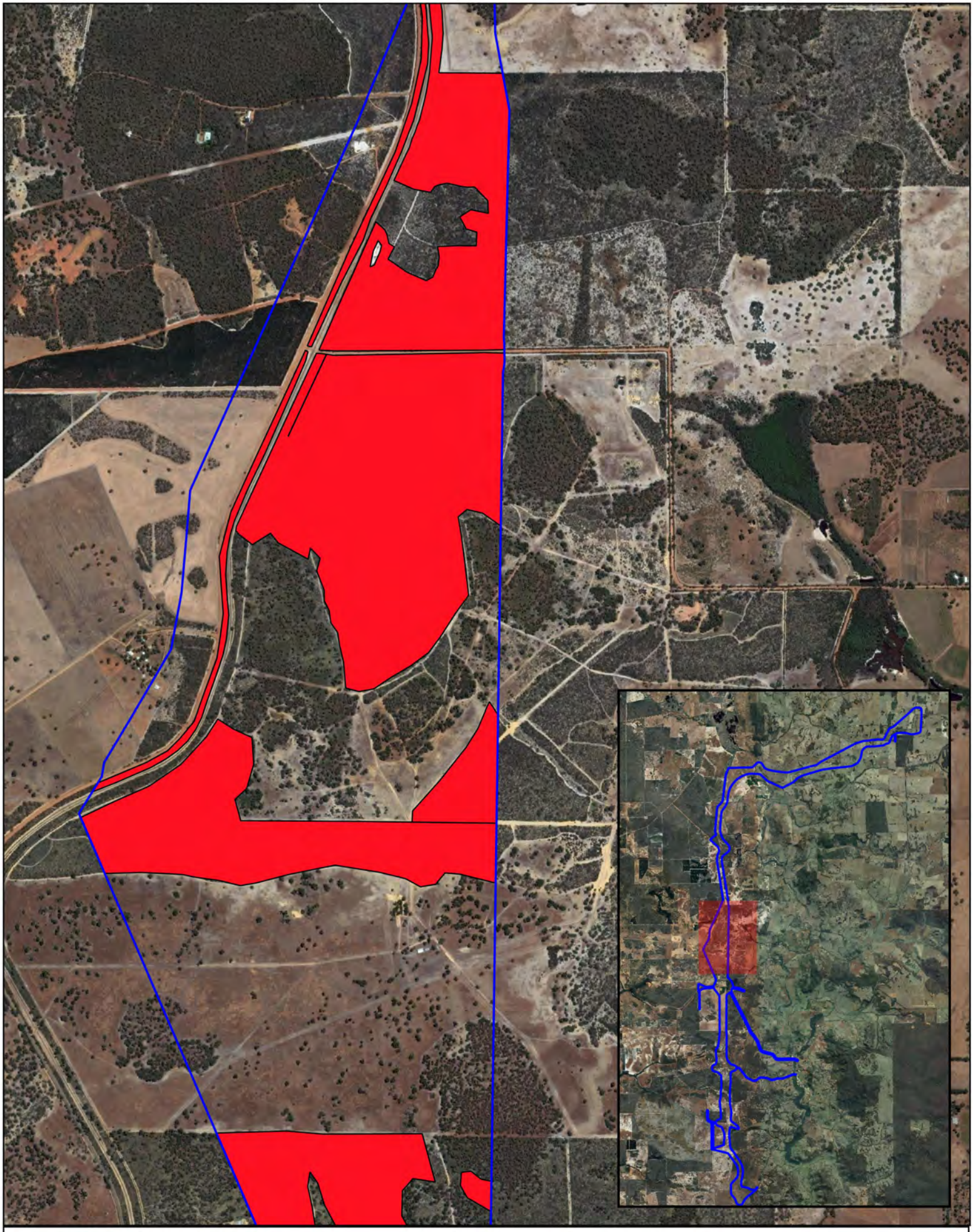
FOCUSED VISION consulting



GDA 94 / MGA Zone 50

Figure 16b - Banksia Woodland Extent

FOCUSED VISION consulting



GDA 94 / MGA Zone 50

Figure 16c - Banksia Woodland Extent

FOCUSED VISION consulting

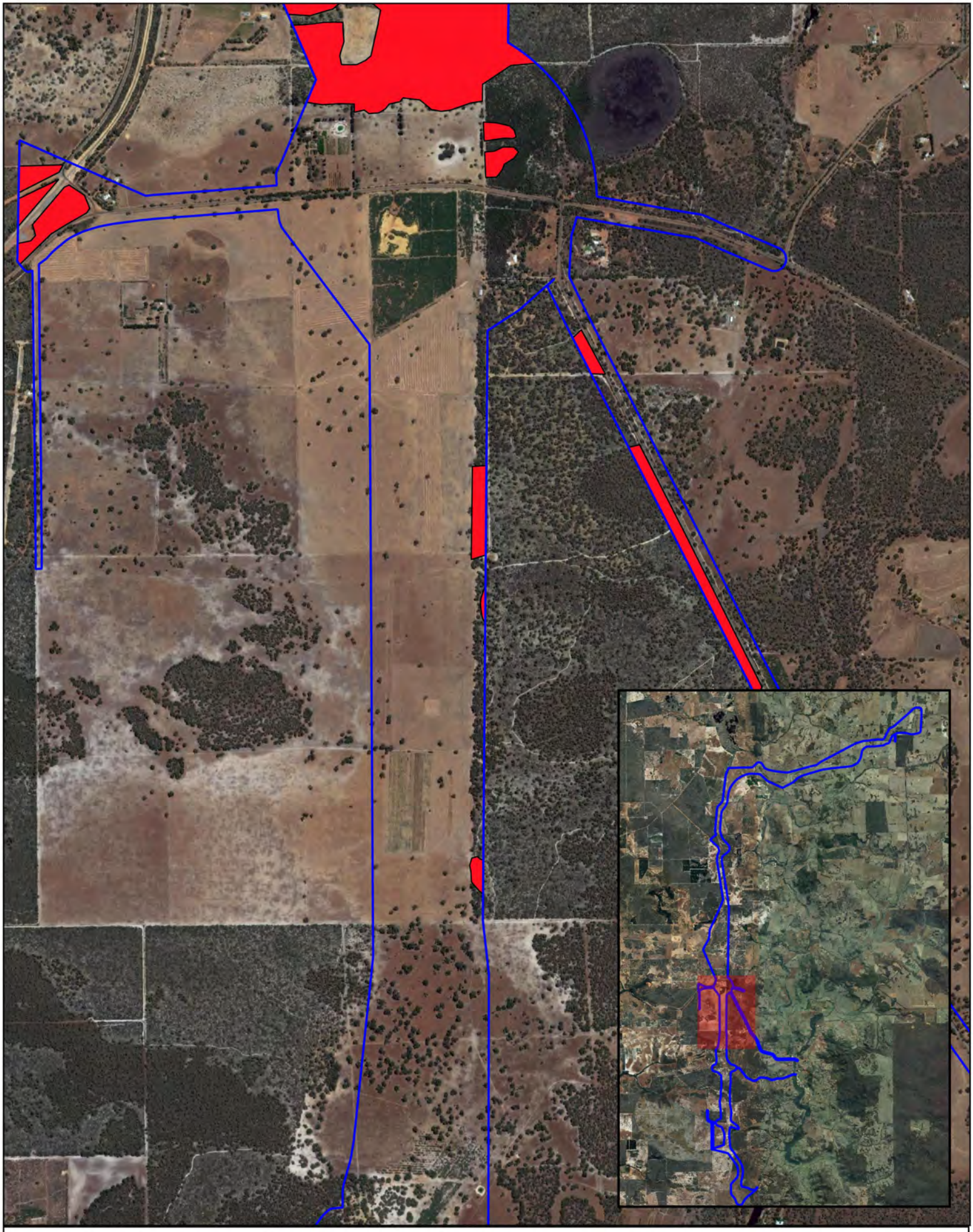


Figure 16d - Banksia Woodland Extent

FOCUSED VISION consulting

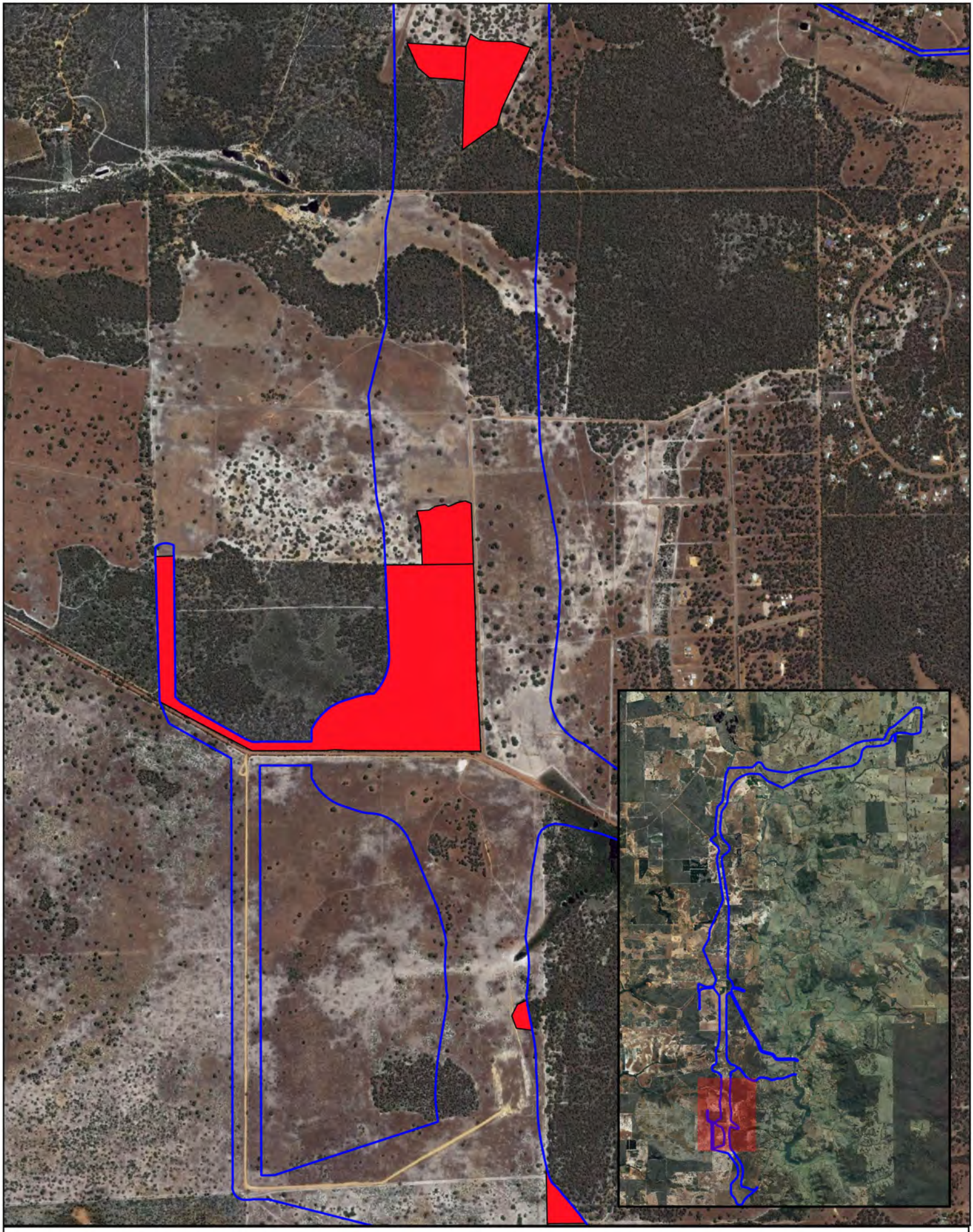


Figure 16e - Banksia Woodland Extent

ASJV17001 29 January 2018

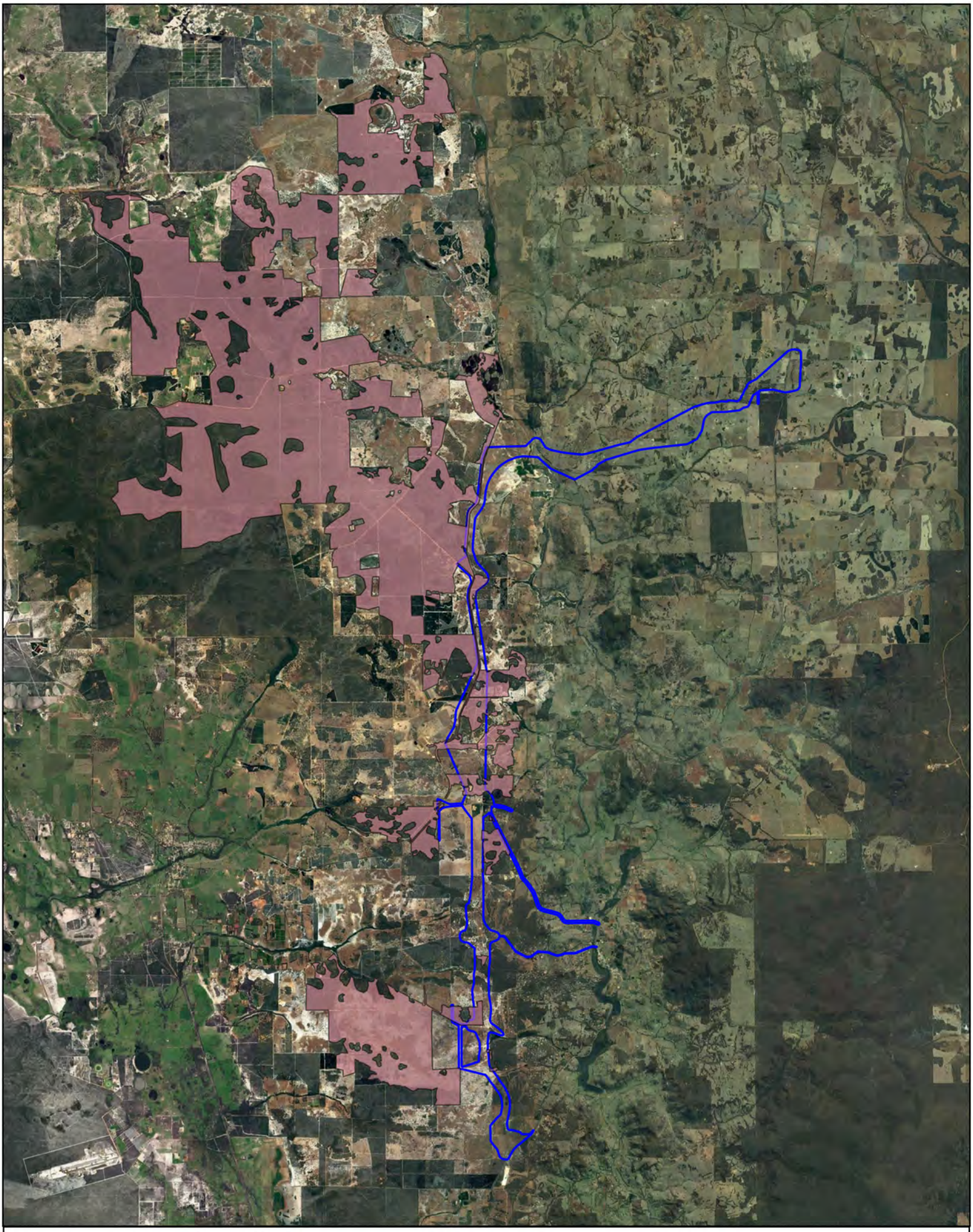
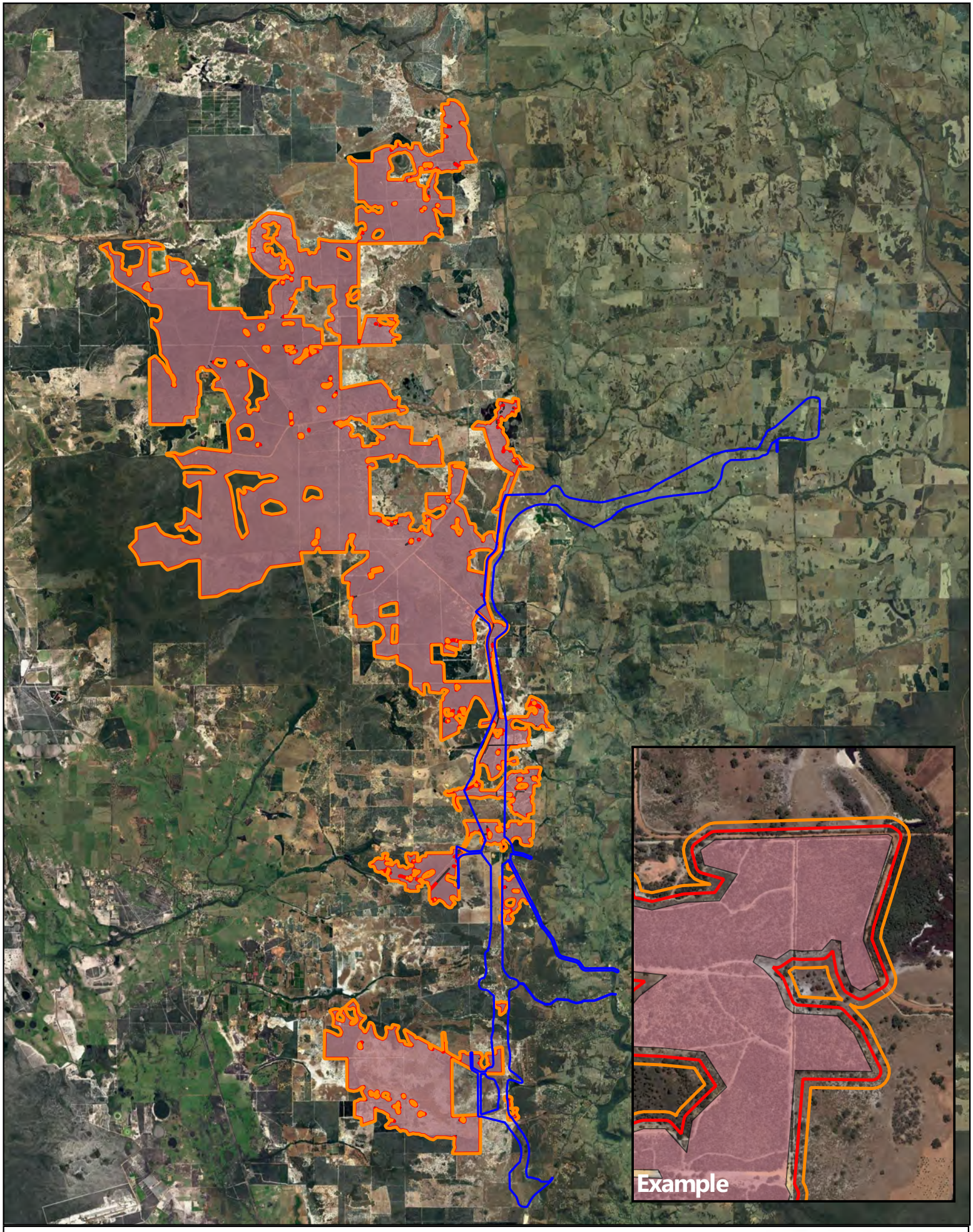


Figure 17 - Banksia Woodland Patches

7.2.2.5 Banksia Woodland Buffers

The Conservation Advice (Threatened Species Scientific Committee, 2016) incorporates the need for buffers around areas of the TEC, in order to protect the integrity of the significant vegetation from surrounding impacts such as weed invasion. The guideline suggests that suitable buffers are a minimum of 20 m but optimally up to 50 m. A protection buffer of at least 20 m and optimally 50 m would therefore apply around the entire Banksia Woodland patch as presented in **Figure 18**.



0 2.5 5 7.5 10 km

GDA 94 / MGA Zone 50

Figure 18 - Banksia Woodland Patch Buffers

N

Legend

Study Area
25m Buffer
Banksia Patch
50m Buffer

FOCUSED VISION consulting

7.2.3 Local Representation and Significance

The local significance of the vegetation units was assessed based on:

- presence of Priority Flora
- presence of flora exhibiting range extensions
- unusually high structural and species diversity
- restricted, small or isolated distribution and/or area.

All twelve of the mapped vegetation units recorded Priority flora, and are therefore are considered to be of local significance.

One vegetation unit, BmKgHg was observed to be locally restricted to two locations in the study area, associated with a wetland, with the two locations separated by Mooliabeenee Road. This vegetation unit is therefore considered to be locally significant due to limited local representation.

Two of the recorded flora species, *Jacksonia ? sericea* (P4) and *Synaphea ? flabelliformis* were found to be a range extension and occurs within vegetation unit EtBeAn which is therefore considered to be locally significant due to this factor.

None of the recorded vegetation units were found to exhibit unusually high structural diversity, although most of the intact vegetation types of the Swan Coastal Plain are considered to be structurally and floristically diverse. Additionally, four of the recorded vegetation units, EmXpHh, EwXpHh, BaXpAn and EmXpAn recorded species richness averages of 38 taxa or more per 100 m^2 from quadrats assessed as part of this study in 2017. Therefore, these vegetation types are considered locally significant due to high species diversity and their relatively high structural diversity is also notable.

The representation of each of the recorded vegetation units within the study area is presented in **Table 17**, which shows that units BmKgHg, EmXpAn, EwBeNa, EwXpHh and MvJspLs are limited in their local extent and therefore considered to be locally significant.

Table 17 Extent of Each Vegetation Unit in the Study Area

Vegetation Unit	Area (ha)	Proportion of Study Area (%)
BaXpAn - *Banksia* spp. sparse woodland	94.88	2.77
BaXpUa – *Banksia attenuata* sparse woodland	47.77	1.40
BmKgHg – *Kunzea glabrescens* shrubland	16.90	0.49
EmBsHh - *Eucalyptus marginata* and *Banksia sessilis* sparse woodland	133.59	3.90
EmXpAn – *Eucalyptus marginata* woodland	22.93	0.67
EmXpHh - *Eucalyptus marginata* sparse woodland	204.18	5.97
ErXpBm – *Eucalyptus rudis* and *Melaleuca preissiana* woodland	41.43	1.21
EtBeAn - *Eucalyptus todtiana* sparse woodland	253.79	7.42
EtEpAn – *Eucalyptus todtiana* sparse woodland	56.45	1.65
EwBeNa – *Eucalyptus wandoo* and *Casuarina obesa* sparse woodland	2.29	0.07
EwXpHh - *Eucalyptus wandoo* sparse woodland	36.43	1.06
MvJspLs - *Melaleuca viminea* shrubland	11.77	0.34
Areas not mapped	88.71	2.59
Pasture communities, open water, planted areas and cleared areas	2,305.27	67.36

NB: Roads not included in area calculations

7.2.4 Regional Significance

The regional significance of the vegetation units was assessed based on:

- presence of Threatened flora
- extents limited to specific landform types
- regionally uncommon or restricted plant community types.

No Threatened flora species were recorded within the study area, and therefore, none of the vegetation units are considered regionally significant due to this factor.

The study area supports three broad landforms:

- woodlands and forests on lateritic hills of the Northern Jarrah Forest
- woodlands and heaths on sands of the Swan Coastal Plain
- wetlands and surrounding low-lying/wet vegetation associated with both the Northern Jarrah Forest and Swan Coastal Plain vegetation.

The wetland landforms and associated vegetation types are relatively less represented in the study area than the other two key landforms listed above. Aditionally, wetland environs tend to support biological values, such as aquatic or wet habitats, that are restricted in areas dominated by woodlands and other upland habitats. The vegetation units associated with such landforms are BmKgHg, ErXpBm, EwBeNa and MvJspLs, which may therefore be considered to be of regional significance.

7.2.4.1 Regional Representation and Extent Remaining

Native vegetation significance can be determined based on a range of factors such as isolation, vegetation supporting conservation significant flora or fauna or representing an unusual landform type, as discussed above. However, the most important factor in the consideration of community significance is the representation of the vegetation unit in the region. Vegetation units are considered significant if they are poorly represented.

In order to analyse the regional representation and therefore significance of the vegetation units recorded in the study area, comparisons were made between data collected from within the study area and that of regional data from the study (from quadrats recorded outside the study area, in the local region), data available in published work, which focused on Shepherd *et al.* (2002), as well as Heddle *et. al.* (1980) the most recent relevant survey in the region, carried out by Phoenix Environmental Sciences for the Great Northern Highway upgrades at Muchea North and Chittering (Phoenix 2015).

This regional vegetation analysis initially used multivariate cluster analysis of species presence/absence using PATN™ (Belbin 2013) and was performed with data from each quadrat of the current (FVC autumn, winter and spring 2017) surveys and that of Phoenix (2015), providing a total of 117 sampling points. The presence and absence data were consolidated with some adjustments to the species matrices to update synonyms to currently accepted nomenclature (Western Australian Herbarium 1998-2018) to maintain consistency across the surveys. An association matrix of the Bray-Curtis coefficient was generated from the presence and absence of site by species matrix using the software.

The resultant dendrogram is presented in **Figure 19** and was used to determine the similarity between the described vegetation units of the 2017 FVC surveys and those from the nearby surveys by Phoenix (2015).

In order to gain a wider context for assessing the regional representation of the vegetation units of the current study, the vegetation units recorded were also aligned with the broad, regional vegetation

associations of Shepherd *et al.* (2002), relevant to the region of the study area. These alignments are also presented in **Figure 19**. Regional vegetation associations that had been aligned by Phoenix (2015) to their recorded vegetation units, and regional associations aligned with vegetation units for current study, are also presented in **Figure 19**. Given that data is available pertaining to the representation of the regional (Shepherd *et al.* 2002) vegetation associations within the relevant Local Government (Shire of Chittering and Shire of Gingin), conclusions as to regional representation, extent remaining and therefore significance are able to be made. The results of this analysis are presented in **Table 18**.

EPA Position Statement No. 2 (EPA 2000) identifies a series of constraints in relation to biodiversity. One of which is to protect at least 30% of the original extent of vegetation complexes in unconstrained areas and 10% in constrained areas such as urban zones in accordance with the principles of Bush Forever (Government of Western Australia 2000). The study area is considered to be an unconstrained area and as such the minimum retention target of 30% applies.

Within the Shire of Chittering, four of the vegetation associations represented by vegetation units within the study area (4, 352, 1017 and 1018) are represented by less than 30% of their pre-European extent remaining (**Table 18**). Vegetation association 1018 is also represtned by less than 30% pre-European extent within the Shire of Gingin. Therefore, these vegetation associations and the vegetation units that align with them (EmBsHh, EmXpAn, EmXpHh, EwXpHh and EwBeNa) are considered to be regionally significant.

One vegetation unit, BmKgHg, associated with a wetland, was found to be locally restricted to only two locations in the study area, with the two locations separated only by Mooliabeenee Road. This vegetation unit is therefore considered to be locally and regionally significant, due to limited local and regional representation, as well as being limited to a specific landform type (wetland).

Four mapped vegetation units, EmBsHh, EmXpHh, EmXpAn and ErXpBm were found to be representative of vegetation associations present in the wider region (1009 and 1018), both of which are not regionally mapped as occurring in the immediate vicinity of the study area. These vegetation types are therefore considered to be of further regional significance.

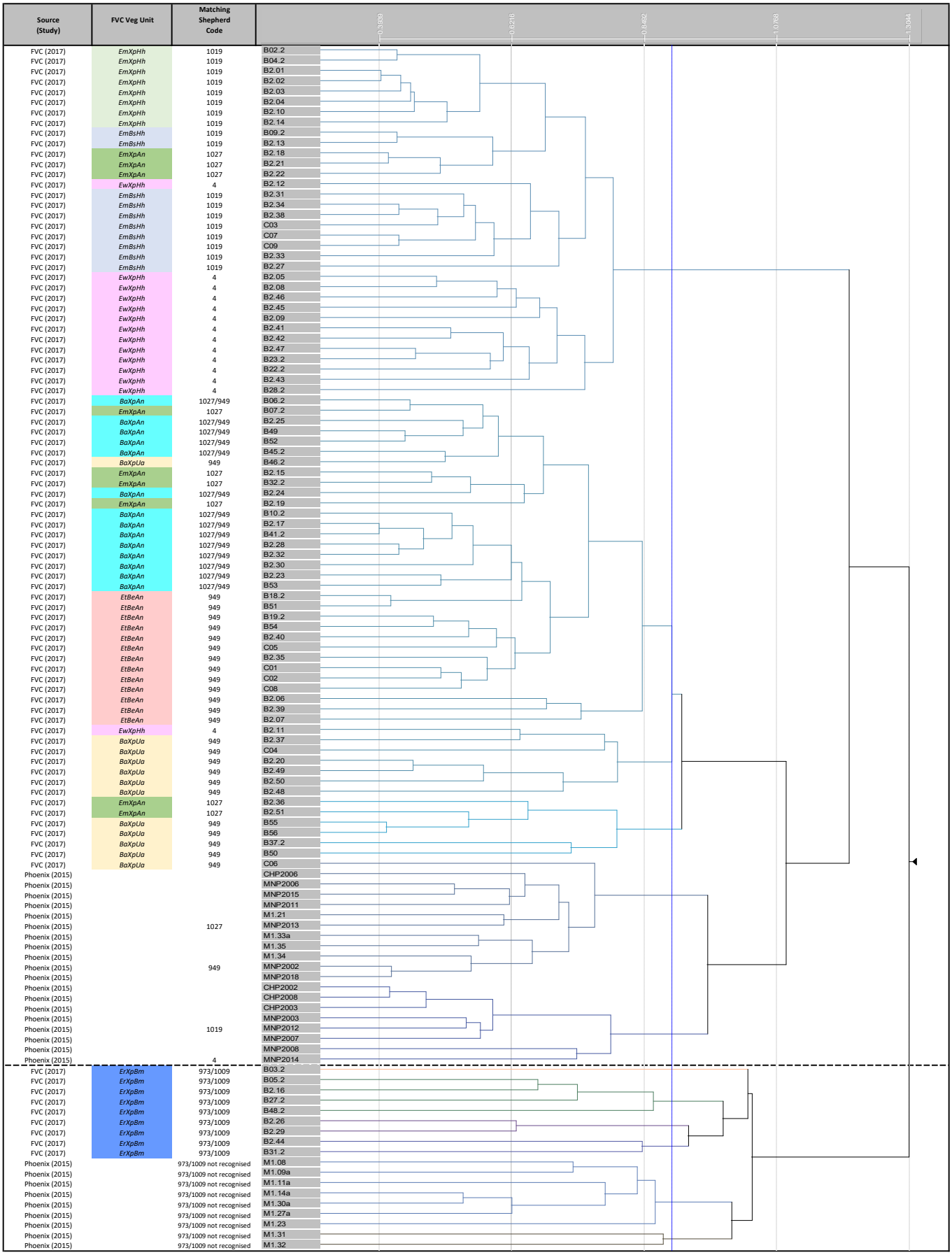


Figure 19: Regional FCT Quadrat Cluster Analysis Dendrogram

Table 18 Regional Extent of Vegetation Associations within the Study Area, as Represented by Vegetation Units Recorded

Shire	Shepherd *et.al.* (2002) Association	Shepherd *et.al.* Description	Corresponding Heddle *et. al.* (1980) Complex/es	Corresponding Vegetation Unit/s	Pre-European Extent (ha)	Current Extent (ha)	% Remaining
Chittering	3	Medium forest; jarrah-marri	Mogumber complex – south Cullula complex	EmXpAn, EmXpHh	7,102.74	3,367.17	47.41
	4	Medium woodland; marri & wandoo	Yalanbee complex in low rainfall Coolakin complex in low rainfall Michibin complex	EwXpHh, EwBeNa	54,209.81	15,314.37	28.25
	37	Shrublands; teatree thicket	Nooning complex Wannamal complex Moondah complex	MvJspLs, BmKgHg, ErXpBm	139.52	104.10	74.62
	352	Medium woodland; York gum	Yalanbee complex Bindoon complex	-	4,895.73	825.99	16.87
	949	Low woodland; *banksia*	Mogumber complex – south Cullula complex Wannamal complex Moondah complex	EtBeAn, EtEpAn, BaXpUa, BaXpAn	13,749.46	12,749.33	92.73
	973	Low forest; paperbark (*Melaleuca rhaphiophylla*)	Nooning complex Wannamal complex	ErXpBm, MvJspLs, BmKgHg	242.04	108.87	44.98
	1017	Medium open woodland; jarrah & marri, with low woodland; banksia	Mogumber complex – south Cullula complex Wannamal complex Moondah complex	EmBsHh, EmXpHh, EmXpAn	1,282.11	241.84	18.86
	1018	Mosaic: Medium forest; jarrah-marri/Low woodland; banksia/Low forest; teatree/Low woodland; *Casuarina obesa*	Mogumber complex – south Cullula complex Wannamal complex Moondah complex Nooning complex	EmBsHh, EmXpHh, EmXpAn	2,861.34	629.63	22.00
	1019	Medium sparse woodland; jarrah & marri	Mogumber complex – south Cullula complex	EmXpHh, EmBsHh, EmXpAn	511.19	192.11	37.58
	1027	Mosaic: Medium open woodland; jarrah & marri, with low woodland; banksia/Medium sparse woodland; jarrah & marri	Mogumber complex – south Cullula complex Wannamal complex Moondah complex	EmBsHh, EmXpHh, EmXpAn	12,176.15	5,626.35	46.21

Shire	Shepherd *et.al.* (2002) Association	Shepherd *et.al.* Description	Corresponding Heddle *et. al.* (1980) Complex/es	Corresponding Vegetation Unit/s	Pre-European Extent (ha)	Current Extent (ha)	% Remaining
Gingin	37	Shrublands; teatree thicket	Nooning complex Wannamal complex Moondah complex	MvJspLs, BmKgHg, ErXpBm	9,484.90	4,023.96	42.42
	949	Low woodland; *banksia*	Mogumber complex – south Cullula complex Wannamal complex Moondah complex	EtBeAn, EtEpAn, BaXpUa, BaXpAn	138,102.71	81,727.70	59.18
	1009	Medium woodland; marri & river gum	Nooning complex	ErXpBm	6,839.88	2,169.17	31.71
	1017	Medium open woodland; jarrah & marri, with low woodland; banksia	Mogumber complex – south Cullula complex Wannamal complex Moondah complex	EmBsHh, EmXpHh, EmXpAn	4,528.98	2,283.32	50.42
	1018	Mosaic: Medium forest; jarrah-marri/Low woodland; banksia/Low forest; teatree/Low woodland; *Casuarina obesa*	Mogumber complex – south Cullula complex Wannamal complex Moondah complex Nooning complex	EmBsHh, EmXpHh, EmXpAn	3,178.56	833.18	26.21
	1019	Medium sparse woodland; jarrah & marri	Mogumber complex – south Cullula complex	EmXpHh, EmBsHh, EmXpAn	293.24	204.05	69.58
	1027	Mosaic: Medium open woodland; jarrah & marri, with low woodland; banksia/Medium sparse woodland; jarrah & marri	Mogumber complex – south Cullula complex Wannamal complex Moondah complex	EmBsHh, EmXpHh, EmXpAn	27,633.06	17,730.69	64.16

7.2.5 National Significance

The national significance of the vegetation units was assessed based on:

- presence of EPBC-listed Threatened flora
- presence of EPBC-listed TECs.

No species of Threatened flora were recorded within the study area, and therefore none of the vegetation types are considered nationally significant due to this factor.

As discussed in **Section 7.2.1**, five of the recorded vegetation units, BaXpAn, BaXpUa, EmXpAn, EtBeAn and EtEpAn are considered likely to be representative of the Commonwealth-listed TEC, *Banksia Woodlands* of the Swan Coastal Plain and, therefore, these areas of vegetation are considered to be of national significance (**Figure 13**).

7.2.6 Summary of Vegetation Significance

The significant vegetation units of the study area, along with the factors determining their significance are summarised in **Table 18**.

Table 19 Summary of Significant Vegetation Units

Vegetation Units	Significance
BaXpAn – *Banksia* sparse woodland	Locally significant (floristically diverse) Locally significant (supports Priority flora) Nationally significant (represents a Commonwealth TEC)
BaXpUa – *Banksia attenuata* sparse woodland	Locally significant (floristically diverse) Locally significant (supports Priority flora) Nationally significant (represents a Commonwealth TEC)
BmKgHg - *Kunzea glabrescens* shrubland	Locally significant (supports Priority flora) Locally significant (locally uncommon) Locally significant (limited local extent) Regionally significant (limited to specific landforms) Regionally significant (regionally uncommon)
EmBsHh - *Eucalyptus marginata* and *Banksia sessilis* sparse woodland	Locally significant (supports Priority flora) Regionally significant (represented by <30% of pre-European extent)
EmXpAn – *Eucalyptus marginata* sparse woodland	Locally significant (floristically diverse) Locally significant (supports Priority flora) Locally significant (limited local extent) Regionally significant (represented by <30% of pre-European extent) Nationally significant (represents a Commonwealth TEC)
EmXpHh - *Eucalyptus marginata* sparse woodland	Locally significant (floristically diverse) Locally significant (supports Priority flora) Regionally significant (represented by <30% of pre-European extent)
ErXpBm – *Eucalyptus rudis* and *Melaleuca preissiana* sparse woodland	Locally significant (supports Priority flora) Regionally significant (limited to specific landforms)
EtBeAn - *Eucalyptus todtiana* sparse woodland	Locally significant (supports Priority flora) Locally significant (supports range extension species) Nationally significant (represents a Commonwealth TEC)
EtEpAn - *Eucalyptus todtiana* sparse woodland	Locally significant (supports Priority flora) Nationally significant (represents a Commonwealth TEC)
EwBeNa - *Eucalyptus wandoo* and *Casuarina obesa* sparse woodland	Locally significant (supports Priority flora) Locally significant (limited local extent) Regionally significant (limited to specific landforms) Regionally significant (represented by <30% of pre-European extent)
EwXpHh - *Eucalyptus wandoo* sparse woodland	Locally significant (floristically diverse) Locally significant (limited local extent) Locally significant (supports Priority flora) Regionally significant (represented by <30% of pre-European extent)
MvJspLs - *Melaleuca viminea* shrubland	Locally significant (supports Priority flora) Locally significant (limited local extent) Regionally significant (regionally uncommon) Regionally significant (limited to specific landforms)

8 CONCLUSIONS

The key results and conclusions from the detailed flora and vegetation assessment, and targeted Threatened and Priority flora survey are as follows:

- No species of Threatened flora, including *Thelymitra stellata* and *Drakaea elastica* were recorded within the study area, despite intensive and systematic targeted surveys having been carried out.
- Eight species listed as Priority Flora under the WC Act, *Drosera sewelliae* (with *Drosera* ?*sewelliae*) (P2), *Hibbertia glomerata* subsp. *ginginensis* (P2), *Acacia drummondii* subsp. *affinis* (with *Acacia drummondii* subsp. ?*affinis*) (P3), *Adenanthos cygnorum* subsp. *chamaephyton* (P3), *Hibbertia miniata* (P4), *Hypolaena robusta* (P4*), Jacksonia* ?*sericea* (P4) and *Verticordia paludosa* (with *Verticordia* ?*paludosa*) (P4) were recorded during the 2017 field assessments.
- A collective total of 11 species listed as Priority Flora under the WC Act, *Gastrolobium* ?*crispatum* (P1), *Synaphea panhesya* (with *Synaphea ?panhesya*) (P1), *Drosera sewelliae* (with *Drosera* ?*sewelliae*) (P2), *Hibbertia glomerata* subsp. *ginginensis* (P2), *Acacia drummondii* subsp. *affinis* (with *Acacia drummondii* subsp. ?*affinis*) (P3), *Adenanthos cygnorum* subsp. *chamaephyton* (P3), *Anigozanthos humilis* subsp. *chrysanthus* (P4), *Hibbertia miniata* (P4), *Hypolaena robusta* (P4), *Jacksonia* ?*sericea* (P4) and *Verticordia paludosa* (with *Verticordia* ?*paludosa*) (P4) were recorded between the 2016 and 2017 field assessments.
- A collective total of 1,967 individual Priority flora plants were recorded in the study area between 2016 and 2017.
- It is considered likely that the distribution and abundance of the Priority flora recorded within the study area is greater than the assessment results would suggest, and that additional species of Priority flora occur that were not recorded, due to the unfavourable season experienced by the region with lower than expected rainfall received during winter 2017.
- Two flora species, *Jacksonia ?sericea* (P4) and *Synaphea* ?*flabelliformis* were found to be occurring outside their known range, based on distributions from the WA Herbarium.
- One State-listed TEC and two PECs are known to occur within or closely adjacent to the study area, with all three of these community types representative of the Commonwealth-listed Banksia Woodlands of the Swan Coastal Plan TEC.
- The study area has been confirmed to support areas of the of the Commonwealth-listed Banksia Woodland TEC, within 476 ha of the TEC mapped, consisting of occurrences of vegetation units BaXpAn, BaXpUa, EmXpAn, EtBeAn and EtEpAn.
- All of the recorded vegetation units have been determined to be of local, regional or national significance, or a combination of these levels of importance. All are locally significant due to supporting populations of Priority flora and many having a limited local representation. Other factors determining local significance are, being considered floristically diverse or locally uncommon. Vegetation units have been determined to be regionally significant due to being represented by less than 30% of their pre-European extent in the local government area, being limited to specific landform types, or being regionally uncommon. Five vegetation units (BaXpAn, BaXpUa, EmXpAn, EtBeAn, EtEpAn) are of national significance due to representing a TEC of Commonwealth significance.

9 LIST OF PARTICIPANTS

Table 20 summarises the FVC personnel who contributed to the project.

Table 20 Project Team

Name	Qualification	Years of Relevant Experience	Role
Kellie Bauer–Simpson Principal Ecologist/Botanist	BSc. (Biological Science)	19	Project manager, flora, vegetation and targeted flora field assessment, report technical review
Gabriela Martinez Senior Botanist/Environmental Scientist	BEnvSc. (Hons) (Conservation Biology)	17	Flora, vegetation and targeted flora field assessment; data analysis, report preparation
Lisa Chappell Senior Botanist/Environmental Scientist	BEnvSc. (Hons) (Conservation Biology)	16	Flora, vegetation and targeted flora field assessment, report preparation
Catherine Krens Senior Botanist/Ecologist	BSc. (Environmental Science)	9	Flora, vegetation, targeted flora field assessment
Udani Sirisena Botanist/Taxonomist	PhD BSc. (Botany and Chemistry)	8	Plant identifications, data and PATN analysis, report preparation
Will Bauer–Simpson Technician/Advisor	Cert IV (Health and Safety)	7	Field safety and logistics planning, targeted flora field assessment, GIS and mapping

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