



Main Roads Western Australia

Brand Highway Passing Lanes

Biological Assessment

May 2016

Executive summary

This report is subject to, and must be read in conjunction with, the limitations set out in Section 1.5 and the assumptions and qualifications contained throughout the Report.

Main Roads Western Australia is proposing to construct eight passing lanes on the Brand Highway between Gingin and Eneabba in Western Australia. The passing lanes are located at:

- SLK 71.0-68.7 southbound (Site 1)
- SLK 79.7-81.5 northbound (Site 2)
- SLK 112.8-110.4 southbound (Site 3)
- SLK 113.6 – 116.3 northbound (Site 4)
- SLK 126.2 – 129.0 southbound (Site 5)
- SLK 160.3 – 163.9 northbound (Site 6)
- SLK 160.0 – 162.0 southbound (Site 7)
- SLK 34.83-36.0 northbound (Site 8).

The Survey area included a larger area than is likely to be required for the passing lanes; however, the survey was focused on the area adjacent to the highway that will be directly impacted by the Project.

A desktop assessment and a flora and fauna field assessment was undertaken 15-19 September 2014 and the 7-13 September 2015, with additional survey effort for Site 8 on 30 March 2014 and 23 January 2016. The assessment identified the following biological features of the Survey area:

- It occurs adjacent or in close proximity to a number of conservation reserves including Moore River National Park, Namming Nature Reserve, Hill River Nature Reserve and an unnamed conservation park south of Badgingarra National Park
- The pre-European vegetation associations of both Vegetation Association 999, 1031 and 1035 are below the 30 % threshold level retention. Vegetation associations 949 and 1030 are above the 30 % threshold level at all levels
- Site 1 and Site 8 occur within the regional vegetation mapping of Hedde *et al.* (1980) which indicates that Site 8 occurs within the Gingin Complex and Site 1 occurs with Coonambidgee Complex. The Gingin Complex is below the 30 % threshold level remaining, whereas the Coonambidgee Complex is above the 30 % threshold level (Local Biodiversity Program – latest updates 2013)
- The Survey area occurs within the road reserve, and includes the cleared shoulder and some small areas that have been previously disturbed due to roadworks. 76.8 hectares (ha) of the Survey area has been mapped as cleared. However, the rest of the road reserve contains native vegetation which is generally in Excellent condition. The predominant vegetation of the Survey area was Banksia woodlands with heaths and shrublands interspersed depending on topography and soils. 219.4 ha of the Survey area was rated Good condition or better

A section of Site 6 supports wetland vegetation, sedgeland and shrubland on low-lying seasonally inundated areas, with a floristic assemblage that is generally restricted to the wet areas. A creekline crosses the Survey area at the northern end of Site 3 and in this area there is a degraded *Eucalyptus rudis* - *Melaleuca raphiophylla* woodland

- No Threatened Ecological Communities were identified within the Survey area or during the field survey. One DPaW listed Priority Ecological Community was recorded within the Survey area, this is the 'Swan Coastal Plain *Banksia attenuata*- *Banksia menziesii* woodlands' (Priority 3). The vegetation type 'Banksia woodlands' recorded in Site 1 and Site 2 is representative of this PEC, with 23.1 ha of this vegetation mapped within Site 1 and 33.3 ha within Site 2. This vegetation is also equivalent to the Priority 3 PEC '*Banksia* dominated woodlands on the Swan Coastal Plain Interim Biogeographic Regionalisation for Australia region'
- The Survey area (Sites 1-7) had a very high floristic diversity and 665 flora taxa (including subspecies and varieties) representing 75 families and 271 genera were recorded in the Survey area during the field survey. This total comprises 562 (84.5 %) native taxa and 103 (15.5 %) introduced taxa, as well as three planted species. Site 8 was less floristically diverse than the other sites as the majority of the road reserve was highly degraded
- The field survey did not record any Threatened flora taxa within the Survey area, however, 13 Priority-listed flora taxa were recorded. These were: *Grevillea synapheae* subsp. *minyulo* (Priority 1), *Lyginia excelsa* (Priority 1), *Chordifex reseminans* (Priority 2), *Guichenotia alba* (Priority 3), *Phlebocarya pilosissima* subsp. *pilosissima* (Priority 3), *Stylidium hymenocraspedum* (Priority 3), *Banksia dallanneyi* subsp. *pollostata* (Priority 4), *Conostephium magnum* (Priority 4), *Desmocladius elongatus* (Priority 4), *Diuris ?recurva* (Priority 4), *Grevillea rudis* (Priority 4), *Grevillea saccata* (Priority 4), *Hibbertia helianthemoides sensu lato*. (Priority 4)
- Six fauna habitat types were identified during the field survey including: Banksia woodland; mixed shrublands; low heath and shrubland; low lying shrublands and sedgeland; parkland cleared/Marri (*Corymbia calophylla*); and highly modified areas
- The native fauna habitat types recorded are not well-represented in the local region, given that historic broad scale clearing has resulted in a mostly cleared agricultural landscape with only isolated habitat remnants remaining. As a result, the fauna habitat present within the Survey area provides important linkage, facilitating landscape connectivity and providing for fauna dispersal between larger isolated bushland fragments
- Based on field surveys and a likelihood of occurrence assessment it was concluded that one fauna species of conservation significance (Carnaby's Black Cockatoo) is known to occur in the Survey area and four fauna species of conservation significance are likely to occur
- The woodlands, shrublands and heathlands habitat types within the Survey area provide high value foraging resources for the Carnaby's Black Cockatoo. There is 261.7 ha of foraging habitat for the Black Cockatoo in the Survey area. These habitat types occur in all eight sites. The Survey area is located within the known breeding range of the species and the foraging resources and potential breeding trees were recorded within Site 3 (along Minyulo Brook) and in Site 8. There were 195 potential breeding trees (i.e. Diameter at Breast Height (DBH) greater than 300/500 mm DBH) recorded within the Survey area: 59 within Site 3, 134 within Site 8 and one within Site 5 and one within Site 7.

Conclusions

The areas of vegetation that are directly adjacent to the cleared shoulder are generally in lower condition than the vegetation within the majority of the road reserve and where possible impacts should be restricted to these areas. The extent of clearing should be minimised to reduce potential impacts on vegetation and flora within the road reserve. In addition, management measures should be implemented to reduce potential impacts on adjacent vegetation in Excellent condition, including the conservation areas that occur in close proximity to the Survey area.

Survey area It is recommended that during the Project design and construction the extent of clearing be reduced wherever possible in order to minimise potential impacts on conservation significant fauna species. The location of the Site 8 passing lane should be reassessed to minimise the number of potential black cockatoo trees that require clearing. In addition, management measures should be implemented during the construction phase to reduce potential off-site impacts

Dependent on the extent of impact on native vegetation required, it is likely that the project will require referred to the Department of the Environment due to the potential impacts on the Carnaby's Black Cockatoo foraging and breeding habitat.

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1. Introduction

1.1 Background

Increased traffic movement to the north of Western Australia has prompted planning for the construction of seven passing lanes on Brand Highway (the Project). Works are proposed to be constructed between:

- Straight Line Kilometre (SLK) 34.83 – 36.0 northbound
- SLK 71.0-68.7 southbound
- SLK 79.7-81.5 northbound
- SLK 112.8-110.4 southbound
- SLK 113.6 – 116.3 northbound
- SLK 126.2 – 129.0 southbound
- SLK 160.3 – 163.9 northbound
- SLK 160.0 – 162.0 southbound.

A preliminary assessment undertaken for the Project identified a number of conservation significant species that may be present within the proposed area of works, including Carnaby's Black Cockatoo and Threatened Flora. A biological survey was requested by Main Roads Western Australia (Main Roads) in order to identify and quantify key biological constraints associated with the Project. The purpose of the survey is to delineate key flora and fauna values including the presence of conservation significant species or habitat.

1.2 Scope of works

Main Roads commissioned GHD Pty Ltd (GHD) to undertake a biological assessment for the Brand Highway passing lanes and surrounding areas (the Survey area). The biological assessment included the following aspects:

- A desktop assessment of the Survey area prior the field survey work to identify biological constraints, which may be in, or near the Survey area which included:
 - Identification of broad vegetation types using J. S. Beard (1979) mapping and Heddlé *et al* (1980) mapping, where relevant
 - Identification of conservation significant species likely to be present in the Survey area and a likelihood of occurrence assessment.
- A field survey to verify the desktop assessment findings which included:
 - Identification of wetland or watercourse vegetation and a calculation of the hectares of such vegetation in the Survey area
 - Mapping of vegetation condition within the Survey area using the Keighery (1994) condition rating scale
 - Mapping of vegetation types within the Survey area
 - Assessment of the plant species diversity, density, composition, structure and weed cover of the Survey area through the use of quadrats
 - Targeted survey for Carnaby's Black Cockatoo including mapping of suitable roosting habitat, feeding habitat, breeding trees and hollows
 - Recording of any conservation significant flora identified within the Survey area

- Identification of any Threatened or Priority Ecological Communities
- Mapping of any Weeds of National Significance or Declared Pests.
- Preparation of a concise report that details the findings of the biological survey and also includes:
 - Mapping of relevant environmental constraints
 - An assessment of the biological Matters of National Environmental Significance (MNES) to determine whether potential impacts on MNES as protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) are likely to require referral of the project to the Australian Government Department of the Environment (DotE)
 - An assessment of all biological aspects likely to require referral of the project to the Environmental Protection Authority (EPA)
 - Determination of the legislative context of environmental aspects required for the assessment.

This biological assessment includes the survey methods and results for a biological assessment completed by GHD for Main Roads for a portion of the Survey area. The 2014 assessment completed by GHD included the first 20 meters (m) from the bitumen seal into the road reserve of the following areas:

- SLK 71.0-68.7 east side of the highway (Site 1)
- SLK 79.7-81.5 west side of the highway (Site 2)
- SLK 112.8-110.4 east side of the highway (Site 3)
- SLK 113.6 – 116.3 west side of the highway (Site 4)
- SLK 126.2 – 129.0 east side of the highway (Site 5)
- SLK 160.3 – 163.9 west side of the highway (Site 6)
- SLK 160.0 – 162.0 east side of the highway (Site 7).

The September 2015 survey was of an expanded area, including the opposite side of the road to the 2014 survey and an area further north and south of the proposed passing lanes (the buffer area described in Table 1 and shown in Figure 1).

Following the completion of the survey of the seven sites in September 2014, Main Roads requested GHD to undertake a survey of an additional site. Site 8 (SLK 34.83 – 36.0 northbound) was first surveyed March 2015 with the additional buffer area surveyed January 2016.

1.3 Survey area

The Survey area includes the eight passing lanes (the Sites) located between Gingin and Eneabba along the Brand Highway (extents in Table 1). The Survey area included an area both sides of the highway and a buffer area north and south of the proposed passing lanes. The Survey area was a larger area than is likely to be required for the passing lanes; however, the survey was focused on the area adjacent to the highway that will be directly impacted by the Project. The Survey area is shown on Figure 1 Appendix A.

Table 1 Survey area site locations

Site Number	Location	Extent (ha)
Site 1	SLK 71.0-68.7, plus a buffer area 500 m north and 2100 m south	37.6
Site 2	SLK 79.7-81.5, plus a buffer area 600 m north and 400 m south	31.6
Site 3	SLK 112.8-110.4, plus a buffer area 260 m north and 280 m south	36.7
Site 4	SLK 113.6-116.3, plus a buffer area 270 m north and 280 m south	53
Site 5	SLK 126.2-129.0, plus a buffer area 1000 m north	78.8
Site 6	SLK 160.3-163.9, plus a buffer area 180 m north and 300 south	21.3
Site 7	SLK 162.0-160.0, plus a buffer area 2000 m north and 850 m south	36.7
Site 8	SLK 34.83-36.0, plus a buffer area 1000 m north and 750 m south	14.3
Total		310 ha

Site 1 and 8 are located within the Shire of Gingin and Sites 2-7 are located within the Shire of Dandaragan.

In a number of places the edge of the Survey area is located outside of the road reserve, within private property. These areas were not assessed during the field survey, which was restricted to the road reserve only.

1.4 Relevant legislation, conservation codes and background information

In Western Australia some ecological communities, flora and fauna are protected under both Federal and State legislation. In addition regulatory authorities provide a range of guidance and information on expected standards and protocols for environmental surveys.

An overview of key legislation and guidelines, conservation codes and background information relevant to this Project is provided in Appendix B.

1.5 Limitations

This report has been prepared by GHD for Main Roads and may only be used and relied on by Main Roads for the purpose agreed between GHD and Main Roads and based on the scope as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Main Roads arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer Section 1.6 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Main Roads and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of infrastructure, access tracks and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

1.6 Assumptions

This report has assessed the flora and fauna within the Survey area, as shown in Figure 1, Appendix A. Should the Survey area change or be refined, further assessment may be required.

2. Methodology

2.1 Desktop assessment

Prior to the commencement of the 2014 field survey, a desktop review was undertaken to identify relevant environmental information pertaining to the Survey area and to assist in survey design. This included:

- A search using the DotE Protected Matters Search Tool (PMST) to identify communities and species listed under the EPBC Act potentially occurring within a 10 km buffer of each of the sites within the Survey area (DotE 2014a) (Appendix C)
- A search of the Department of Parks and Wildlife (DPaW) Threatened Ecological Communities (TEC) and Priority Ecological Communities (PEC) database to determine the potential for TECs or PECs to be present within a 10 km buffer of each of the sites of the Survey area
- A search of DPaW's *NatureMap* database for flora and fauna species previously recorded within a 10 km buffer of each of the sites of the Survey area (DPaW 2007–) (Appendix C)
- A search of the DPaW Threatened and Priority Flora database (TPFL) and Western Australian Herbarium database (WAHERB) for Threatened and Priority flora species listed under *Wildlife Conservation Act 1950* (WC Act) and listed by the DPaW, previously recorded within a 10 km buffer of each of the sites of the Survey area
- A review of existing datasets including: previous vegetation mapping of the Survey area (Beard 1979), aerial photography and hydrology information to provide background information on the variability of the environment, likely vegetation units and fauna habitats and to identify areas with potential to contain TECs, PECs, and Threatened and Priority listed flora and fauna species.

2.2 Field survey

Ecologists conducted a flora and fauna assessment of the Survey area in Spring 2014 and Spring 2015. The 2014 survey was undertaken from 7-13 of September 2014 and surveyed the first 20 m from the bitumen seal of the following areas:

- SLK 71.0-68.7 east side of the highway (Site 1)
- SLK 79.7-81.5 west side of the highway (Site 2)
- SLK 112.8-110.4 east side of the highway (Site 3)
- SLK 113.6 – 116.3 west side of the highway (Site 4)
- SLK 126.2 – 129.0 east side of the highway (Site 5)
- SLK 160.3 – 163.9 west side of the highway (Site 6)
- SLK 160.0 – 162.0 east side of the highway (Site 7)

The 2015 survey was undertaken from the 7-13 September of an expanded area, including the opposite side of the road to the 2014 survey and an area further north and south of the proposed passing lanes (the buffer area described in Table 1 and shown in Figure 1).

Site 8 (SLK 34.83 – 36.0 northbound) was surveyed on 30 March 2015 with the buffer area surveyed on 23 January 2016.

2.2.1 Vegetation and flora

The vegetation and flora field survey was undertaken to identify and describe the dominant vegetation units, assess vegetation condition and identify and record vascular flora taxa present at the time of survey.

Field assessment methodology involved a combination of quadrat and transect sampling. Quadrats were established in areas representative of a vegetation assemblage. The quadrats were 10 metre (m) x 10 m in size (area of 100 m²), with shape and/or size adjusted as necessary. Field data at each quadrat was recorded on a pro-forma data sheet. 38 non-permanent quadrats were described throughout the Survey area. Where possible, at least two quadrats were established in each vegetation type; however small or restricted vegetation types were not sampled using quadrats. No quadrat sampling was undertaken in Site 8 as the vegetation within the Survey area was no longer considered intact native vegetation and consisted of only scattered natives over weedy species.

An ecologist walked the entire length of each Site as a transect, at a distance approximately 5 m from the edge of the vegetation. The area surveyed in 2015 was walked by two ecologists in two transects, one approximately 5 m and the other approximately 10-15 m from the edge of vegetation. Where conservation significant flora species were recorded within these transects a wider search of the road reserve was undertaken to record population numbers.

A flora inventory was compiled from taxa listed in described quadrats, transects and from opportunistic floristic records throughout the Survey area.

Vegetation units

Vegetation units were identified and boundaries delineated using a combination of aerial photography, topographical features, previous mapping (Beard 1979) and field data.

Vegetation units were described based on structure, dominant taxa and cover characteristics as defined by releve data and field observations. Vegetation unit descriptions follow the National Vegetation Information System (NVIS) and are consistent with NVIS Level V (Association), and are grouped within NVIS Level III (Broad Floristic Formation). At Level V up to three taxa per stratum are used to describe the association (ESCAVI 2003).

Vegetation condition

The vegetation condition of the Survey area was assessed using a vegetation condition rating scale (Keighery 1994) that recognises the intactness of vegetation, which is defined by the following:

- Completeness of structural levels
- Extent of weed invasion
- Historical disturbance from tracks and other clearing or dumping
- The potential for natural or assisted regeneration

The scale, therefore, consists of six rating levels as outlined below in Appendix B.

Flora identification and nomenclature

Species that were well known to the survey ecologists were identified in the field, while species that could not be identified in the field were collected and assigned a unique number to facilitate tracking. Plant species were identified by the use of local and regional flora keys and by comparison with the named species held at the Western Australian Herbarium (WA Herbarium).

The conservation status of all recorded flora was compared against the current lists available on *FloraBase* (Western Australian Herbarium 1998–) and the EPBC Act Threatened species database provided by the DotE (2014a).

Nomenclature used in this report follows that used by the WA Herbarium as reported on *FloraBase* (WA Herbarium 1998–).

Any specimens that could not be satisfactorily identified, as well as priority species that required confirmation, were submitted to the Western Australian Herbarium for paid identification (Accession 6198 (2014) and 6735 (2015)).

Targeted surveys for conservation significant flora

Prior to the field survey, information obtained from the desktop assessment (e.g. aerial photography, geology/soils, hydrology and *NatureMap*, TPFL and WAHERB database search results) was reviewed to determine potential conservation significant flora taxa and locations. Additionally, ecological information (e.g. habitat, associated flora taxa and phenology) was sourced from *FloraBase* (DPaW 2007–) and other relevant publications where available, to provide further details.

Potential habitat was searched for conservation significant flora taxa. Locations within the Survey area with differing hydrology, fire or disturbance history to the surrounding areas were also searched where identified.

When conservation significant flora were identified, the location of each individual was recorded by Global Positioning System (GPS), or if the stand was extensive the boundary recorded by GPS (+/-5m). A sample was also collected for verification at the Western Australian Herbarium.

2.2.2 Fauna

The fauna field survey of the Survey area was undertaken by a zoologist to identify and describe the dominant fauna habitat types and their condition, assess habitat connectivity, identify and record fauna taxa and undertake targeted searches for conservation significant fauna taxa and their habitats.

The survey methodology employed was consistent with the EPA Guidance Statement No. 56 *Assessment of Environmental Factors for Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004b).

Habitat assessment

A fauna habitat assessment was conducted to document the type, condition and extent of habitats within the Survey area, this included:

- Habitat structure (e.g. vegetation type, presence/absence of overstorey, mid-storey, understorey, ground cover)
- Presence/absence of refuge including: fallen timber (coarse woody debris), hollow-bearing trees and stags and rocks/boulder piles, and the type and extent of each refuge
- Presence/absence of waterways including type, extent and habitat quality within waterways
- Land use or disturbance history
- Location of habitat within the surrounding landscape and habitat connectivity
- Identification of wildlife corridors within and immediately adjacent to the Survey area and
- A photograph of the habitat type.

Opportunistic fauna searches

Fauna searches were also conducted across the Survey area. Opportunistic searches involved:

- Searching through microhabitats including turning over logs or rocks, turning over leaf litter and examining tree hollows and hollow logs
- Visual and aural surveys. This accounted for many bird species potentially utilising the Survey area
- Searching the Survey area for tracks, scats, bones, diggings and feeding areas for both native and feral fauna.

Conservation significant fauna survey

During the field survey, targeted searches for conservation significant fauna species and their habitats were also conducted. These searches included:

- Identification of key distinguishing features
- Evaluation of habitat types likely to support listed threatened fauna species
- Recording of GPS locations of any listed threatened fauna species, as well as potential habitat boundaries
- An assessment of quality of the habitat types identified as known to support, likely to support or possibly supporting conservation significant fauna.

Targeted habitat survey for Carnaby's Black Cockatoo

The aim of the habitat assessment was to assess the presence, quality and extent of habitat for Carnaby's Black Cockatoo within the Survey area. The assessment involved visual and aural assessment of the Survey area identifying breeding habitat (presence/absence of actual and potential breeding trees), foraging habitat, roosting areas, current activity and any other signs of use by Carnaby's Black Cockatoos. For the purpose of this assessment, the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2012) Black Cockatoo referral guidelines were used to define breeding, foraging and night roosting habitat.

Information collected during the field survey included:

- Foraging habitat – the location and extent of suitable Carnaby's Black Cockatoo foraging habitat was identified for the Survey area, based on the vegetation associations and presence/absence of known foraging species. During the field surveys any direct or indirect evidence of foraging by Carnaby's Black Cockatoos was recorded via GPS
- Breeding habitat – suitable breeding habitat for Carnaby's Black Cockatoo is defined by DSEWPaC (2012) as trees of species known to support breeding within the range of the species which either have a suitable nest hollow or are of a suitable diameter at breast height (DBH) to develop a nest hollow. For most tree species, suitable DBH is 500 mm. For Salmon Gum (*Eucalyptus salmonophloia*) and Wandoo (*Eucalyptus wandoo*), suitable DBH is 300 mm (DSEWPaC 2012). Breeding habitat was identified and recorded via GPS, and mapped according to the presence of suitable breeding trees (including the presence and size of tree hollows). On average, Carnaby's Black Cockatoos are known to nest in hollows with an entrance diameter greater than 20-30 cm (Johnstone and Storr 1998; Groom 2010). Therefore, during the field survey a suitable nesting hollow currently able to support breeding was defined as a tree hollow with an entrance diameter greater than 20 cm. All trees with hollows with an entrance diameter less than 20 cm were also recorded

- Night roosting habitat – suitable roosting habitat is defined by DSEWPaC (2012). Suitable roosting habitat was identified based on the presence of suitable tall trees, proximity of known roosting sites (for Carnaby's Black Cockatoo – Department of Planning Western Australia 2011) and the presence of suitable foraging habitat
- Opportunistic observations (both visual and aural) of Black Cockatoos within the Survey area and surrounding region.

This information was used to map and calculate the amount of foraging habitat, potential breeding habitat and night roosting sites within the Survey area. Any area containing known foraging species or potential nesting trees was considered as habitat for Black Cockatoos. It is important to note that the accuracy of the GPS used to record breeding habitat is approximately ± 5 m, and therefore location data for individual trees includes up to ± 5 m error.

Fauna nomenclature

Nomenclature used in this report follows that used by the Western Australian Museum and the DPaW NatureMap database (DPaW 2007–) with the exception of birds, which uses Christidis and Boles (2008).

2.3 Limitations

2.3.1 Desktop limitations

The EPBC Act PMST is based on bioclimatic modelling for the potential presence of species. As such, this does not represent actual records of the species within the area. The records from the DPaW searches of threatened flora and fauna provide more accurate information for the general area. However, some records of collections, sightings or trappings can be dated and often misrepresent the current range of threatened species.

Species identified in the EPBC Act PMST that are solely listed as marine, migratory marine or migratory wetland were excluded from the fauna assessment as no marine or wetland habitat was present within or nearby the Survey area. Species listed as migratory terrestrial were considered as part of fauna assessment.

New Wildlife Conservation (Rare Flora) and Wildlife Conservation (Specially Protected Fauna) Notices were gazetted on 3 November 2015. The format of these Notices has been changed to align with the EPBC Act threatened species lists. To date information contained in publically available databases such as *NatureMap* does not reflect these newly gazetted Notices. This report has been updated to reflect the conservation status of flora and fauna listed in these Notices. However, the outputs of database searches contained in this report such as *NatureMap*, does not reflect the conservation status of flora and fauna listed in these Notices.

2.3.2 Field survey limitations

Guidance Statement No. 51 and No. 56 (EPA 2004a, 2004b) both state that flora and fauna survey reports for environmental impact assessment in Western Australia should contain a section describing the limitations of the survey methods used. The limitations and constraints associated with this field survey are discussed Table 2.

Table 2 Field survey constraints and limitations

Limitation	Constraint	Impact on survey outcomes
Sources of information and availability of contextual information	Minor	Adequate information is available for the Survey area, this includes: <ul style="list-style-type: none"> Broad scale (1:250,000) mapping (Beard 1979) and digitised by Shepherd <i>et al.</i> (2002) Vegetation complex mapping (Hedde <i>et al.</i> 1980) (for two sites only) Regional biogeography (Desmond 2001; Desmond and Chant 2001 and Mitchell, Williams and Desmond 2002).
Scope (i.e. what life forms were sampled etc.)	N/A	Vascular flora and terrestrial vertebrate fauna were sampled during the survey. Non-vascular flora, invertebrate and aquatic fauna were not assessed as part of survey.
Proportion of flora collected and identified (based on sampling, timing and intensity) Proportion of fauna identified, recorded and/or collected	Minor	<p>The flora recorded from the field survey is detailed in Section 4.2.1 and a full flora species list provided in Appendix D. 665 flora taxa (including subspecies and varieties) representing 75 families and 271 genera were recorded. Potential Priority flora taxa were submitted to the Western Australian herbarium for identification and/or verification (Accession 6198 and 6735). Due to lack of flowering/fruiting material some specimens could not be identified to species level.</p> <p>The flora survey was undertaken in early September 2014 and September 2015. As the Survey area is in such a floristically diverse area traverses were conducted across the length of the Survey area to identify the maximum number of flora species. While traverses were conducted across the entire Survey area and are likely to have captured the majority of species present, in order to record the complete suite of species grid-based searching of the entire Survey area would be required, which was outside the scope of this assessment. There are a number of flora genera that are likely underrepresented from the survey as the survey was conducted outside the flowering period of these taxa. This includes <i>Verticordia</i> species and Ericaceae species.</p> <p>The fauna survey was undertaken in early September 2014, March 2015 and January 2016 and was a reconnaissance survey only. The fauna assessment only sampled those species that can be easily seen, heard or has distinctive signs, such as tracks, scats, diggings etc. Many cryptic and nocturnal species would not have been identified during a reconnaissance survey and seasonal variation within species often requires targeted surveys at a particular time of the year. Of the fauna species recorded during the survey, all species were identified to a species level.</p> <p>The fauna assessment was aimed at identifying habitat types and terrestrial vertebrate fauna utilising the Survey area. No sampling for invertebrates or aquatic species occurred. The information available on the identification, distribution and conservation status of invertebrates is generally less extensive than that of vertebrate species.</p>
Flora determination	Nil	Flora determination was undertaken in field and at the Western Australian Herbarium. All potential Priority flora taxa were submitted to the WA Herbarium for identification and/or verification.

Limitation	Constraint	Impact on survey outcomes
Completeness and further work which might be needed (e.g. was the relevant area fully surveyed?)	Minor - Moderate	<p>Conservation significant species were recorded opportunistically during the field survey and complete population counts were not undertaken. A targeted conservation significant flora assessment would be required to determine all conservation significant species within the Survey area and to provide full population counts. At present, details of the extent of impact required for the project is unknown. Depending on the extent of impact and the amount of clearing required, further assessment may be required.</p> <p>Vegetation units were compared to known Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs) by inference only, no floristic/statistical analysis was undertaken. Further detailed surveys (at least two season survey of quadrats) would be required to allow floristic analysis.</p>
Mapping reliability	Nil	The vegetation was mapped using aerial photography, topographical features, previous mapping (Beard 1979) and field data.
Timing, weather, season, cycle	Minor	<p>The first part of the vegetation and flora field survey was conducted during spring, 15-19 September 2014. In the three months prior to the survey (Jun-Aug), Badgingarra Research Station weather recording station (No. 9037, BoM 2014) recorded a total of 235.2 mm of rainfall. This total is lower than the long term average for the same period (Jun-Aug; 290.2 mm) (BoM 2014).</p> <p>The second part of the vegetation and flora field survey was conducted during spring, 7-13 September 2015. In the three months prior to the survey (Jun-Aug), Badgingarra Research Station weather recording station (No. 9037, BoM 2016) recorded a total of 172.2 mm of rainfall. This total is lower than the long term average for the same period (Jun-Aug; 288 mm) (BoM 2015).</p> <p>The weather conditions (when recorded) during the 2014 field survey included:</p> <ul style="list-style-type: none"> • Daily maximum temperature ranging from 24.1 to 26.4 °C. • Daily minimum temperature ranging from 10.2 to 12.8 °C • Total rainfall 0.2 mm. <p>The weather conditions (when recorded) during the 2015 field survey included:</p> <ul style="list-style-type: none"> • Daily maximum temperature ranging from 16.9 to 25.4 °C. • Daily minimum temperature ranging from 4 to 12.9 °C • Total rainfall 9.4 mm. <p>The weather conditions recorded during the survey period were considered unlikely to have impacted upon the vegetation and flora survey.</p> <p>The survey timing was considered optimal for the flora and fauna field survey; however the survey was conducted during only one season. In addition, there are a number of flora groups that may not have been present, or not flowering, during the time of the field survey and these groups would be underrepresented in the survey, such as <i>Verticordia</i> species and Ericaceae species.</p>

Limitation	Constraint	Impact on survey outcomes
Disturbances (fire, flood, accidental human intervention etc.)	Nil	Small sections of Site 3 and Site 5 had been recently burnt, with the last year. While most of the species had resprouted/germinated some species in this area may not have recovered fully and may not have been recorded during the survey.
Intensity (in retrospect, was the intensity adequate?)	Nil	The Survey area was sufficiently covered during the survey to determine the major constraints in the Survey area. Dependent on the extent of impact required further surveys may be required.
Resources	Nil	Adequate resources were employed during the field survey. A total of 25 person days were spent undertaking the survey.
Access problems	Nil	There were no access issues associated with the survey. In some instances the Survey area passed beyond the extent of the road reserve and these private properties were not accessed (and not assessed) during the survey.
Experience levels	Nil	The ecologists who executed the survey were practitioners suitably qualified in their respective fields. The botanists undertaking the field survey (Megan Dilly; Flora license SL011308 and Gaynor Owen) have more than eight years' and 12 years experience, respectively, undertaking botanical surveys in Western Australia and on the Swan Coastal Plain. The zoologist (Jo Kuiper) undertaking the field survey has more than 17 years of experience in Western Australia.

3. Existing environment

3.1 Climate

The Survey area is located on the northern Swan Coastal Plain and southern Geraldton sandplains region of Western Australia and experiences a temperate climate with distinctly dry and hot summers and cool, wet winters.

The Bureau of Meteorology (BoM) Badgingarra station (site number: 009037) is the nearest weather station to the Survey area (approximately 10 km south of the northern end of the Survey area), with continuous long-term data. Climatic data from this site indicates the mean maximum temperature of the area ranges from 17.6 °C in July to 34.7 °C in January and February, and the mean minimum temperature of the area ranges from 7 °C in August to 17.8 °C in February. The mean annual rainfall is 542.7 mm, with an average of 65.3 rain days per year (BoM 2014).

Climatic data for the region is summarised in Plate 1 (Source: data from BoM 2014).

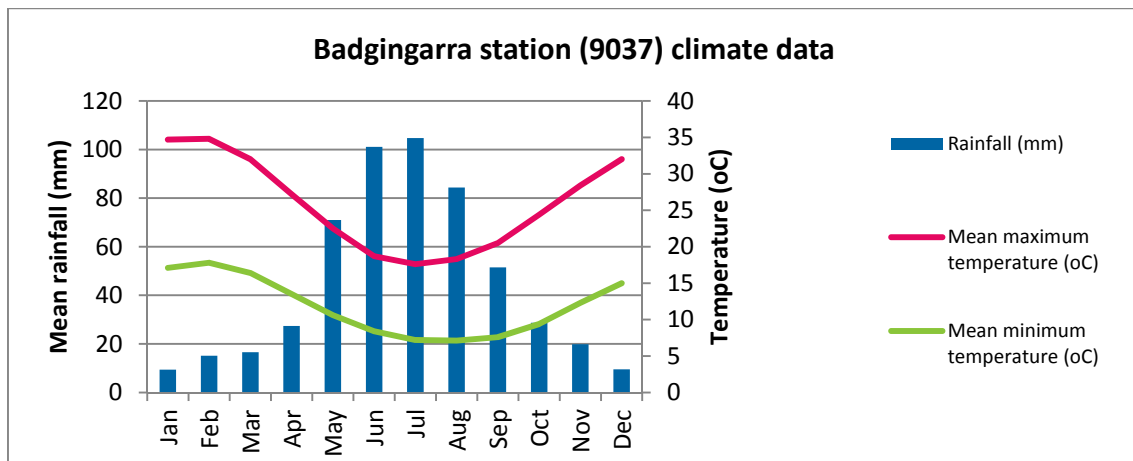


Plate 1 Mean Annual Temperatures and Rainfall for Badgingarra weather Station (009037) (BoM 2014)

The seasonal climatic information relevant to the field survey is discussed under “timing, weather, season, cycle” in Section 2.3.

3.2 Landform, geology and soils

The Project Area lies on the Perth Basin, which is a rift basin on the western margin of Western Australia, adjacent to the Yilgarn Craton. There are three main geomorphologic regions across the Project Area: the Swan Coastal Plain, the Dandaragan Plateau and the Geraldton sandplains. A number of the sites lie along the boundary of two of these regions. Site 1 is located on the Swan Coastal Plain, Site 8 and Site 2 are located on the Dandaragan Plateau and Site 5, 6 and 7 are located in the Arrowsmith region. Site 3 and 4 are located on the boundary of the Swan Coastal Plain and the Arrowsmith region.

The Swan coastal Plain is flat to gently undulating and covered by sediments that have been deposited by fluvial, Aeolian and marine activity. The Dandaragan Plateau rises above the plain, at approximately 200 m above sea level, and is covered by outcropping lateritic deposits and superficial sands (Smolinski and Scholz 1997). The Arrowsmith region is a laterite capped plateau which is predominantly sandy and gravelly, formed from colluvium and weathered rock (CSIRO 2009).

Soil-landscape mapping is a survey of land resources which delineates repeating patterns of landscapes and associated soils (Schoknecht *et al* 2004). The mapping of the South-West of Western Australia was investigated to determine the soil-landscapes present within the Project (Table 3 - DAFWA 2007).

Table 3 Soil-landscape system/subsystem/phases within the Project Area (DAFWA 2007)

Site	System/ subsystem/ phase	Description	Location
Site 1	Bassendean system	Sand dunes and sandplains with pale deep sand, semi-wet and wet soil. Banksia-paperbark woodlands and mixed heaths.	Whole of site
	Bassendean MI Subsystem (212BsMI)	Gently undulating plain and footslopes. Yellow deep sand	
Site 2	Rowes System	Subdued partly dissected lateritic plateau, gently undulating plains and gently undulating to undulating rises; yellow and pale sand, sandy earth and sandy gravel; weathered sandstone. <i>Banksia prionotes</i> low woodland and species rich heath	Whole of site
	Rowes 3 Subsystem (222Rw_3)	Colluvial slopes, very gently to gently inclined hillslopes and sand filled minor valleys; yellow deep sand, some pale deep and gravelly pale deep sand gravel and sandy earths. <i>Banksia prionotes</i> and <i>B. attenuata</i> open low woodland and patches of heath.	
Site 3	Yerramullah System	Subdued dissected lateritic plateau, undulating low hills and rises on lateritised weathered sandstone. Pale deep sand, sandy gravels and yellow deep sand. Banksia woodlands on lower slopes/depressions, heathlands elsewhere.	Southern 2/3 of site
	Yerramullah 3 Subsystem (224Ye_3)	Colluvial slopes and some plateau remnants, very gently to gently inclined hillslopes and sand filled minor valleys; pale and yellow deep sands, pale sandy gravels, shallow gravel over duricrust, some sandy duplexes and sandy earths	
	Bassendean system	Sand dunes and sandplains with pale deep sand, semi-wet and wet soil. Banksia-paperbark woodlands and mixed heaths.	Northern 1/3 of site
	Bassendean Phase 1 (212Bs_1)	Red to yellowish-red weak clayey sands to 150 cm +, commonly associated with limestone.	

Site	System/ subsystem/ phase	Description	Location
Site 4	Bassendean system	Sand dunes and sandplains with pale deep sand, semi-wet and wet soil. Banksia-paperbark woodlands and mixed heaths.	Southern and Northern section of site
	Bassendean Phase 1 (212Bs_1)	Red to yellowish-red weak clayey sands to 150 cm +, commonly associated with limestone.	
	Nylagarda system	Alluvial plains and terraces of the Hill River and major creeks of the north coastal plain. Brown deep sands and brown sandy earths predominate, with minor pale deep sand and saline wet soil. <i>Eucalypt</i> Woodlands.	Centre third of site
	Nylagarda 3 Subsystem (224Ny_3)	Relict alluvial plain; Grey or yellow/brown sandy duplexes and pale, yellow or brown deep sands. mixture of Marri woodlands and scrub.	
Site 5	Yerramullah System	Subdued dissected lateritic plateau, undulating low hills and rises on lateritised weathered sandstone. Pale deep sand, sandy gravels and yellow deep sand. Banksia woodlands on lower slopes/depressions, heathlands elsewhere.	Whole of site
	Yerramullah 4 Subsystem (224Ye_4)	Plateau residuals, complex of Ye2 and Ye3; pale sandy gravels, gravelly pale deep sand, shallow gravel over duricrust, pale deep sand, some sandy duplexes, yellow deep sand. Heath, occasionally with <i>Eucalyptus todtiana</i>	Southern half of site
	Yerramullah 2 Subsystem (224Ye_2)	Plateau residuals, very gently to gently inclined hillcrest and hillslopes; pale sandy gravels, shallow gravel over duricrust, gravelly pale deep sand, pale and yellow deep sands. Heath	Small section in north of site
	Yerramullah 6 Subsystem (224Ye_6)	Colluvial slopes, very gently to gently inclined mid to lower hillslopes and sand filled minor valleys; pale deep sand, some sandy duplexes and shallow sand over pan or bog iron. Heath with emergent <i>Eucalyptus todtiana</i> , <i>E. calophylla</i> or <i>E. lane-poolei</i>	Central part of site
	Yerramullah 12 Subsystem (224Ye_12)	Dune blown from old drainage lines; Pale and yellow deep sands. Open low woodland of Banksia attenuata over heath with occ. <i>Eucalyptus todtiana</i>	Northern area of site
	Yerramullah 3 Subsystem (224Ye_3)	Plateau remnants; pale and yellow deep sands, pale sandy gravels. Heath, occasionally with <i>Eucalyptus todtiana</i>	Very small section in north of site

Site	System/ subsystem/ phase	Description	Location
Site 6	Yerramullah System	Subdued dissected lateritic plateau, undulating low hills and rises on lateritised weathered sandstone. Pale deep sand, sandy gravels and yellow deep sand. Banksia woodlands on lower slopes/depressions, heathlands elsewhere.	Central part of site
	Yerramullah 3 Subsystem (224Ye_3)	Colluvial slopes and some plateau remnants, very gently to gently inclined hillslopes and sand filled minor valleys; pale and yellow deep sands, pale sandy gravels, shallow gravel over duricrust, some sandy duplexes and sandy earths. Heath, occasionally <i>Banksia attenuata</i> low open woodland, commonly with <i>Eucalyptus todtiana</i>	Small section in the south of site, covers most of central part of site
	Yerramullah 2 Subsystem 224Ye_2	plateau residuals, very gently to gently inclined hillcrest and hillslopes; pale sandy gravels, shallow gravel over duricrust, gravelly pale deep sand, pale and yellow deep sands. Heath.	Central part of site (on rise)
	Nylagarda system	Alluvial plains and terraces of the Hill River and major creeks of the north coastal plain. Brown deep sands and brown sandy earths predominate, with minor pale deep sand and saline wet soil. <i>Eucalypt</i> Woodlands.	Southern and northern end of site
	Nylagarda 3 Subsystem 224Ny_3	Relict alluvial plain; Grey or yellow/brown sandy duplexes and pale, yellow or brown deep sands. Mixture of Marri woodlands and scrub.	Southern and northern part of site
Site 7	Nylagarda system	Alluvial plains and terraces of the Hill River and major creeks of the north coastal plain. Brown deep sands and brown sandy earths predominate, with minor pale deep sand and saline wet soil. <i>Eucalypt</i> Woodlands.	
	224Ny_3	Relict alluvial plain; Grey or yellow/brown sandy duplexes and pale, yellow or brown deep sands. Mixture of Marri woodlands and scrub.	Covers majority of site
	Yerramullah System	Subdued dissected lateritic plateau, undulating low hills and rises on lateritised weathered sandstone. Pale deep sand, sandy gravels and yellow deep sand. Banksia woodlands on lower slopes/depressions, heathlands elsewhere.	
	Yerramullah 2	Plateau residuals, very gently to gently inclined	Small patch in

Site	System/ subsystem/ phase	Description	Location
	Subsystem 224Ye_2	hillcrest and hillslopes; pale sandy gravels, shallow gravel over duricrust, gravelly pale deep sand, pale and yellow deep sands. Heath.	north of site (low hill) and small patch in south of site (low hill)
	Yerramullah 3 Subsystem (224Ye_3)	Colluvial slopes and some plateau remnants, very gently to gently inclined hillslopes and sand filled minor valleys; pale and yellow deep sands, pale sandy gravels, shallow gravel over duricrust, some sandy duplexes and sandy earths. Heath, occasionally <i>Banksia attenuata</i> low open woodland, commonly with <i>Eucalyptus tottiana</i>	Small patch in north of site and south of site (adjacent to hill)
Site 8	222Da Dandaragan System	Subdued dissected lateritic plateau, undulating low hills and rises with narrow alluvial plains. Variable deep sands and sandy gravels plus minor earths, duplexes and clays. Marri woodlands and shrublands.	Whole of site
	222Da_16 Dandaragan Subsystem – Phase 16		Northern section
	222Da_15 Dandaragan Subsystem – Phase 15	Dark brown humic medium to coarse sands to sandy loams overlying gleyed mottled coarse sandy clays between 70-140 cm.	Southern section

3.3 Hydrology

The watercourses and geomorphic wetlands that have been mapped within the Survey area are detailed in Table 4.

Table 4 Drainage lines that occur within or adjacent to the Survey area

Site	Drainage lines
Site 1	<p>No drainage lines have been mapped within the Survey area. An unnamed drainage line occurs approximately 80 m to the east of the Survey area, near Marri Heights Rd; however does not intersect the Survey area.</p> <p>A series of Conservation category geomorphic wetlands occur to the west of the Survey area in the northern part of the site. The closest wetland to the Survey area occurs in the north of the Survey area and is approximately 30 m west of the Survey area.</p>
Site 2	<p>There are no watercourses within, or immediately adjacent, to the Project area. Moore River occurs approximately 3.7 km to the south of the Project area.</p> <p>No wetlands have been mapped within the Survey area. The closest mapped geomorphic wetlands occurs approximately 50 m west of the Survey area.</p>
Site 3	<p>Minyulo Brook crosses Brand Highway within the northern section of this Site.</p>
Site 4	<p>There are no mapped watercourses that cross the Project area and none were recorded during the field survey. The closest watercourse is Minyulo Brook, which crosses Brand Highway approximately 300 m south of the Project area.</p>
Site 5	<p>There are no mapped watercourses that cross the Project area and none were recorded during the field survey. The closest watercourse to the Project area is Mullering Brook runs parallel to the site, approximately 3.3 km east of the site.</p>
Site 6	<p>There are no watercourses that cross the Project area; however the site runs parallel to Boothendarra Creek, a tributary of Hill River, for almost its entire length. At its closest point the creek is approximately 50 m from the Project Area.</p>
Site 7	<p>An unnamed drainage line crosses the site at the southern end of the Project Area. At the northern end of the Project area Boothendarra Creek, a tributary of Hill River occurs on the opposite side of the road to the site, approximately 80 m from the road.</p>
Site 8	<p>Two creeklines cross Brand Highway (via culvert) within this site. One in the north of the Survey area (Wallerung Brook) and one in the south.</p> <p>The majority of the southern area of the site, as well as the area surrounding Wallerung Brook in the north, has been mapped as a Multiple-use palus-plain wetland.</p>

3.4 Conservation areas

There are number of conservation areas recorded within 10 km of the Survey area including: Boonarring Nature Reserve (Site 8), Bundarra Nature Reserve (Site 2), Moochamulla Nature Reserve (Site 2), Quins Hill Nature Reserve (Site 2), Eneminga Nature Reserve (Site 3), Minyulo Nature Reserve (Site 3 and 4), Badgingarra National Park (Site 5, Site 6/7), Coomaloo Nature Reserve (Site 6/7). In addition, four DPaW-managed properties occur adjacent, or within 1 km of the Survey area as detailed in Table 5.

Table 5 Conservation areas within 1 km of the Survey area

Name	Class	Location
Moore River National Park	C	Adjacent to the southern section of Site 1, south of SLK 68.7
Namming Nature Reserve	C	Located near SLK 79.9 and 81.5 approx. 500 m- 1 km to the south west
Unnamed Conservation Park, south of Badgingarra National Park	C	Adjacent to SLK 126.2 to 129 (Site 5)
Hill River Nature Reserve/Twyta Nature Reserve	C	Located 1.6km to the south west of SLK 160 (Site 6 and 7)

3.5 Regional biogeography

The Survey area is situated in the Southwest Botanical Province of Western Australia (Beard 1990). The southern sites (Sites 1, 2, 8 and part of 3) occur in the Swan Coastal Plain bioregion and the Perth and Dandaragan subregions and the northern sites (Sites 3-7) occur in the Geraldton Sandplains bioregion and Lesueur Sandplain subregions, as described by the Interim Biogeographic Regionalisation of Australia (IBRA) (DotE 2014b). IBRA divides the Australian continent into 89 biogeographic regions based on similar climate, geology, landform, vegetation and fauna (DotE 2014b).

The Swan Coastal Plain Bioregion comprises the Dandaragan Plateau and the Perth Coastal Plain. Its climate is classified as warm Mediterranean and rainfall ranges between 6000 and 1000 mm annually. It includes urban development associated with the City of Perth, and is dominated by woodlands of banksia and tuart on sandy soils, sheoak on outwash plains, and paperbark in swampy areas. The colluvial and aeolian sand areas represent three phases of Quaternary marine sand dune development (which provide relief), and include a complex series of seasonal fresh water wetlands, alluvial river flats, coastal limestones and several offshore islands. Younger sandy areas and limestones are dominated by heath and/or tuart woodlands, while *Banksia* and jarrah-*Banksia* woodlands are found on the older dune systems. In the north-east, the plain rises to duricrusted Mesozoic sediments dominated by jarrah woodland (Department of Conservation and Land Management 2002).

The Dandaragan Plateau subregion is composed of cretaceous marine sediments mantled by sands and laterites. The plateau is characterised by *Banksia* low woodland, jarrah-marri woodland, marri woodland, and by scrub-heaths on laterite pavement and gravelly sandplains. A variety of plants, including tuart are endemic to the region (Desmond 2001).

The Perth subregion is composed of colluvial and Aeolian sands, alluvial river flats, coastal limestone. Heath and/or Tuart woodlands occur on limestone, *Banksia* and Jarrah- *Banksia* woodlands on Quaternary marine dunes of various ages, and Marri on colluvial and alluvials. It includes a complex series of seasonal wetlands and also includes Rottnest, Carnac and Garden Islands. Rainfall ranges between 600 and 1000 mm annually and the climate is Mediterranean. The subregional area is 1,333,901 ha (Mitchell, Williams and Desmond 2002).

The Geraldton Sandplains bioregion comprises the central and northern Perth Basin, the Pinjarra Orogen, and the south end of the Carnarvon Basin. Outcrops of Jurassic siltstones and sandstones can be heavily lateralized. Extensive proteaceous heaths and scrub-heaths often with emergent mallees, *Banksia* and *Actinostrobus*, occur on an undulating, lateritic sandplain mantling Permian to Cretaceous strata. These heaths are rich in endemics (Department of Conservation and Land Management 2002).

The Lesueur Sandplain subregion comprises coastal Aeolian and limestones, Jurassic siltstones and sandstones (often heavily lateritised) of the central Perth Basin. Alluvials are associated with drainage systems. There are extensive yellow sandplains in south-eastern parts, especially where the subregion overlaps the western edge of the Pilbara Craton. Shrub-heaths rich in endemics occur on a mosaic of lateritic mesas, sandplains, coastal sands and limestones. Heath on lateritised sandplains occurs along the subregion’s north-eastern margins. The climate is Mediterranean and the subregional area is 1,358,915 ha (Desmond and Chant 2001).

3.6 Vegetation and flora

3.6.1 Broad vegetation associations and extent

Pre-European vegetation associations mapped at a broad scale (1:250,000) was undertaken by J. S. Beard (1979). This mapping indicates that five vegetation associations are present within the Survey area, these are:

- Medium woodland: Marri (Association 999)
- Low woodland; banksia (Association 949)
- Mosaic: Medium open woodland; marri / Shrublands; dryandra heath (Association 1035)
- Low woodland; *Banksia attenuata* & *B. menziesii* (Association 1030)
- Mosaic: Shrublands; hakea scrub-heath / Shrublands; dryandra heath (Association 1031)

Table 6 Pre-European (Beard 1979) vegetation associations within the Survey area

Vegetation Association	Location
999	Covers all of Site 8
949	Covers all of Site 1
1035	Covers the majority of the eastern side of Site 2
1030	Covers the majority of Site 2 Covers the majority of Site 3 Covers the northern end of Site 4
1031	Covers the southern end of Site 3 Covers the majority of Site 4 Covers all of Site 5, 6 and 7

The mapping has been adapted and digitised by Shepherd *et al.* (2002). The extent the vegetation associations have been determined by the State-wide vegetation remaining extent calculations maintained by DPaW (update used: 2014 – Government of Western Australia 2015). As shown in Table 7 the extent of Vegetation Association 999 is below the 30 % threshold at all levels and the extent of Vegetation Association 1035 is below 30 % threshold level for the state and local government level. Vegetation Association 1031 is below the 30 % threshold level at the IBRA bioregion (Swan Coastal Plain), IBRA subregion (Perth) and the local government area. Vegetation Association 949 and 1030 is above the 30 % threshold level at all levels.

Table 7 Extent and status of Beard (1979) vegetation associations within the Survey area (Government of Western Australia 2013)

Vegetation association	Scale	Pre-European extent (ha)	Current extent (ha)	Remaining (%)	% Current extent in all DPaW managed lands
IBRA Region – Swan Coastal Plain		1,501,221.93	580,697.31	38.68	37.35
IBRA Region – Geraldton Sandplains		3,136,037.56	1,404,375.00	44.70	40.33
IBRA Subregion – Perth		1,117,757.03	467,145.63	41.79	38.06
IBRA Subregion – Lesueur Sandplains		1,171,775.19	502,918.10	42.92	41.89
IBRA Subregion – Dandaragan Plateau		383,464.9	113,551.68	29.61	34.44
999	State	115,706.59	13,034.84	11.27	23.89
	IBRA Bioregion- Swan Coastal Plain	1,951.76	321.97	16.50	11.57
	IBRA Subregion- Perth	762.54	160.83	21.09	0
	LGA- Shire of Gingin	11,993.26	1,077.27	8.98	0
949	State	218,193.94	123,249.37	56.49	55.74
	IBRA Bioregion- Swan Coastal Plain	209,983.26	120,389.67	57.33	58.95
	IBRA Subregion- Perth	184,475.82	104,231.82	56.50	61.64
	LGA- Shire of Gingin	138,102.71	81,746.22	59.19	60.5
1035	State	5,018.34	494.12	9.85	53.65
	IBRA Bioregion- Swan Coastal Plain	3,435.37	360.96	10.51	70.73
	IBRA Subregion- Perth	23.72	10.51	44.30	97.63
	LGA- Shire of Dandaragan	5,018.34	494.12	9.85	53.65
1030	State	139,012.86	88,997.10	64.02	17.98
	IBRA Bioregion- Swan Coastal Plain	134,788.56	86,061.30	63.85	16.11
	IBRA Subregion- Perth	114,215.61	79,563.77	69.66	15.47
	LGA- Shire of Dandaragan	121,005.02	80,802.97	66.78	19.50
1031	State	269,490.91	88,606.05	32.88	42.30
	IBRA Bioregion- Geraldton Sandplains	241,349.97	83,155.02	34.45	44.13
	IBRA Bioregion-Swan Coastal Plain	27,729.97	5,352.64	19.30	14.56
	IBRA Subregion- Lesueur Sandplains	241,349.97	83,155.02	34.45	44.13
	IBRA Subregion- Perth	4,740.90	439.52	9.27	1.11
	LGA- Shire of Dandaragan	230,488.23	67,978.55	29.49	52.13

3.6.2 Vegetation complexes and extents

Site 1 and Site 8 occur within the regional vegetation mapping of Heddle *et al.* (1980) which is based on major geomorphic units on the Swan Coastal Plain. Heddle *et al.* (1980) mapping indicates that Site 8 occurs within the 'Gingin Complex'. The Gingin Complex is described as "open woodland of *Corymbia calophylla* with second storey of *Banksia grandis* and *Nuytsia floribunda*. Fringing woodland of *Eucalyptus rudis*-*Melaleuca raphiophylla* along streams" (Heddle *et al.* 1980). Site 1 occurs with Coonambidgee Complex, described as vegetation that ranges from a low open forest and low woodland of *Eucalyptus-todtiana*-*B. attenuata*-*B. menziesii*-*B. ilicifolia* with localised admixtures of *B. prionotes* to an open woodland of *C. calophylla*-*Banksia* sp.

The Perth Biodiversity Project has assessed the extent of Heddle *et al.* (1980) vegetation complexes currently present against presumed pre-European extents for the Perth Region (Local Biodiversity Program –updates 2013). As shown in Table 8, the Gingin Complex mapped within Site 8 is below the 30 % threshold level, whereas the Coonambidgee Complex mapped in Site 1 is above the 30 % threshold level.

Table 8 Extent and status of vegetation complex within the Survey area for Bioregion (Source: Local Biodiversity Program 2013)

Vegetation Complex	Scale	Total Pre-European extent (ha)	2013 remnant Vegetation extent (ha)	% of Pre-European extent
Gingin Complex	Swan Coastal Plain	7,113.47	855.82	12.03
Coonambidgee Complex	Swan Coastal Plain	6272.27	2859.50	45.59

3.6.3 Conservation significant ecological communities

A search of the EPBC Act PMST (DotE 2014a) identified one Australian Government-listed TEC that could potentially occur within 10 km of the Survey area (Table 9). A search of the DPaW TEC/PEC database identified one DPaW-listed PEC occurring within 10 km of the Survey area (Table 9 and Figure 2, Appendix A).

Table 9 Conservation significant ecological communities recorded within 10 km of the Survey area

Name	Status	Description	Location
<i>Swan Coastal Plain Banksia attenuata-Banksia menziesii</i> woodlands (SCP 23b)	Priority 3 PEC (state)	These woodlands occur in the Bassendean system, from Melaleuca Park to Gingin. Occurs in reasonably extensive Banksia woodlands north of Perth.	The buffer of this PEC intersects the southern part of Site 1 and there are a number of other locations of this PEC in the area around Site 1.
<i>Claypans of the Swan Coastal Plain</i>	Critically Endangered TEC (federal – EPBC Act) Priority 1 PEC (state)	Claypans (predominantly basins) usually dominated by a shrubland of <i>Melaleuca lateritia</i> occurring both on the coastal plain and the adjacent plateau. These claypans are characterized by aquatic species (<i>Hydrocotyle lemnoides</i> <i>Glossostigma diandrum</i> , <i>Villarsia capitata</i> and <i>Eleocharis keigheryi</i> - DRF)	Site 1 Identified in EPBC PMST as potentially occurring within Site 1 and Site 8; however the DPaW database search did not identify this TEC within 10 km of the Survey area.

3.6.4 Flora diversity

A search of the *NatureMap* database (DPaW, 2007–) identified a large number of plant taxa that have previously been recorded within 10 km of each site of the Survey area:

- Site One: 493 taxa representing 63 families
- Site Two: 381 taxa representing 55 families
- Site Three: 597 taxa representing 64 families
- Site Four: 597 taxa representing 64 families
- Site Five: 369 taxa representing 46 families
- Site Six: 686 taxa representing 71 families
- Site Seven: 686 taxa representing 71 families
- Site Eight: 641 taxa representing 91 families

The Lesueur sandplains are known to have a very high floristic diversity and the Lesueur area, to the north of the Survey area, is considered as one of the three most important areas for flora conservation in southern Western Australia (Burbidge *et al.* 1990).

3.6.5 Conservation significant flora

Diversity in the Lesueur subregion, the northern section of the Survey area, is extremely high and the region is known to support high numbers of conservation significant species (Burbidge *et al.* 1990).

Desktop searches of the EPBC Act PMST database (DotE 2014a), *NatureMap* database (DPaW 2007–), DPaW TPFL and WAHERB databases identified the presence/potential presence of 183 conservation significant flora taxa within 10 km of each Site in the Survey area.

- Site 1: 49 conservation significant species
- Site 2: 45 conservation significant species
- Site 3: 87 conservation significant species
- Site 4: 87 conservation significant species
- Site 5: 74 conservation significant species
- Site 6: 96 conservation significant species
- Site 7: 96 conservation significant species
- Site 8: 53 conservation significant species

Likelihood of Occurrence assessment

A likelihood of occurrence assessment (based on the range, habitat requirements and previous records of the species) was conducted for all conservation significant flora taxa identified in the desktop assessment (Appendix D). The desktop assessment concluded that 159 conservation significant taxa could possibly occur and 24 taxa are unlikely to occur in the Survey area.

3.7 Fauna

3.7.1 Fauna diversity

A search of the *NatureMap* database (DPaW 2007–) identified 255 fauna species that have been previously recorded within 10 km of each of the Sites of the Survey area including:

- 173 birds
- 58 reptiles
- 17 mammals (which included three introduced species)
- Seven amphibians

3.7.2 Conservation significant fauna

A search of the EPBC PMST (DotE 2014a) and DPaW *NatureMap* records (DPaW 2007–) identified the presence/potential presence of 23 conservation significant fauna species within 10 km of each of the Sites in the Survey area. These include nine threatened fauna (listed under the EPBC Act/WC Act) and 7 Priority fauna. As the Survey area is spread across the eight sites, separate searches were conducted for each site. Species identified by the PMST and DPaW *NatureMap* records as marine and migratory marine were excluded from this assessment as no marine habitat was present within or nearby the Survey area however species identified by the PMST as migratory terrestrial and migratory wetland were considered as part of this assessment.

A breakdown of the conservation significant fauna species identified within 10 km of each of the eight sites is summarised in Appendix E.

4. Field results

4.1 Vegetation

4.1.1 Vegetation types

During the field assessment fifteen native vegetation types were identified and described within the Survey area. These vegetation types have been mapped in Figure 3, Appendix A and are detailed in Table 10. Additionally, there were a number of areas that were not mapped as a vegetation type as they were devoid of any vegetation, and were mapped as 'Cleared' (76.8 ha). A number of areas were recently burnt (within the last year) and could not be allocated a vegetation type, these were mapped as "uninterpretable" (3.46 ha).



The southern sites are predominantly composed of woodlands of *Banksia attenuata* and *B menziesii* with scattered *Eucalyptus todtiana*. Further north the *Banksia* woodland becomes more open and low and is interspersed with sections of tall mixed species-rich shrubland with scattered *Banksias* and areas of low, species-rich heath.



The vegetation types within the Survey area generally form a complex mosaic based on slight variations in topography, substrate and soils. The vegetation types were broadly mapped based on structural layers rather than a floristic basis and most of the vegetation types contained a mosaic of floristic communities. The northern sites (Sites 6 and 7) are located on gently undulating terrain, which results in a more variable vegetation structure with vegetation types that included *Banksia* woodland on deeper soils on the slopes, a diverse heathland on the hilltops and tall shrubland on the low-lying areas. A section of Site 6 also supports a sedgeland and shrubland on low-lying seasonally inundated areas, with a floristic assemblage dominated by herbs and sedges associated with low-lying wet areas.



A creekline crosses the Survey area at the northern end of Site 3 and in this area there is a degraded *Eucalyptus rudis* - *Melaleuca raphiophylla* woodland.




Site 8 is further south than the Sites on the Gingin Complex (Hedde *et al.* 1980) and the original vegetation present at the site was likely to have been Marri (*Corymbia calophylla*) woodland. However, Site 8 has been subject to significant disturbances and at present only a thin strip of Marri trees occur within the Survey area. There are some additional scattered native species that are either remnants or have been planted, including *Banksia prionotes*, *Xanthorrhoea preissii* and *Grevillea vestitata*. In addition a number of eucalypt species have been planted along the road and at driveway entrances. Two creeks cross Site 8 and along the southern creekline there is a *Melaleuca raphiophylla* woodland. However, the majority of the *Melaleucas* occur within private property and there is limited riparian vegetation within the road reserve.




Table 10 Vegetation associations




Vegetation association	Description	Landform	Mapped extents (ha) and representative sample locations	Photograph
<p><i>Banksia attenuata</i> and <i>B. menziesii</i> woodland (BaBmW)</p>	<p>Woodland of <i>Banksia menziesii</i> and <i>B. attenuata</i> over sparse tall shrubland of <i>Adenanthos cygnorum</i>, <i>Jacksonia floribunda</i> and <i>Xanthorrhoea preissii</i> over low shrubland of <i>Bossiaea eriocarpa</i>, <i>Eremaea pauciflora</i>, <i>Stirlingia latifolia</i> and open sedgeland of <i>Lyginia barbata</i>, <i>Alexgeorgea nitens</i> and <i>Mesomelaena pseudostygia</i> over sparse herbland of <i>Haemodorum</i> sp., <i>Drosera erythrorhiza</i> and <i>Dampiera linearis</i></p> <p>Other common species include: <i>Hibbertia hypericoides</i>, <i>Phlebocarya ciliata</i>, <i>Amphipogon turbinatus</i>, <i>Philothea spicata</i>, <i>Conostephium pendulum</i>, <i>Astroloma xerophyllum</i>, <i>Synaphea spinulosa</i>, <i>Gompholobium tomentosum</i></p>	Sandplains	<p>Site 1: 23.1 ha Site 2: 33.3 ha</p> <p>Q01, Q02, Q03, Q20, Q23, Q24, Q25, Q26</p>	
<p><i>Melaleuca preissiana</i> Woodland (MpW)</p>	<p>Woodland of <i>Melaleuca preissiana</i> over tall shrubland of <i>M. incana</i> subsp. <i>incana</i>, <i>Hypocalymma angustifolium</i>, <i>Gastrolobium obovatum</i> over closed sedgeland of <i>Gahnia trifida</i>, <i>Juncus kraussii</i> subsp., <i>australiensis</i>, <i>Schoenus caespitius</i> over sparse herbland of <i>Laxmannia ramosa</i> subsp. <i>ramose</i>, <i>Drosera erythrorhiza</i>, <i>Isotropis cuneifolia</i> subsp. <i>cuneifolia</i></p>	Swamp	<p>Site 1: 0.2 ha Q38</p>	


Vegetation association	Description	Landform	Mapped extents (ha) and representative sample locations	Photograph
Tall Mixed Shrubland TMS	Tall shrubland of <i>Xanthorrhoea preissii</i> , <i>Hakea trifurcata</i> and <i>Jacksonia sternbergiana</i> over shrubland of <i>Hibbertia hypericoides</i> , <i>Petrophile macrostachya</i> and <i>Calothamnus quadrifidus</i> subsp. <i>quadrifidus</i> and grassland of <i>Austrostipa elegantissima</i> , <i>*Ehrharta longiflora</i> , <i>Neurachne alopecuroides</i> over open herbland of <i>Drosera erythrorhiza</i> , <i>Hypochaeris glabra</i> , <i>*Ursinia anthemoides</i> Other common species include: <i>Cassytha</i> spp., <i>Caustis dioica</i> , <i>Mesomelaena pseudostygia</i> , <i>Allocasuarina humilis</i> , <i>Leptospermum erubescens</i> , <i>Mesomelaena pseudostygia</i> , <i>Eremaea pauciflora</i>	Sandplains	Site 2: 2.1 ha Site 3: 3.1 ha Q04, Q27	
<i>Banksia attenuata</i> and <i>B. menziesii</i> woodland over mixed shrubland and sedgeland BaBmWMS	Woodland of <i>Banksia menziesii</i> and <i>B. attenuata</i> over sparse tall shrubland of <i>Allocasuarina humilis</i> , <i>Jacksonia sternbergiana</i> and <i>Xanthorrhoea preissii</i> over low shrubland of <i>Bossiaea eriocarpa</i> , <i>Hibbertia hypericoides</i> and <i>Hypocalymma xanthopetalum</i> over mixed grassland and sedgeland of <i>Mesomelaena pseudostygia</i> , <i>*Ehrharta</i> spp. and <i>*Briza maxima</i> Other common species include: <i>Eucalyptus todtiana</i> , <i>Eremaea pauciflora</i> var. <i>pauciflora</i> , <i>Conospermum stoechadis</i> subsp. <i>stoechadis</i> , <i>Logania spermacocea</i> , <i>Mesomelaena pseudostygia</i> , <i>Dasypogon obliquifolius</i> In some sections <i>Banksia prionotes</i> is dominant in a thin strip adjacent to the edge of the road.	Sandplains	Site 3: 16.6 ha Q05, Q06	

Vegetation association	Description	Landform	Mapped extents (ha) and representative sample locations	Photograph
<p><i>Eucalyptus rudis</i> – <i>Melaleuca raphiophylla</i> woodland</p> <p>ErMrW</p>	<p><i>Eucalyptus rudis</i> – <i>Melaleuca raphiophylla</i> woodland over weedy grasses, including *<i>Ehrharta</i> spp. and *<i>Eragrostis curvula</i>.</p>	<p>Occurs along Minuylo Brook at the northern end of Site 3</p>	<p>Site 3: 1.8 ha Q30</p>	
<p>Low, mixed heath</p> <p>LMH</p>	<p>Sparse shrubland of <i>Allocasuarina humilis</i>, <i>Leptospermum erubescens</i> and <i>Conospermum stoechadis</i> over sedgeland of <i>Ecdeiocolea monostachya</i> over low shrubland of <i>Calothamnus sanguineus</i>, <i>Hibbertia hypericoides</i> and <i>Daviesia nudiflora</i> over mixed sedgeland and grassland of <i>Neurachne alopecuroidea</i>, <i>Desmocladius</i> spp and <i>Mesomelaena pseudostygia</i>, <i>Schoenus</i> spp. and sparse herbland of <i>Trachymene pilosa</i>, <i>Drosera</i> spp. and <i>Poranthera microphylla</i></p> <p>Other common species include: <i>Hakea trifurcata</i>, <i>Calothamnus quadrifidus</i>, <i>Jacksonia nutans</i>, <i>J. floribunda</i>, <i>Hakea incrassata</i>, <i>Synaphea spinulosa</i>, <i>Lepidobolus preissianus</i> subsp. <i>preissianus</i>, <i>Dasypogon obliquifolius</i>, <i>Chordifex sinosus</i></p>	<p>Sandplains</p>	<p>Site 3: 4.5 ha Site 4: 31.8 ha Site 5: 4.6 ha Q8, Q9, Q10, Q28, Q31, Q33</p>	

Vegetation association	Description	Landform	Mapped extents (ha) and representative sample locations	Photograph
<p><i>Eucalyptus tottiana</i> and <i>Banksia attenuata</i> very open woodland</p> <p>BaEtOW</p>	<p>Open woodland of <i>Banksia attenuata</i>, <i>B. menziesii</i> and <i>Eucalyptus tottiana</i> over open shrubland of <i>Hakea ruscifolia</i>, <i>Xanthorrhoea preissii</i> and <i>Allocasuarina humilis</i> over low shrubland of <i>Petrophile macrostachya</i>, <i>Eremaea pauciflora</i> and <i>Hakea incrassata</i> and grassland of <i>*Ehrharta</i> spp., <i>*Eragrostis curvifolia</i> and <i>*Bromus diandrus</i></p> <p>Other common species include: <i>Adenanthos cygnorum</i>, <i>Jacksonia floribunda</i>, <i>J. nutans</i>, <i>Hibbertia hypericoides</i>, <i>Schoenus caespititius</i>, <i>Patersonia occidentalis</i> var. <i>occidentalis</i>, <i>Dasypogon obliquifolius</i>, <i>Drosera erythrohiza</i>, <i>Alexgeorgea nitens</i>,</p>	Sandplains	<p>Site 3: 7.3 ha Site 4: 14 ha</p> <p>Q07, Q29</p>	
<p>Tall <i>Adenanthos</i> and <i>Allocasuarina</i> Shrubland</p> <p>AcAhS</p>	<p>Tall shrubland of <i>Adenanthos cygnorum</i>, <i>Allocasuarina humilis</i> and <i>Leptospermum erubescens</i> over mixed, low shrubland of <i>Jacksonia floribunda</i>, <i>Hibbertia hypericoides</i> and <i>Daviesia podophylla</i> over herbland of <i>Dampiera linearis</i>, <i>Dampiera linearis</i> and <i>Conostylis teretifolia</i></p> <p>Other common species include: <i>Xanthorrhoea preissii</i>, <i>Hibbertia hypericoides</i>, <i>Bossiaea eriocarpa</i>, <i>Hypocalymma xanthopetalum</i>, <i>Mesomelaena pseudostyiga</i>, <i>Dasypogon obliquifolius</i>, <i>Dampiera linearis</i></p>	Sandplains	<p>Site 5: 19.6 ha</p> <p>Q18</p>	
<p>Mixed Tall shrubland</p> <p>MTS</p>	<p>Sparse woodland of <i>Banksia attenuata</i> over tall shrubland of <i>Adenanthos cygnorum</i>, <i>Allocasuarina humilis</i>, <i>Jacksonia nutans</i> over mixed, low shrubland of <i>Jacksonia floribunda</i>, <i>Hibbertia hypericoides</i> and <i>Eremaea asterocarpa</i> over sedgeland of <i>Alexgeorgea nitens</i>, <i>Lyginia barbata</i> and <i>Mesomelaena pseudostyiga</i></p> <p>Other common species include: <i>Conospermum stoechadis</i>, <i>Dasypogon obliquifolius</i>, <i>Calothamnus sanguineus</i>, <i>Hibbertia aurea</i>, <i>Schoenus</i> spp., <i>Eremaea pauciflora</i></p>	Sandplains	<p>Site 5: 31.9 ha</p> <p>Q17, Q19, Q32</p>	

Vegetation association	Description	Landform	Mapped extents (ha) and representative sample locations	Photograph
Low <i>Calothamnus</i> heath CqS	Closed shrubland of <i>Calothamnus</i> species over herbland of <i>Drosera</i> spp., <i>Hypochaeris</i> sp. and <i>Stylidium</i> sp.	Sandplains	Site 5: 7.2 ha	
Mixed heath MH	Sedgeland of <i>Ecdeiocolea monostachya</i> over heathland of <i>Allocasuarina microstachya</i> , <i>Banksia</i> spp. and <i>Petrophile</i> spp. over herbland of <i>Dampiera spicigera</i> , <i>Pterochaeta paniculata</i> and <i>Drosera</i> spp. Other common species include: <i>Petrophile shuttleworthiana</i> , <i>Hakea gilbertii</i> , <i>Isopogon divergens</i> , <i>Allocasuarina humilis</i> , <i>Hakea auriculata</i> , <i>Gastrolobium polystachyum</i> , <i>Dodonaea ericoides</i> , <i>Banksia glaucifolia</i> , <i>Xanthorrhoea drummondii</i> , <i>Banksia tridentata</i> , <i>Hibbertia hypericoides</i> , <i>Austrostipa elegantissima</i> , <i>Mesomelaena pseudostygia</i>	Low rises	Site 6: 7.7 ha Site 7: 9.3 ha Q12, Q13, Q34, Q35	
Mixed tall shrubland TS	Sparse tall shrubland of <i>Adenanthos cygnorum</i> and <i>Hakea trifurcata</i> over shrubland of <i>Melaleuca</i> spp., <i>Hypocalymma xanthopetalum</i> and <i>Banksia</i> spp. and grassland of <i>Neurachne alopecuroidea</i> , <i>Avena barbata</i> and <i>Briza maxima</i> . Other common species include: <i>Banksia laricina</i> , <i>Chordifex sinuosus</i> , <i>Ecdeiocolea monstachya</i> , <i>Mesomelaena preissii</i> , <i>Neurachne alopecuroidea</i>	Sandplains	Site 6: 6.9 ha Site 7: 10.7 ha Q11, Q15	

Vegetation association	Description	Landform	Mapped extents (ha) and representative sample locations	Photograph
Northern Banksia woodland BW	Sparse woodland of <i>Banksia attenuata</i> and <i>B. menziesii</i> over shrubland of <i>Melaleuca seriata</i> , <i>M. leuropoma</i> and <i>Acacia pulchella</i> over mixed grassland and sedgeland of <i>Lyginia</i> spp., <i>Desmocladius</i> spp. and * <i>Ehrharta calycina</i> over herbland of <i>Burchardia congesta</i> , * <i>Ursinia anthemoides</i> and <i>Conostylis aculeata</i> subsp. <i>aculeata</i> . Other common species include: <i>Conospermum wycherleyi</i> subsp., <i>wycherleyi</i> , <i>Eremaea pauciflora</i> , <i>Mesomelaena pseudostygia</i> , <i>Blancoa canescens</i> , <i>Amphipogon turbinatus</i> , <i>Alexgeorgea nitens</i> .	Deeper sands on low-slopes	Site 6: 10.5 ha Site 7: 11.3 ha Q14, Q16	
<i>Calothamnus</i> shrubland and <i>Meeboldina</i> sedgeland CtSMcS	Low shrubland of <i>Calothamnus hirsutus</i> , <i>Thryptomene mucronulata</i> and <i>Verticordia</i> spp. over mixed sedgeland of <i>Meeboldina coangustata</i> , <i>Schoenus insolitus</i> and <i>Centrolepis</i> spp. and herbland of <i>Tribonanthes australis.</i> , <i>Stylidium flagellum</i> and <i>Drosera gigantea</i> subsp. <i>gigantea</i> Other common species: <i>Petrophile seminuda</i> , <i>Allocasuarina microstachya</i> , <i>Ecdeiocolea monostachya</i> , <i>Lepidobolus chaetocephalus</i>	Low-lying, seasonally inundated flats	Site 6: 2.1 ha Site 7: 6.7 ha Q21, Q22, Q37	
<i>Petrophile seminuda</i> heathland PsS	Heathland of <i>Petrophile seminuda</i> , <i>Sholtzia parviflora</i> and <i>Verticordia picta</i> over open herbland of <i>Stylidium flagellum</i> , * <i>Romulea rosea</i> and * <i>Ursinia anthemoides</i> Other common species: <i>Acacia scirpifolia</i> , <i>Hakea trifurcata</i> , <i>Jacksonia hakeoides</i> . <i>Scholtzia teretifolia</i>	Slope	Site 6: 0.81 ha Site 7: 0.81 ha Q36	

Vegetation association	Description	Landform	Mapped extents (ha) and representative sample locations	Photograph
Parkland cleared	Woodland of <i>Corymbia calophylla</i> over weed grassland of * <i>Ehrharta calycina</i> , * <i>E. longiflora</i> and * <i>Avena</i> spp. with occasional <i>Banksia prionotes</i> , <i>Xanthorrhoea preissii</i> and <i>Grevillea vestita</i> , and occasional trees of <i>Eucalyptus rudis</i> in low-lying areas	Sandplains	Site 8: 2.7 ha	
<i>Melaleuca raphiophylla</i> woodland MrW	Woodland of <i>Melaleuca raphiophylla</i> over weedy grasses	Drainage line	Site 8: 0.1 ha	n/a
Highly modified HM	Includes areas that have been predominantly cleared but which still contain either scattered natives or introduced species. These include bulldozed firebreaks that contain seed and which may support occasional native species These areas were generally rated as Condition 6 (<i>Completely Degraded</i>)		Site 1: 2 ha Site 2: 0.2 ha Site 3: 3.2 ha Site 4: 2.5 ha Site 5: 1.6 ha Site 6: 0.03 ha Site 7: -.1 ha Site 8: 5.5 ha	n/a

4.1.2 Vegetation condition

The Survey area is located within the road reserve and includes the road shoulder and an area of road reserve vegetation adjacent to the shoulder. The condition of the vegetation within the Survey area was assessed and mapped during the field survey and ranged from Pristine or Nearly So - Excellent (1-2) to Completely Degraded (6).

The vegetation directly adjacent to the cleared road shoulder has been impacted by previous clearing, and is generally in poorer condition than the vegetation further from the road. The areas that display edge effects range in width from around 3 to 5 m from the road shoulder. Edge effects include increased weed invasion and littering. In Sites 1-7 the vegetation further from the road is generally in excellent condition, and shows few signs of disturbance. The main disturbance within this vegetation is the presence of small numbers of herbaceous weeds. The vegetation structure and floristic diversity displays minimal disturbance and the majority of vegetation is in Pristine or Nearly So or Excellent condition (144.1 ha, 46.5 % of the Survey area).

Site 8 has been previously cleared leaving only scattered native trees and shrubs. The majority of this site was rated either Degraded-Completely Degraded (5-6) or Completely Degraded (8.4 ha) as the understorey is primarily comprised of introduced species with few natives. This site has little chance of natural regeneration due to the large areas of disturbance.

The existing highway, road shoulder and other hardstand/gravel areas with no native vegetation were not given a vegetation condition rating (65.6 ha). There were a number of firebreaks or sandy tracks, have been previously cleared of vegetation, but which contain some scattered native species and these areas were rated Completely Degraded (6) (11.5 ha, 3.7 % of the Survey area).

Within Site 5 there is an old borrow pit area that is infested with *Phytophthora cinnamomi* and is fenced off to minimise the spread of the disease. The vegetation within this area has been severely impacted by the past disturbances and many of the susceptible species are dead or dying due to the *Phytophthora* infestation (Plate 2).



Plate 2 Fenced area that is infested with *Phytophthora cinnamomi*

The extents of the vegetation condition ratings mapped within the Survey area are detailed in Table 11 with the vegetation condition of the Survey area mapped in Figure 4, Appendix A.

Table 11 Extent of vegetation condition ratings mapped within the Survey area

Condition rating	Total Extent (ha)	Site 1 Extent (ha)	Site 2 Extent (ha)	Site 3 Extent (ha)	Site 4 Extent (ha)	Site 5 Extent (ha)	Site 6 Extent (ha)	Site 7 Extent (ha)	Site 8 Extent (ha)
1-2 (<i>Pristine or nearly so – Excellent</i>)	61.8	-	-	-		59.1	-	2.7	
2 (<i>Excellent</i>)	82.3	12.1	15	15	35.1	-	2.8	2.3	
2-3	34.7	1.4	-	1.9	3.4	-	10.1	17.8	
3 (<i>Very Good</i>)	9.8	6.7		-	-	-	1.1	2.1	
3-4	29.6	1.6	8.2	4.4	6.2	2.9	2.8	3	
4 (<i>Good</i>)	1.2	0.7		0.3	0.2	-	-	-	
4-5	1.9	0.75	0.2				0.2	0.75	
5 (<i>Degraded</i>)	2.3		-	1.9		0.4	-	-	
5-6	2.8	-	-	-	-	-		-	2.8
6 (<i>Completely Degraded</i>)	11.5	2	0.2	2.1	1.1	0.4	0.03	0.1	5.6
Uninterpretable (burnt)	6.9	-	2.2	-	-	4.7	-	-	
Not Assessed (highway etc)	65.6	12.3	5.8	11.1	7	11.3	4.3	7.9	5.9
Total	310	37.6	31.6	36.7	53	78.8	21.3	36.7	14.3

4.1.3 Conservation significant ecological communities

No Australian Government-listed TECs were identified within the Survey area during the field survey.

The *Banksia* woodlands that occur within Site 1 and Site 2 are likely representative of the PEC 'Swan Coastal Plain *Banksia attenuata* – *Banksia menziesii* woodlands'. This PEC is listed as a Priority 3 by the DPaW. These woodlands occur in the Bassendean system, on the northern part of the Swan Coastal Plain. The description of these woodlands state they occur only as far north as Gingin; however this PEC has been mapped by DPaW near Regan's Ford, which is within the area of Site 1 and 2.

Statistical analysis of quadrat data would be required to ascertain which of the *Banksia* woodlands within the Survey area align to this PEC; however based on the presence of dominant species it is likely that this PEC does occur within the Survey area. There was 23.1 ha of this vegetation mapped within Site 1 and 33.3 ha within Site 2.

These *Banksia* woodlands types are also equivalent to the Priority 3 PEC '*Banksia* dominated woodlands on the Swan Coastal Plain IBRA region'.

4.1.4 Other significant vegetation

The vegetation of the Survey area was assessed to determine whether the vegetation could be considered as 'other significant vegetation' as determined by the EPA (2004a). The majority of the vegetation is relatively uniform and was considered to be widespread in the road reserve adjacent to the Survey area and in adjacent areas of native vegetation. However, two vegetation types '*Calothamnus* shrubland and *Meeboldina* sedgeland on low-lying seasonally inundated areas' and '*Petrophile seminuda* shrubland' (Site 6 and 7) were restricted in extent and were considered to contain an assemblage of flora species that weren't found elsewhere within the Survey area.

This vegetation occurs within and adjacent to a seasonally wet area in a low-lying area adjacent to the highway. This vegetation contains a number of ephemeral wetland species such as *Centrolepis* species, *Triglochin* species, *Drosera porrecta* and sedges and rushes. 10.4 ha of these vegetation types were mapped within Site 6 and 7. The road reserve is narrow in this area and is adjacent to a paddock and so this vegetation is relatively restricted in the Survey area.

In addition the vegetation type that occurs along Minyulo Brook within Site 3 (*Eucalyptus rudis* – *Melaleuca raphiophylla* woodland) could be considered significant as it is comprised of riparian vegetation that is not well represented in the local area and which offers a role as a refuge for flora and fauna species. 1.77 ha of this riparian vegetation occurs within the Survey area.

Within the northern end of Site 1 there is a small area of wetland vegetation mapped as *Melaleuca preissiana* woodland. 0.17 ha of this vegetation occurs within the Survey area.

Within Site 8 there is 0.1 ha of degraded *Melaleuca raphiophylla* woodland that occurs along a drainage line.

4.2 Flora

4.2.1 Flora diversity

The Survey area is located within a highly diverse area within the south-west of Western Australia. During the field survey the floristic diversity of the Survey area (Sites 1-7) was noted to be very high and representative of the species-rich flora found within the area, as documented in a number of surveys and reports (Burbidge *et al.* 1990). During the field survey high species turn-over was noted even within the same vegetation type.

Site 8 was less floristically diverse than the other sites as the majority of the road reserve was highly degraded and consisted of scattered native trees and shrubs over introduced grasses.

A total of 665 flora taxa (including subspecies and varieties) representing 75 families and 271 genera were recorded in the Survey area during the field survey. This total comprises 562 (84.5 % native taxa) and 103 (15.5 % introduced taxa), as well as three planted species.

Dominant families recorded from the Survey area included:

- Myrtaceae 87 taxa
- Fabaceae 83 taxa
- Proteaceae 70 taxa
- Poaceae 38 taxa

Dominant genera recorded from the Survey area included:

- *Acacia* 21 taxa
- *Stylidium* 13 taxa
- *Drosera* 13 taxa
- *Hakea* 12 taxa
- *Eucalyptus* 12 taxa
- *Daviesia* 11 taxa
- *Banksia* 10 taxa
- *Schoenus* 10 taxa
- *Verticordia* 10 taxa

Table 12 Number of flora taxa recorded during the field survey at each Site

Number recorded	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Taxa	244	217	234	264	284	278	241	60
Native taxa	193	175	180	225	257	234	215	27
Introduced taxa	51	42	54	39	27	44	26	33

Species richness recorded in the quadrats ranged from 8 to 53 species per 100 m², with the lowest species richness occurring within the degraded creekline quadrats (*Eucalyptus rudis* - *Melaleuca raphiophylla* woodland) and the highest richness occurring within the low mixed heathland and *Banksia* woodland vegetation types. However, it should be noted that the quadrats were only able to be assessed during one season and in one year which would provide an underrepresentation of species richness. In order to obtain a full species list the quadrats would require reassessment over a number of seasons.

4.2.2 Conservation significant species

The field survey did not record any EPBC Act or WC Act-listed Threatened flora taxa within the Survey area. During the field survey 13 DPaW-listed Priority flora taxa were recorded:

- *Grevillea synapheae* subsp. *minyulo* (Priority 1)
- *Lyginia excelsa* (Priority 1)
- *Chordifex reseminans* (Priority 2)
- *Guichenotia alba* (Priority 3)
- *Phlebocarya pilosissima* subsp. *pilosissima* (Priority 3)
- *Stylidium hymenocraspedum* (Priority 3)
- *Banksia dallanneyi* subsp. *pollostata* (Priority 4)
- *Conostephium magnum* (Priority 4)
- *Desmocladius elongatus* (Priority 4)
- *Diuris ?recurva* (Priority 4)
- *Grevillea rudis* (Priority 4)
- *Grevillea saccata* (Priority 4)
- *Hibbertia helianthemoides sensu lato*. (Priority 4)

Priority species were recorded in all of the sites except Site 2 and 8:

- Site 1 two Priority species
- Site 3 one Priority species
- Site 4 three Priority species
- Site 5 six Priority species
- Site 6 three Priority species
- Site 7 five Priority species

A brief description of each of these taxa is provided below (Source: WA Herbarium 1998–). The conservation significant flora species recorded during the field survey have been mapped at Figure 3, Appendix A.

***Grevillea synapheae* subsp. *minyulo* (Priority 1)**

Grevillea synapheae subsp. *minyulo* is a spreading to sprawling, lignotuberous shrub that grows to 0.5 m high with white-cream-yellow flowers. This species grows on gravel and laterite in a restricted range around the Minyulo area. This species was recorded in Site 3, with three plants recorded in one population.



Plate 3 *Grevillea synapheae* subsp. *minyulo* recorded *in situ* in Site 3

***Lyginia excelsa* (Priority 1)**

Lyginia excelsa is a caespitose species that can form large, dense tussocks. This species can grow to 1.5 m tall with straight, erect culms (Briggs and Johnson 2000). This species is known from only a few sites near Cataby and north of Badgingarra, mostly on sand in dry heath and *Banksia* woodland (Briggs and Johnson 2000).

This species was recorded in scattered locations in both Site 4 (one plant) and Site 5 (45 plants) (Plate 4). In many locations this species was recorded along the edge of the road reserve vegetation, above the road batter.



Plate 4 *Lyginia excelsa* *in situ* in the Survey area

***Chordifex reseminans* (Priority 2)**

Chordifex reseminans is a rhizomatous, erect, tufted herb that grows to 0.9 m high and occurs in heath on sands. This species closely resembles the more common *Chordifex sinuosus* and can be difficult to distinguish these two species without sufficient rootstock material. This species was recorded in low-lying sedgeland and shrubland in sand within Site 7. Only one plant was recorded within a quadrat during the field survey; however this species may be more scattered throughout the low-lying area.

***Guichenotia alba* (Priority 3)**

Guichenotia alba is a slender, few-branched shrub that grows to 0.45 m high. It has white flowers from July to August and grows in sand and gravelly soils in low-lying flats and depressions. This species is restricted to northern heathlands between Three Springs and Cataby and is not considered rare or endangered but surveys are required to determine the species occurrence in reserves (Keighery 1992). One plant was recorded within Site 4, seven within Site 5, one within Site 6 and ten within Site 7, usually growing in previously disturbed soil (Plate 5).



Plate 5 *Guichenotia alba* recorded *in situ* in the Survey area

***Phlebocarya pilosissima* subsp. *pilosissima* (Priority 3)**

Phlebocarya pilosissima subsp. *pilosissima* is a shortly rhizomatous, compactly tufted perennial to 0.4 m high. This species occurs on the Swan Coastal Plain and Lesueur sandplains in white or grey sand and lateritic gravel. One plant was recorded in Site 1 and one in Site 5 (Plate 6).



Plate 6 *Phlebocarya pilosissima* subsp. *pilosissima* recorded *in situ* in the Survey area

***Stylidium hymenocraspedum* (Priority 3)**

Stylidium hymenocraspedum is a rosetted, perennial herb that grows to 0.7 m high. The leaves are adpressed to the soil and spatulate with a hyaline margin. This species has yellow flowers from September to October. *Stylidium hymenocraspedum* has a restricted distribution and occurs in sand over laterite on hillslopes in heath, *Banksia* and *Eucalyptus* low open woodland. This species was recorded in a localised patch of four individuals at the southern end of Site 5 (Plate 7).



Plate 7 *Stylidium hymenocraspedum* recorded *in situ* in Site 5

***Banksia dallanneyi* subsp. *pollostata* (Priority 4)**

Banksia dallanneyi subsp. *pollostata* is a prostrate, lignotuberous shrub that grows in grey/yellow sands on flats and lateritic rises. This species was recorded within *Banksia* woodland in Site 1 (Plate 8). This species belongs to group of similar prostrate *Banksias* that can be difficult to differentiate with suitable material. This species likely occurs more widely within Site 1.



Plate 8 *Banksia dallanneyi* subsp. *pollostata* recorded *in situ* in Site 1

***Conostephium magnum* (Priority 4)**

Conostephium magnum is an erect, compact multi-stemmed heath shrub, to 2 m high. This species grows in white-grey sands, sometimes associated with laterite gravels. This species was recorded in Site 5 where it was scattered throughout heathland and shrubland (Plate 9).



Plate 9 *Conostephium magnum* recorded *in situ* in Site 5

***Desmocladius elongatus* (Priority 4)**

Desmocladius elongatus is a rhizomatous, perennial rush to 0.5 m high. This species occurs in dry kwongan in sands at the northern extent of the Swan Coastal Plain and the southern Lesueur sandplains. This species was recorded within Site 4 with five clumps recorded from a localised area (Plate 10).



Plate 10 *Desmocladius elongatus* recorded *in situ* in Site 4

***Diuris ?recurva* (Priority 4)**

Diuris recurva is a small donkey orchid, up to 30 cm high with small yellow and brown flowers. This species flowers from July to August and occurs in loam in winter-wet areas. This species occurs north of Geraldton and in scattered locations in the northern to southern Wheatbelt.

This species was recorded in one location in Site 7. The plant recorded was at the end of its flowering period and the petals and sepals were starting to senesce making identification difficult (Plate 11). However, based on the size of the plant and flower and the material available it was determined most likely to be *Diuris recurva*. The survey was within the flowering period of the very similar *Diuris refracta*; however, this species usually has larger flowers than *Diuris recurva*. The survey was done at the end of the flowering period of this species and more plants may have occurred within the site but would not have been recorded due to the timing of the survey. An earlier survey would be required to confirm the presence and extent of this species within the Survey area.



Plate 11 *Diuris ?recurva* in situ in Site 7

***Grevillea rudis* (Priority 4)**

Grevillea rudis is a loose, spreading to erect shrub to 1.2 m high. This species has white-cream flowers and grows in white, grey, yellow or red sand, often with gravel and over laterite. This species was recorded in scattered locations throughout Site 6 and 7 (Plate 12). Fifteen plants were recorded within the Survey area.



Plate 12 *Grevillea rudis* recorded in situ in the Survey area

***Grevillea saccata* (Priority 4)**

Grevillea saccata is a diffuse, scrambling or trailing shrub that grows to 0.5 m high. This species grows in yellow or brown sand, often with lateritic gravel. This species is restricted to the Lesueur sandplain region and was recorded in both Site 6 and Site 7, growing in disturbed areas, including along the edge of the road and in a roadside drain (Plate 13). Twenty-two plants were recorded within the Survey area.



Plate 13 *Grevillea saccata* recorded *in situ* in the Survey area

***Hibbertia helianthemoides sensu lato* (Priority 4)**

Hibbertia helianthemoides is a spreading to erect, low or prostrate shrub that grows to 0.3 m high. *Hibbertia helianthemoides sensu stricto* occurs in the Stirling Range area and the specimen collected in the Survey area is one of several atypical morphotypes that are currently under study. It is likely that these morphotypes will be recognised as segregate taxa in the future.

This species was recorded within Site 5, in an area that had been burnt within the last year (Plate 14). It was only recorded in one location; however, once the vegetation recovers from fire it may be spread more widely at this location.



Plate 14 *Hibbertia ?helianthemoides* recorded *in situ* in Site 5, and habitat showing recent burn

Likelihood of Occurrence

The likelihood of occurrence assessment was reassessed following the field survey to take into consideration more detailed habitat and condition information and the efficacy of survey (Appendix D). This assessment determined that 13 species are known to occur, 93 species may possibly occur and 77 species are unlikely to occur within the Survey area.

4.2.3 Other significant flora

The flora species recorded during the field surveys were assessed to determine whether any were regarded as other 'significant flora' as defined by the EPA (2004a). A large number of species were recorded that are either regional endemics (endemic to the Lesueur subregion or endemic to the Swan Coastal Plain e.g. *Dielsia stenostachyus*). Within Site 6 and 7 there are a number of species that have a limited distribution within the Eneabba area, such as *Banksia glaucifolia*, *B. tridentata*, *Conospermum wycherleyi* subsp., *wycherleyi*, *Grevillea acrobotrya*, *Hakea flabellifolia*, *Isopogon inconspicuus*, *Desmocladius elongatus*. In addition one species was recorded that is endemic to a localised area, *Philothea spicata* subsp. Moore River National Park (G. & D Woodman Op 47).

Parts of the Survey area occur in a transitional area near the boundary of two IBRA regions, the Swan Coastal Plain and the Geraldton sandplains. This transitional area has a high species diversity and represents the edge of range for some species. A number of species were recorded on the outer extent of their recorded range, including *Allocasuarina campestris*, *Eremaea xphoenicea*, *Scholtzia teretifolia* (Site 5), *Dielsia stenostachya*.

A number of the species recorded within the Survey area exhibit morphological variation and some require further taxonomic consideration (e.g.. *Hibbertia helianthemoides*). The *Eucalyptus rudis* trees recorded within Site 3 are also morphologically variable as this species starts to intergrade with *Eucalyptus camaldulensis* north of Perth and can exhibit intergrade characteristics.

4.2.4 Introduced flora

One hundred and two introduced (weed) taxa were recorded within the Survey area during the field survey. Dominant weeds included grasses (Poaceae), daisies (Asteraceae) or Brassicas (Brassicaceae). The majority of weed species were recorded along the edge of the road and in disturbed areas such as along old tracks and within the spoon drains adjacent to the shoulder.

Grasses such as **Avena barbata* (Bearded Oat), **Eragrostis curvula* (African Lovegrass), **Ehrharta* species (Veldt grass) and **Lolium* species (rye species) were recorded along the edge of the shoulder and invading disturbed areas of bushland. Herbaceous species such as **Ursinia anthemoides* and **Hypochaeris glabra* (Flatweed) were recorded scattered throughout the good quality vegetation, generally in open sandy patches.

A number of weed species had not previously been recorded on *FloraBase* (WA Herbarium 1998) or *NatureMap* (DPaW 2007-) within the region. These species are likely to have been under-recorded previously and have an expanded range. These include **Coriandrum sativum*, **Sida rhombifolia* and **Euphorbia maculata*.

Plants of **Leptospermum laevigatum* (Victorian Teatree) were noted during the field survey and mapped in Figure 4 Appendix A. This species is not listed as a WoNS or DP but is known to be an environmental weed of bushland areas and its control is recommended.

Weeds of National Significance (WoNS) and Declared Pests (DP)

None of the weed species recorded within the Survey area have been listed as Weeds of National Significance (WoNS). However, three of the weed species are listed at the state level as a Declared Pest (DP): *Moraea flaccida* (Cape Tulip), **Emex australis* (Doublegee) and **Echium plantagineum* (Paterson's Curse). **Echium plantagineum* has a "C3 Management" control category for the Shire of Gingin or Dandaragan. However, *Moraea flaccida* (Cape Tulip) and **Emex australis* (Doublegee) do not have a control category for these two Shires. The locations of these significant weeds within the Survey area are mapped in Figure 4, Appendix A.

4.3 Fauna

4.3.1 Habitat types

Six broad fauna habitat types were identified within the Survey area during the field survey, based on the predominant landforms, soils and vegetation structure. The location of each habitat type is mapped in Figure 5, Appendix A. These fauna habitat types are closely aligned with the vegetation associations outlined in Section 4.1.1, and include:

- Banksia woodland
- Mixed shrublands
- Low heath and shrubland
- Low lying shrublands and sedgelands
- Highly modified
- Parkland Cleared – Marri Woodland



A description of each of these habitat types is provided in Table 13.



Overview of habitats within the Survey area


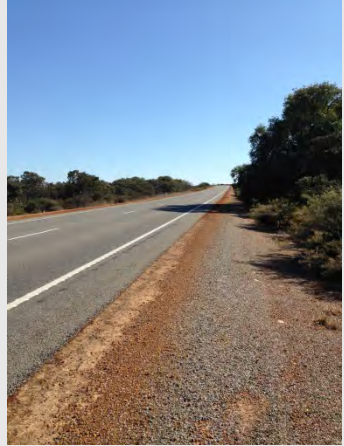
There is a variety of habitat compositions in each of the seven sites of the Survey area, however the sites are all similar in that:

- The Survey area is located within a broadly cleared region and as such any remnant vegetation has higher importance (see Section 3.6.1 for clearing extents). Even though each site is relatively small, the habitat in the Survey area has value because it is within a reasonably continuous stretch of vegetation which provides resource and habitat connectivity for fauna throughout the local landscape.
- The eight sites of the Survey area are spread along a stretch of the Brand Highway and cover various vegetation associations and soil types. This attributes to the variation in habitat types and the suite of fauna that are likely to utilise the different sites (particularly when comparing the most southern sites to the most northern sites).
- The Survey area is directly adjacent to the existing Brand highway which has meant increased disturbances to fauna such as increased noise and light from traffic, increased risk of vehicle strike, increased amounts of rubbish and weeds.

Table 13 Fauna habitat types

Description	Indicative Photograph
<p>Banksia woodland</p> <p>In Sites 1, 2, 3, 6 and 7 there are large tracts of Banksia woodland with mosaic of <i>Banksia menziesii</i> and <i>B. attenuata</i>. These woodlands vary in density and include scattered <i>Eucalyptus todtiana</i> trees over diverse mixed shrubs, grasses, herbs and sedges.</p> <p>These woodlands are both structurally and floristically diverse and contain a wide-variety of habitat resources for fauna. Structurally, the vegetation varies throughout the Survey area from very dense to more open woodlands, with some areas comprising very dense patches of Banksia shrubs. Throughout this habitat there are also several micro-habitat features such as logs, branches and thick leaf litter.</p> <p>Disturbances in this habitat type include fire, weeds and rubbish particularly in the areas immediately adjacent to the highway and side tracks.</p> <p>This habitat type is of particular importance to Carnaby’s Black Cockatoo as foraging resources (discussed further in Section 4.3.4).</p>	
<p>Mixed shrublands</p> <p>In Sites 3, 4, 5, 6, and 7 there are patches of shrublands with a diverse variety of species compositions including <i>Adenanthos cygnorum</i> (Woolly Bush), <i>Grevillea</i> shrubs, <i>Calothamnus</i> shrubs, <i>Jacksonia</i> species, <i>Allocasuarina humilis</i>, <i>Xanthorrhoea preissii</i> (grass tree), <i>Daviesia</i> shrubs and a variety of <i>Hakea</i> shrub species. These shrublands also include scattered trees such as <i>Banksia menziesii</i>, <i>B. attenuata</i> and <i>Eucalyptus todtiana</i>.</p> <p>The height and density of these shrublands varies between thick and open structures and the diversity of flora species provides a range of habitat resources. There is evidence of recruitment of vegetation with a variety of age classes within each taxa. The habitat has a diverse range of micro habitat types including thick leaf litter and continuous ground cover through most of the habitat type.</p> <p>Disturbances in this habitat type include fire (in the northern part of Site 5), weeds and rubbish, particularly in the areas immediately adjacent to the highway (and associated drains) and side tracks.</p> <p>The diverse shrublands in the Survey area are likely to support a wide range of fauna species including birds, insects, reptiles and small mammals; however the value of this habitat is reduced by its proximity to the busy Brand Highway. This habitat type would also provide foraging resources for Carnaby’s Black Cockatoo (discussed further in section 4.3.4)</p>	

Description	Indicative Photograph
<p>Low heath and shrubland</p> <p>In Sites 4, 6 and 7 there are patches of low heath and shrublands that occur on the shallower soils as a mosaic around the taller shrublands and woodlands. This low habitat has a high diversity of shrubs species including low shrubs <i>Synaphea spinulosa</i>, <i>Banksia laricina</i>, <i>Acacia stenoptera</i>, <i>Calytrix</i> species, <i>Gastrolobium</i> species and <i>Petrophile</i> species and mixed native woody herbs such as <i>Comesperma</i>, <i>Conostylis</i> and <i>Cassutha</i>. The habitat type includes scattered taller shrubs such as <i>Allocasuarina humilis</i> and <i>Xanthorrhoea</i>.</p> <p>These shrublands are low (up to 1 m high), thick and provide variation in habitat types present within the Survey area. The habitat includes patches with rocky substrates and continuous ground cover of dense low shrubs, prostrate and climbing species and leaf litter.</p> <p>The diverse low shrublands habitat is likely to support a wide range of fauna species including birds (particularly those species that are suited to open areas and heath lands), reptiles and small mammals; however the value of this habitat is reduced by its proximity to the busy Brand Highway. Disturbances are limited to the edges of the highway and side tracks, and include weeds and rubbish. This habitat is in <i>Very Good</i> condition or better (as mapped in Figure 3, Appendix A and described in section 4.1.2).</p>	
<p>Low lying shrublands and sedgeland</p> <p>In Site 6 there is a small patch (2.1 ha) of low lying dampland habitat that consists of low heath, sedges and wetland species such as low ground cover of <i>Desmocladus</i>, <i>Lepidosperma</i>, <i>Schoenus</i> species with scattered shrubs such as <i>Viminaria juncea</i> and a variety of <i>Melaleuca</i> shrubs. This habitat type is situated on a natural clay-pan area that holds water after rainfall events. The area is unlikely to hold water through drier seasons and as such the availability of resources is likely to vary over the year.</p> <p>These lower lying shrublands and sedgelands provides water and wetland habits that are otherwise generally limited in the local landscape. The habitat would be used by a different suite of species to that of the other habitat types in the Survey area, such as frogs, ducks and water birds. During drier seasons any water resources available in the landscape become increasingly important.</p>	

Description	Indicative Photograph
<p>Parkland cleared – Marri Woodland</p> <p>This habitat type occurs only in Site 8 and is comprised of a parkland cleared site that is likely to have originally been a Marri (<i>Corymbia calophylla</i>) woodland prior to clearing. This habitat contains scattered native shrubs in the mid layer and ground layer dominated by weedy grasses. There is some evidence of recruitment of the Marri with variation in age classes recorded. There is 2.74 ha of the habitat in the Survey area which occurs in a discontinuous strip along the side of the highway. There was limited recruitment and limited floristic variation recorded for the native shrub species in the Site. The ground cover includes a thick layer of grass and debris including fallen timber, branches and leave litter. The habitat is currently impacted extensively by rubbish and weeds. The habitat is in poor condition and has limited floristic diversity and as such would not support a wide range of fauna species.</p>	
<p>Highly modified</p> <p>In every site within the Survey area there are areas that have been completely cleared for the existing highway, side roads, fences lines and drainage. These areas offer very little habitat resources for fauna and are mostly devoid of vegetation.</p>	

4.3.2 Habitat connectivity and regional importance

In agricultural landscapes of Western Australia (primarily the Wheatbelt region), roadside reserves of remnant native vegetation are an important component, facilitating landscape connectivity and providing for fauna dispersal between larger isolated bushland fragments. Native fauna and feral animals utilise these corridors for movement between otherwise isolated remnants of native vegetation as 'stepping stones'. The persistence of these 'stepping stones' is important for the fauna populations to ensure connectivity of habitat patches for movement and dispersal. The fauna habitats present within the Survey area are connected both locally and regionally to other habitat linkages, and therefore play an important function in linking the habitat patches in a fragmented landscape and enhancing wildlife dispersal.

The road reserve of Brand Highway is up to 100 m wide on both sides of the road throughout the Gingin/Cataby/Badgingarra area. The road reserve provides connectivity to the broader landscape that has predominantly been cleared for agriculture. At a local scale, the habitat within this long linear strip is fragmented by the existing highway, side tracks, driveways and other roads. However at a larger regional scale, the habitat present within the Brand Highway road reserve provides an important habitat linkage between larger patches of vegetation, such as the Badgingarra National Park and other conservation estates adjacent to the highway. The habitat within the Survey area contributes to the value of the overall road reserve as a habitat linkage.

4.3.3 Fauna diversity

The field survey recorded 56 fauna species, consisting of 41 birds, 11 reptiles and four mammals. Of these, 53 are native species and three are introduced species. The three introduced species include the Cat (**Felis catus*), Fox (**Vulpes vulpes*) and Rabbit (**Oryctolagus cuniculus*). Evidence of all three of these species was recorded regularly during the field survey throughout the Survey area. A list of the fauna species recorded during the field survey is provided in Appendix E.

4.3.4 Conservation significant fauna

During the field survey, one conservation significant fauna species was recorded, the Carnaby's Black Cockatoo (*Calyptrorhynchus latirostris*). This species is listed as Endangered under the EPBC Act and under the WC Act. Several small groups of Carnaby's Black Cockatoo were observed, specifically at Sites 1, 2, 3 and 5 foraging and flying through the area. In addition, foraging evidence of the species was recorded in all 8 sites.

Likelihood of occurrence assessment

A likelihood of occurrence assessment was conducted for all conservation significant fauna species identified in the desktop assessment (Appendix C). This assessment is based on species biology, habitat requirements, the quality and availability of suitable habitat as determined during the field survey and records of the species in the Survey area.

The parameters used to determine the outcomes for this likelihood of occurrence assessment and the full likelihood of occurrence assessment are described in Appendix E. The assessment concluded that in addition to the one species that is known to occur (Carnaby's Black Cockatoo), four species are considered likely to occur and 21 species are unlikely or highly unlikely to occur within the Survey area.

The four conservation significant fauna species considered likely to occur in the Survey area include:

- Rainbow Bee-eater (*Merops ornatus*) Migratory (EPBC Act) and Schedule 5 – Migratory (WC Act)
- Peregrine Falcon (*Falco peregrinus*) “Schedule 1 - other specially protected fauna” (WC Act)
- Chuditch (*Dasyurus geoffroi*) EPBC Act (Vulnerable) and Schedule 3 - Vulnerable (WC Act)
- Western Brush Wallaby (*Macropus irma*) Priority 4 listed by DPaW

All of these species are all generally wide ranging, are known to utilise the habitats available in the Survey area and have been recorded in proximity to the Sites. The extent and location suitable habitat within the Survey area for each of these species are described in Table 14.

Table 14 Description of use for conservation significant fauna species considered likely to occur within the Survey area

Species	Description, extent and location of suitable habitat
<p><i>Calyptrorhynchus latirostris</i> (Carnaby's Cockatoo black-cockatoo)</p>	<p>All sites in the Survey area contain habitat for the Carnaby's Black Cockatoo. The Carnaby's Black Cockatoo is known to occur in Sites 1, 2, 3 and 5 and foraging evidence of the species was recorded regularly in all 8 sites. The foraging evidence recorded at the sites included old, recent and fresh evidence of foraging, and most of this evidence was on the seeds and flowers of <i>Banksia</i> tree species. The woodlands, shrublands and heathlands habitat types provide high value foraging resources for the Carnaby's Black Cockatoo. There are a total of 261.7 ha of foraging habitat for the Black Cockatoo in the Survey area. These habitat types occur in all eight sites.</p> <p>The Survey area is located within the known breeding range of the species and the foraging resources in the Survey area may support breeding in the area. An area of vegetation around Cataby Brook has been identified as supporting Carnaby's Black Cockatoo breeding and feeding habitats (EPA 2014). Bird Life Australia has recognised a 314 ha tract of land 2 km south of Cataby (which is within 5 km of Sites 3 and 4) as an Important Bird Area because it supports up to 24 breeding pairs of Carnaby's Black Cockatoo (Dutson <i>et al.</i> 2009). Breeding success is dependent on both the nesting and foraging areas being relatively close together and sufficient to support the population (EPA 2005). The foraging habitat available in the Survey area (particularly Sites 3 and 4) is likely to be utilised by breeding Carnaby's Black Cockatoos.</p> <p>In addition, potential breeding trees were recorded within Site 3 (along Minyulo Brook) and in Site 8. There were 195 potential breeding trees (i.e. DBH greater than 300/500 mm DBH) recorded within the Survey area: 59 within Site 3, 134 within Site 8 and one within Site 5 and one within Site 7. No suitably sized breeding hollows were recorded during the field survey.</p>
<p><i>Falco peregrinus</i> (Peregrine Falcon)</p>	<p>All sites in the Survey area contain habitat for the Peregrine Falcon. The habitat in all sites would provide foraging resources for the Peregrine Falcon though none were recorded during the field survey. The Peregrine Falcon is known to have large home ranges and utilise a variety of habitat types. All eight sites could provide foraging resources for the Peregrine Falcon however there is no breeding habitat in (or in close proximity to) the sites.</p>
<p><i>Dasyurus geoffroii</i> (Chuditch)</p>	<p>All sites in the Survey area contain habitat for the Chuditch. The Chuditch occurs in low density throughout the southwest and is known to utilise rural landscapes. All the habitat types in the Survey areas (in all sites) could provide resources for the Chuditch, however the rate of occupancy is likely to be low given the fragmentation of the habitat by the existing highway and extent of cleared agricultural land surrounding the sites.</p>

Species	Description, extent and location of suitable habitat
<p><i>Macropus irma</i> (Western Brush Wallaby)</p>	<p>All sites in the Survey area contain habitat for the Western Brush Wallaby. There are multiple records of the Brush Wallaby in proximity to the Survey area and the species is known to utilise rural landscapes. It is likely that the wallaby would utilise the sites occasionally for refuge or may use the road verge vegetation as linear passage between habitat resources.</p>
<p><i>Merops ornatus</i> (Rainbow Bee-eater)</p>	<p>All sites in the Survey area contain habitat for the Rainbow Bee-eater. This migratory species is likely to be common in some seasons in the Survey area.</p>

5. Environmental Approvals and referrals

5.1 Australian Government approvals

5.1.1 Matters of National Environmental Significance

Referral to the DotE under the EPBC Act is triggered if a proposed action has/or potentially has a significant impact on any MNES. An assessment of the Project against each of the biological MNES is provided in Table 15 and concludes that referral of the project due to potential impacts to the Carnaby's Black Cockatoo is recommended.

Table 15 Assessment of the Survey area against biological MNES

Matters of National Environmental Significance	Occurrence	Potential Impact
Threatened flora Species	None recorded	No known impacts; however there were 15 Threatened flora species which have the potential to occur in the Survey area
Threatened Ecological Communities	None recorded	None expected
Threatened Fauna Species; Carnaby's Black Cockatoo	<p>Carnaby's Black Cockatoo is known to utilise the Survey area for foraging resources. Carnaby's Black Cockatoos were recorded in sites 1, 2, 3 and 5. Furthermore, old, recent and fresh evidence of foraging by the Cockatoo was recorded in all sites of the Survey area.</p>	<p>261.7 ha of quality foraging resources will be lost across the eight sites. The high quality foraging habitat includes the Banksia Woodlands, Mixed Shrublands, the low lying heath and shrublands and the Cleared Parkland/Marri as mapped in Figure 5, Appendix A. The low lying shrubland and sedge land may provide some additional resources (such as water and foraging resources) as well but contains fewer preferred foraging plant species for the Cockatoo. The clearing of 261.7 ha of foraging resources is above the 1 ha of clearing threshold of high risk to the species and requires referral to the DotE under the DotE (DSEWPaC 2012) EPBC Act referral guidelines for three threatened Black Cockatoo. This foraging habitat is in proximity to known breeding areas for the species and is likely to be part of the resources used by breeding Carnaby's Black Cockatoos. 195 potential breeding trees were recorded within the Survey area: 59 within Site 3, 134 within Site 8 and one within Site 5 and one within Site 7.</p> <p>Referral of the project due to potential impacts to the Carnaby's Black Cockatoo is recommended.</p>
Threatened Fauna Species; Chuditch	<p>Chuditch are considered likely to occur in the Survey area and utilise all the habitat types. All of the habitats in the Survey area could provide foraging/ hunting, denning and dispersal resources for the Chuditch though the rate of occurrence is likely to be low considering the ecology of the species, the proximity of the Survey area to the existing highway and the small extent of each site.</p>	<p>There are no species-specific referral guidelines for the Chuditch so an assessment against the DotE Significant Impact Guidelines 1.1 (DotE 2013) was conducted. The Chuditch is a wide ranging species with a home range of between 120 ha (females) and 400 ha (males) (Van Dyck and Strahan 2008) that utilises a diverse range of habitats throughout the south-west of WA. The Survey area does not contain habitat that is necessary for the survival Chuditch. The project is unlikely to exceed any of the significant impact criteria identified in the DotE 1.1 guidelines (page 10) for vulnerable species (DotE 2013). Clearing for the Project is considered unlikely to have a significant impact on the Chuditch, and as such is unlikely to trigger referral to the DotE.</p>

Matters of National Environmental Significance	Occurrence	Potential Impact
Migratory Species; Rainbow Bee-eater	Rainbow Bee-eater are likely to occur in the Survey area and utilise all the habitat types	As there are no species-specific referral guidelines for the Rainbow Bee-eater so an assessment against the DotE Significant Impact Guidelines 1.1 (DotE 2013) was conducted. The Rainbow Bee-eater is a wide ranging species that utilises a diverse range of habitats throughout Australia. The project is unlikely to exceed any of the significant impact criteria identified in the DotE 1.1 guidelines (page 12) for migratory species. As a result, the project is considered unlikely to trigger referral to the DotE.

5.1 State approvals

5.1.1 Environmental Protection Authority

Significant proposals must be referred to the EPA under Section 38 of the *Environmental Protection Act 1986* (EP Act). In deciding whether a proposal will be subject to the formal environmental impact assessment process, the EPA takes into account the environmental significance of any potential impacts that may result from the implementation of the scheme or proposal.

In the absence of a broader environmental assessment, the majority of the likely biological impacts associated with the Project are linked to native vegetation clearing and loss of fauna habitat. The potential impacts from the loss of native vegetation and loss of fauna habitat may be effectively assessed through the Environmental Protection (Clearing of Native Vegetation) Regulations 2004. Therefore with consideration of the biological values discussed in this report, it is considered unlikely that the Project would require referral to the EPA under Section 38 of the EP Act.

5.1.2 Department of Environment and Regulation

The clearing of native vegetation in Western Australia requires a permit under Part V of the EP Act, unless an exemption applies. Main Roads has been granted a State-wide vegetation clearing permit (Clearing Permit CPS 818 and 817) which allows Main Roads to clear native vegetation for road projects and associated activities.

The Federal and Western Australia Governments have entered into a bilateral agreement under the EPBC Act relating to environmental assessment (assessment bilateral agreement). Specifically, this agreement now includes the clearing permit assessment process under Part V Division 2 of the EP Act. Under the assessment bilateral agreement, if a native vegetation clearing permit is required and the clearing will have, or is likely to have an impact on a MNES, the assessment of the clearing application including the potential impacts to the MNES can be conducted by the Department of Environment Regulation (DER) or Department of Mines and Petroleum under delegation.

There were no flora species listed under the EPBC Act (MNES) recorded during the survey, however, 13 DPaW Priority-listed flora taxa were recorded within the Survey area. Furthermore, four fauna of conservation significance are considered likely to occur in the Survey area, including one listed under the EPBC Act that may warrant referral to DotE in the absence of further investigations. Any Clearing Permit application should assess the significance of any potential impacts on these species and can be assessed by DER under the bilateral agreement.

6. Conclusions and recommendations

The Survey area is located directly adjacent to the existing Brand Highway and includes both the existing cleared shoulder and areas of native vegetation adjacent to the road. The Survey area comprises native vegetation which supports species and communities of conservation significance.

Flora & Vegetation

The Survey area includes sections of road reserve vegetation that are in excellent condition. It is located in a region of high floristic diversity and very high numbers of native species were recorded during the field survey, including a number of endemic species and thirteen species that are listed by DPaW as priority species. A targeted conservation significant flora survey would be required to determine the extent of populations of conservation significant flora species within the Survey area.

Site 1 and Site 2 contain vegetation that is considered representative of the PEC 'Swan Coastal Plain *Banksia attenuata*- *Banksia menziesii* woodlands' which is listed as Priority 3 by DPaW. This vegetation is also equivalent to the Priority 3 PEC *Banksia* dominated woodlands on the Swan Coastal Plain.IBRA region.

Wetland and riparian vegetation was recorded in Sites 1, 3, 6 and 7. Within the northern end of Site 1 there is a small area of wetland vegetation mapped as *Melaleuca preissiana* woodland. 0.17 ha of this vegetation occurs within the Survey area. Within Site 3 there is 1.77 ha of *Eucalyptus rudis* – *Melaleuca raphiophylla* riparian woodland. 10.4 ha of low-lying, seasonally-inundated areas were mapped within Site 6 and 7. Within Site 8 there is 0.1 ha of degraded *Melaleuca raphiophylla* woodland that occurs along a drainage line.

The areas of vegetation that are directly adjacent to the cleared shoulder are generally in lower condition than the vegetation within the majority of the road reserve and where possible impacts should be restricted to these areas. The extent of clearing should be minimised to reduce potential impacts on vegetation and flora within the road reserve. In addition, management measures should be implemented to reduce potential impacts on adjacent vegetation in *Excellent* condition, including the conservation areas that occur in close proximity to the Survey area.

Fauna & Fauna Habitat

There are five fauna species of conservation significance known, or likely, to occur in the Survey area including the EPBC Act-listed Carnaby's Black Cockatoo, Chuditch and Rainbow Bee-eater.

It is recommended that during the Project design and construction the extent of clearing be reduced wherever possible in order to minimise potential impacts on these species. The location of the Site 8 passing lane should be reassessed to avoid clearing of potential black cockatoo trees. In addition, management measures should be implemented during the construction phase to reduce potential off-site impacts

Dependent on the extent of impact on native vegetation required, it is likely that the project will require referred to the DotE due to the potential impacts on the Carnaby's Black Cockatoo foraging and breeding habitat.

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Appendices

Appendix A - Figures

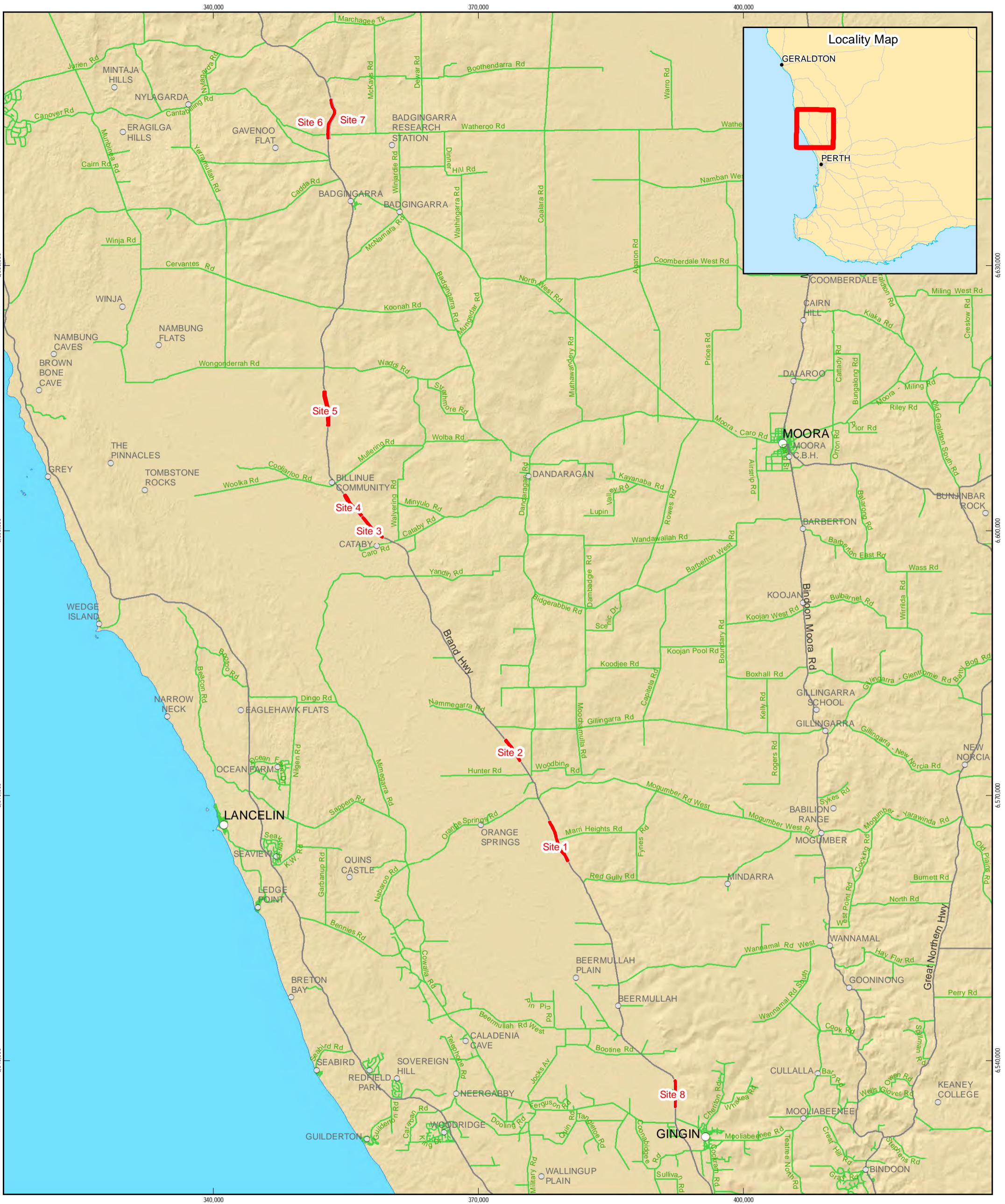
Figure 1 Survey area location

Figure 2 Ecological context

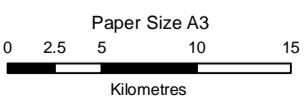
Figure 3 Vegetation types, quadrat locations and conservation significant flora species

Figure 4 Vegetation condition and significant weed locations

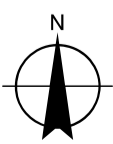
Figure 5 Fauna habitat and significant fauna locations



- LEGEND**
- Town
 - Locality
 - State Road
 - Local Road
 - ▭ Survey Area



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 Grid: GDA 1994 MGA Zone 50



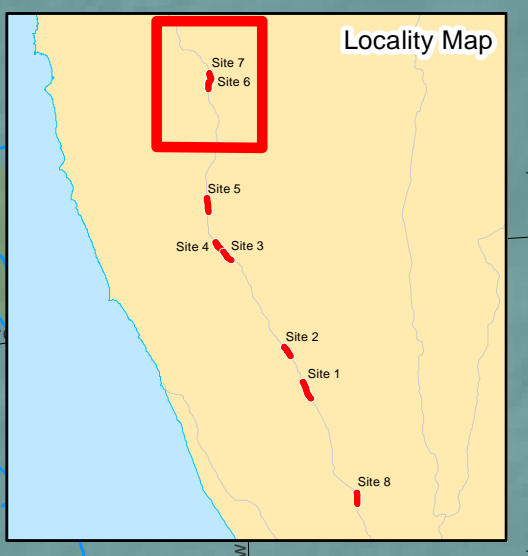
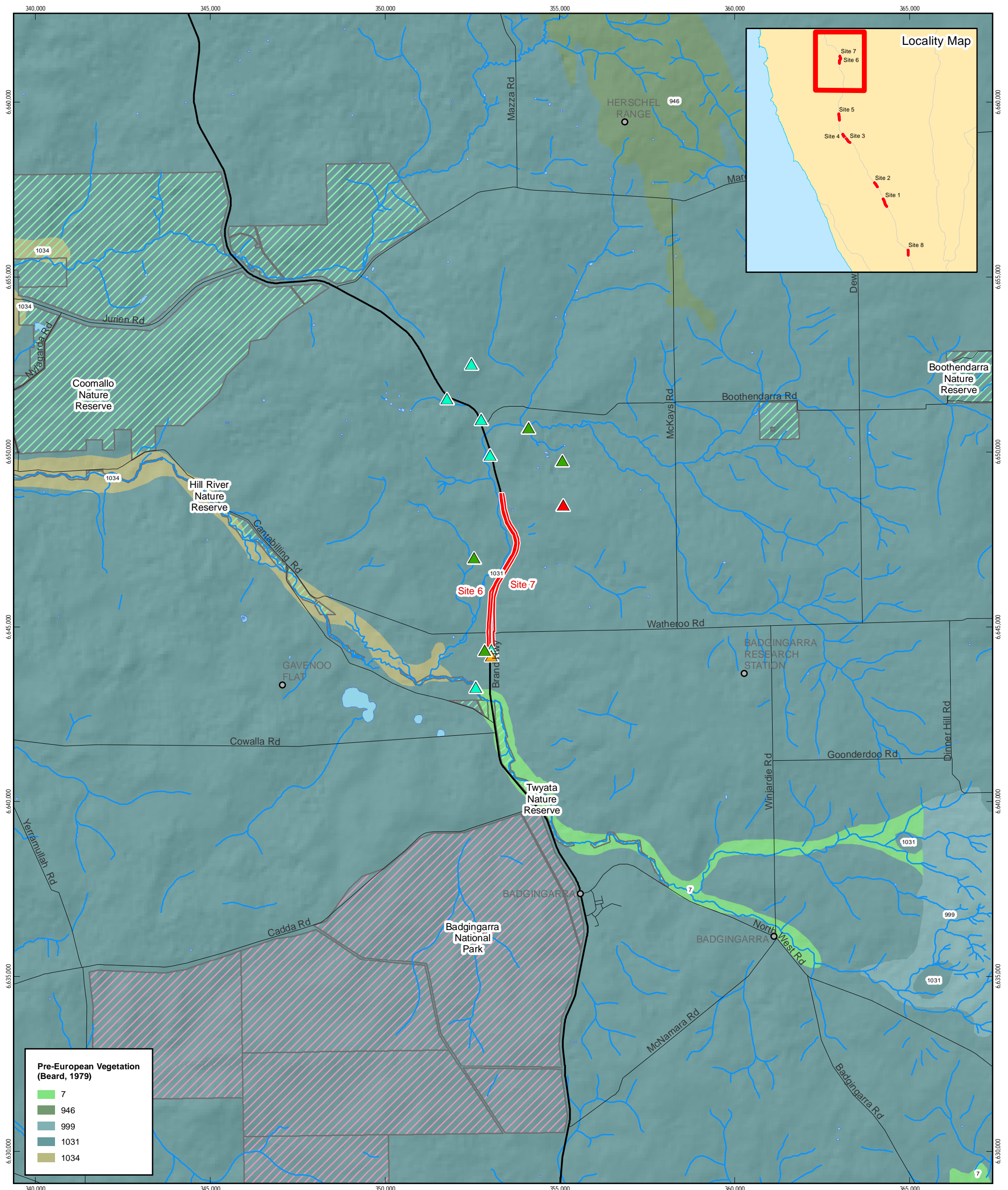
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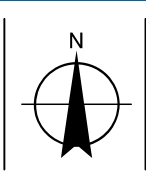
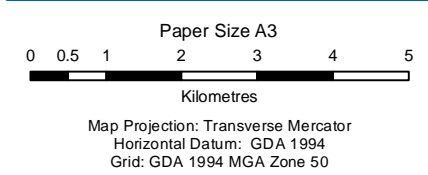
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 Revision | 1
 Date | 23 May 2016

Survey Area Location

Figure 1



Survey Area	(T) Threatened Rare Flora - Extant Taxa	Priority 3 - Poorly Known Taxa	Conservation Park
River	Priority 1 - Poorly Known Taxa	Priority 4 - Rare Taxa	National Park
Wetland	Priority 5 - Conservation Dependent Taxa	Nature Reserve	
TEC / PEC	Priority 2 - Poorly Known Taxa		

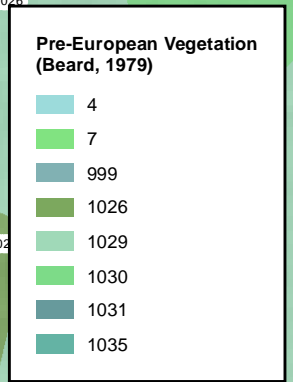
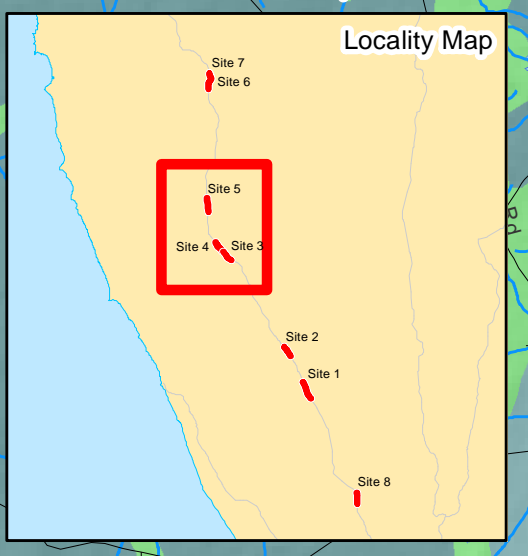
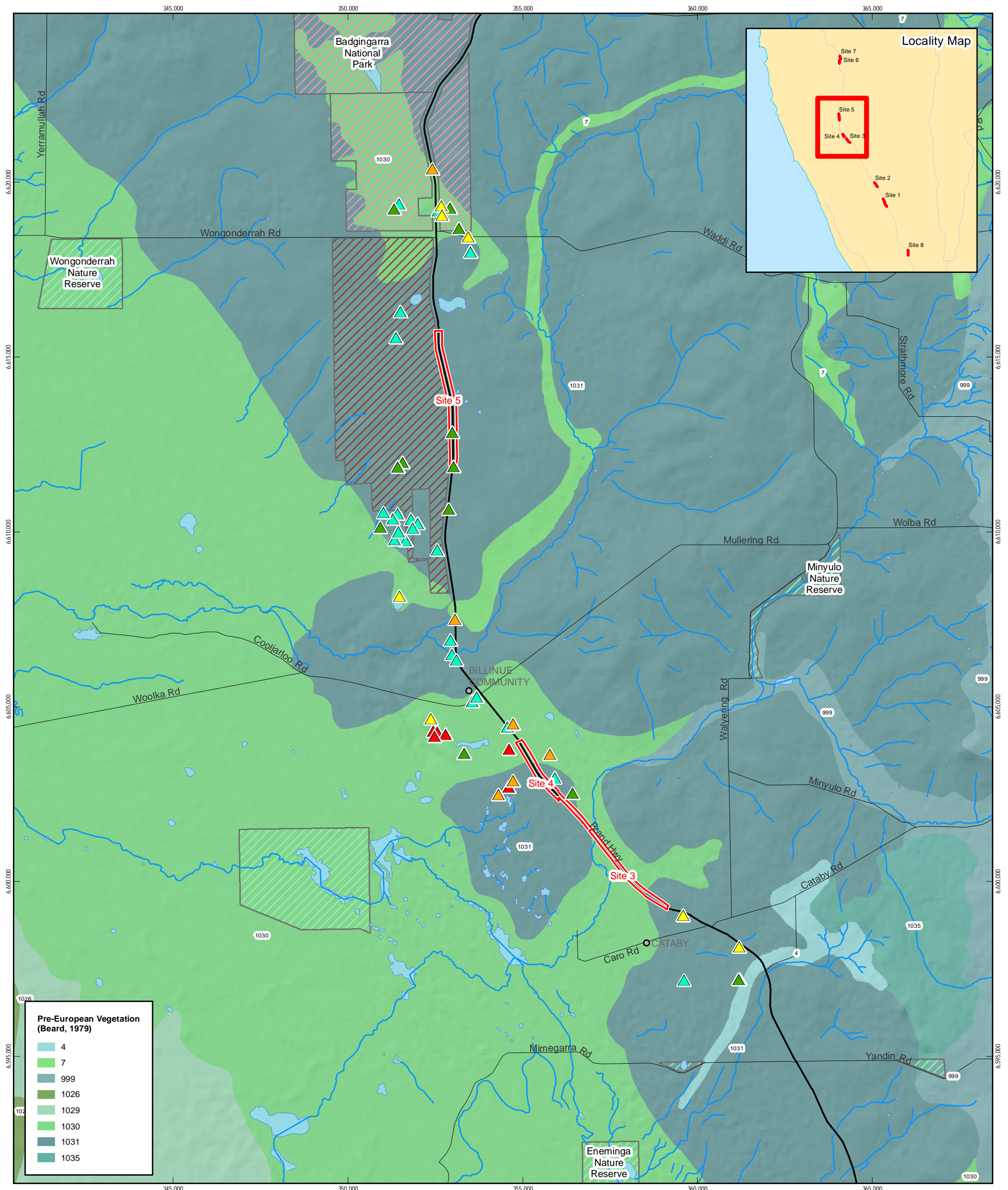


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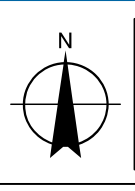
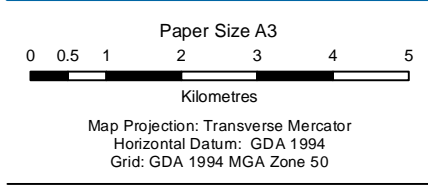
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Date | 23 May 2016

Ecological Context

Sheet 1 of 4
Figure 2



Survey Area	Threatened (Declared Rare) & Priority Flora	Priority 3 - Poorly Known Taxa	DPaW Managed Lands
River	(T) Threatened Rare Flora - Extant Taxa	Priority 4 - Rare Taxa	Conservation Park
Wetland	Priority 1 - Poorly Known Taxa	Priority 5 - Conservation Dependent Taxa	National Park
TEC / PEC	Priority 2 - Poorly Known Taxa		Nature Reserve

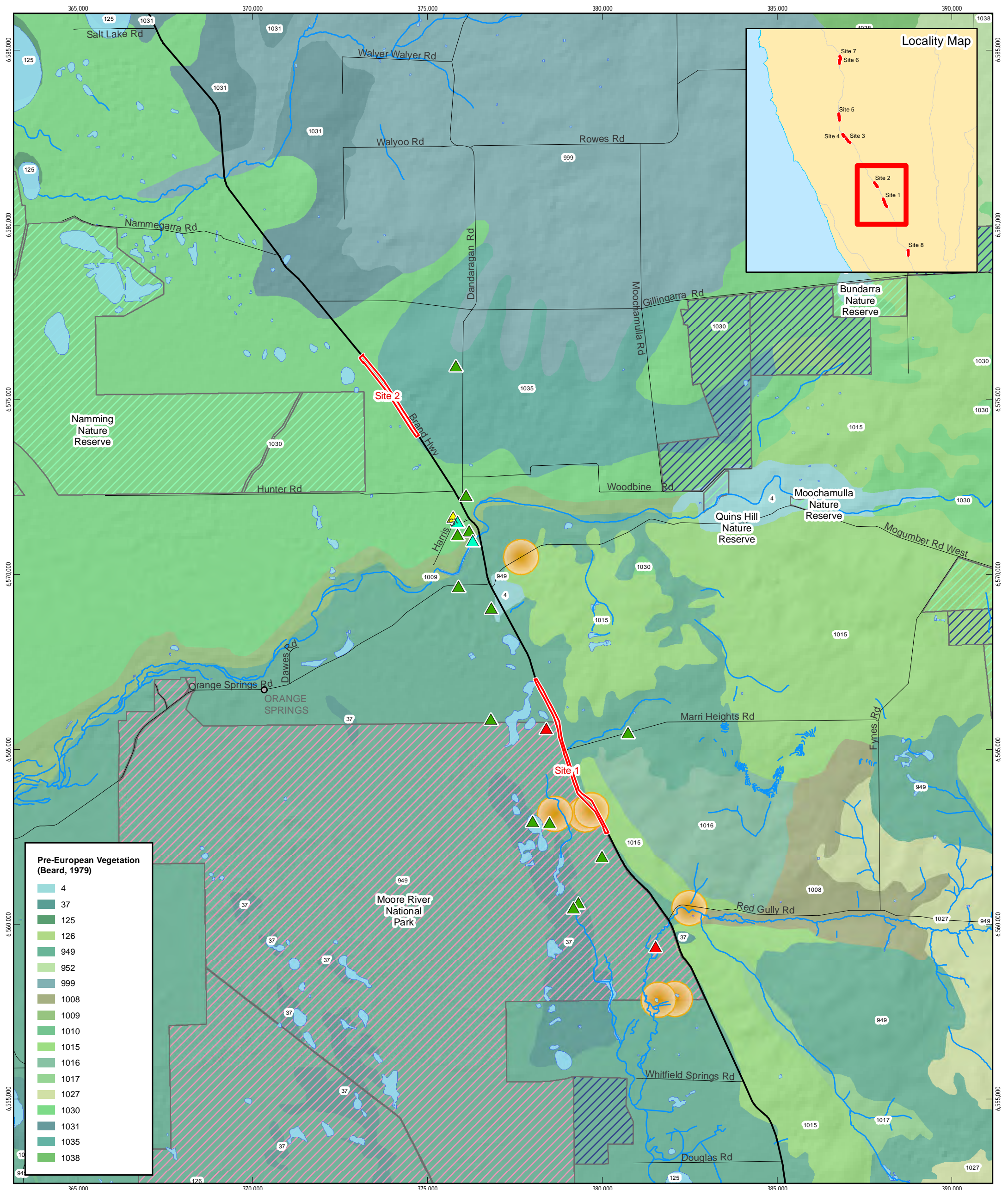


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Ecological Context

Sheet 2 of 4 Figure 2

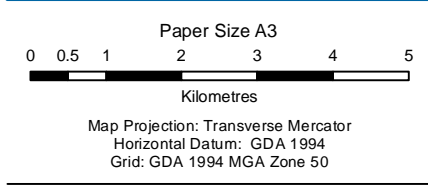


Pre-European Vegetation (Beard, 1979)

4
37
125
126
949
952
999
1008
1009
1010
1015
1016
1017
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1030
1031
1035
1038

LEGEND

Survey Area	(T) Threatened Rare Flora - Extant Taxa	Priority 3 - Poorly Known Taxa	DPaW Managed Lands
River	Priority 1 - Poorly Known Taxa	Priority 4 - Rare Taxa	National Park
Wetland	Priority 2 - Poorly Known Taxa	Priority 5 - Conservation Dependent Taxa	Nature Reserve
TEC / PEC			

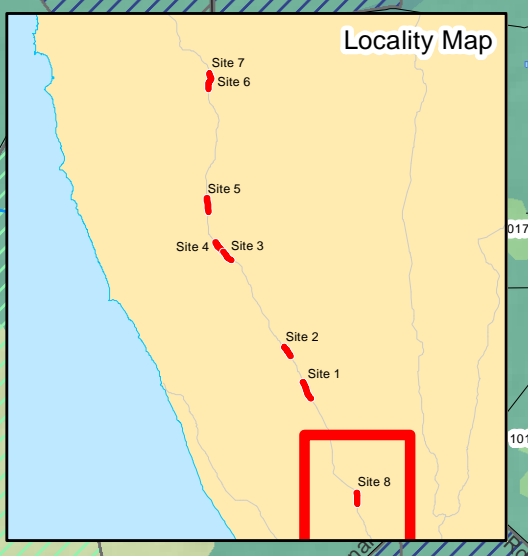
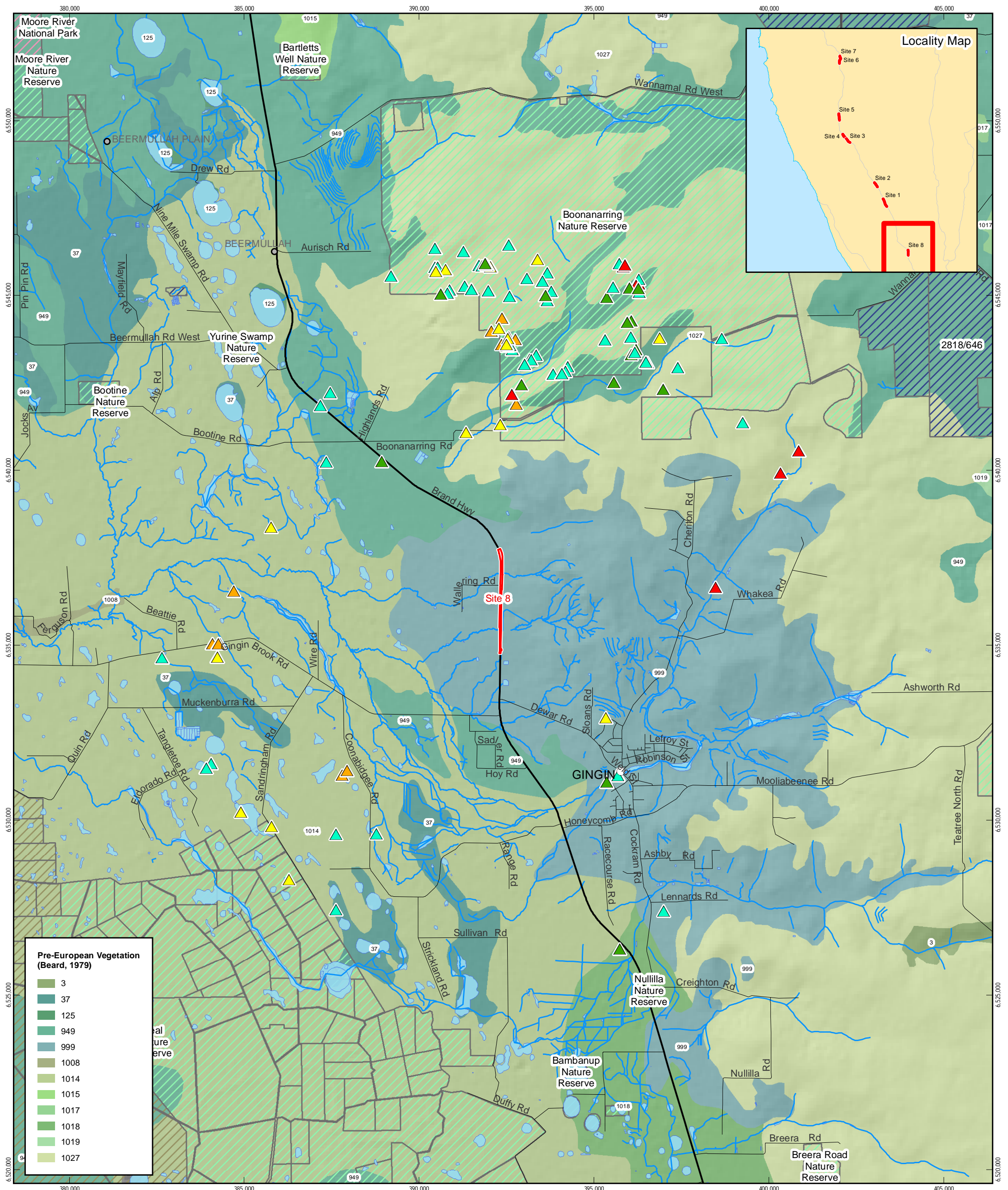


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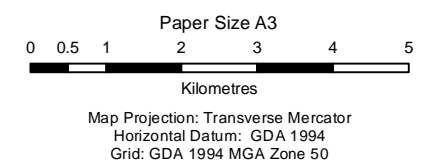
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Sheet 3 of 4
Figure 2



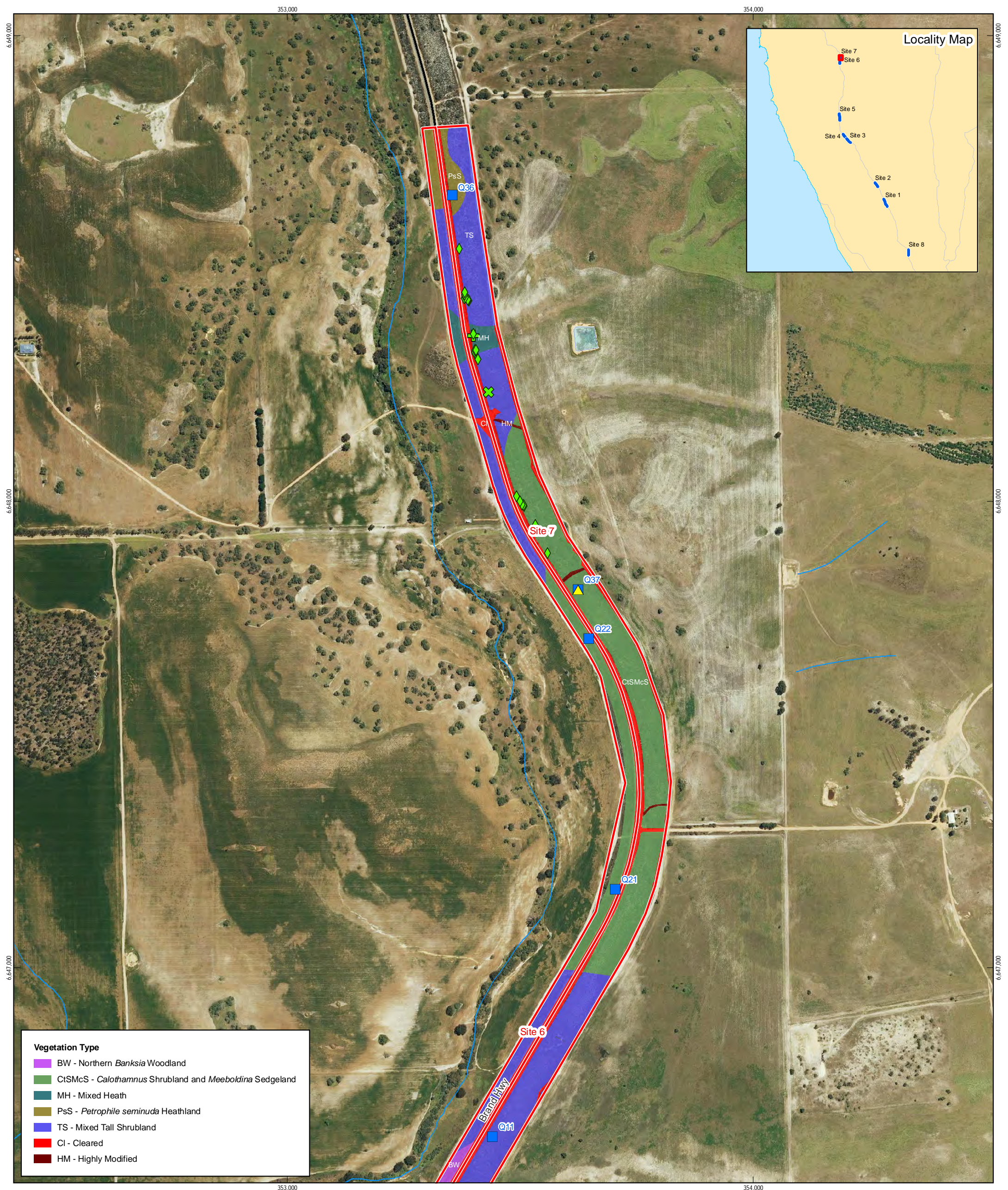
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River	(T) Threatened Rare Flora - Extant Taxa	Priority 4 - Rare Taxa	Crown Freehold - Dept Interest
Wetland	Priority 1 - Poorly Known Taxa	Priority 5 - Conservation Dependent Taxa	National Park
TEC / PEC	Priority 2 - Poorly Known Taxa		Nature Reserve
			State Forest



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Ecological Context

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Figure 2



Vegetation Type

- BW - Northern *Banksia* Woodland
- CtSMcS - *Calothamnus* Shrubland and *Meeboldina* Sedgeland
- MH - Mixed Heath
- PsS - *Petrophile seminuda* Heathland
- TS - Mixed Tall Shrubland
- CI - Cleared
- HM - Highly Modified

LEGEND

 Survey Area	 State Road	Priority Flora (GHD 2014 & 2015 Survey)	△ P3 - <i>Guichenotia alba</i>	▽ P4 - <i>Conostephium magnum</i>	✕ P4 - <i>Grevillea rudis</i>
 Quadrat	 Local Road	▲ P1 - <i>Grevillea synaphea</i> subsp. <i>minuylo</i>	▽ P3 - <i>Phlebocarya pilosissima</i> subsp. <i>pilosissima</i>	◇ P4 - <i>Desmocladius elongatus</i>	◇ P4 - <i>Grevillea saccata</i>
 River		▼ P1 - <i>Lyginia excelsor</i>	◇ P3 - <i>Stylidium hymenocraspedum</i>	+ P4 - <i>Diuris recurva</i>	★ P4 - <i>Hibbertia ?helianthemoides</i>
 Wetland		▲ P2 - <i>Chordifex ?reseinans</i>	▲ P4 - <i>Banksia dallanneyi</i> subsp. <i>pollostia</i>		

Paper Size A3

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Metres

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Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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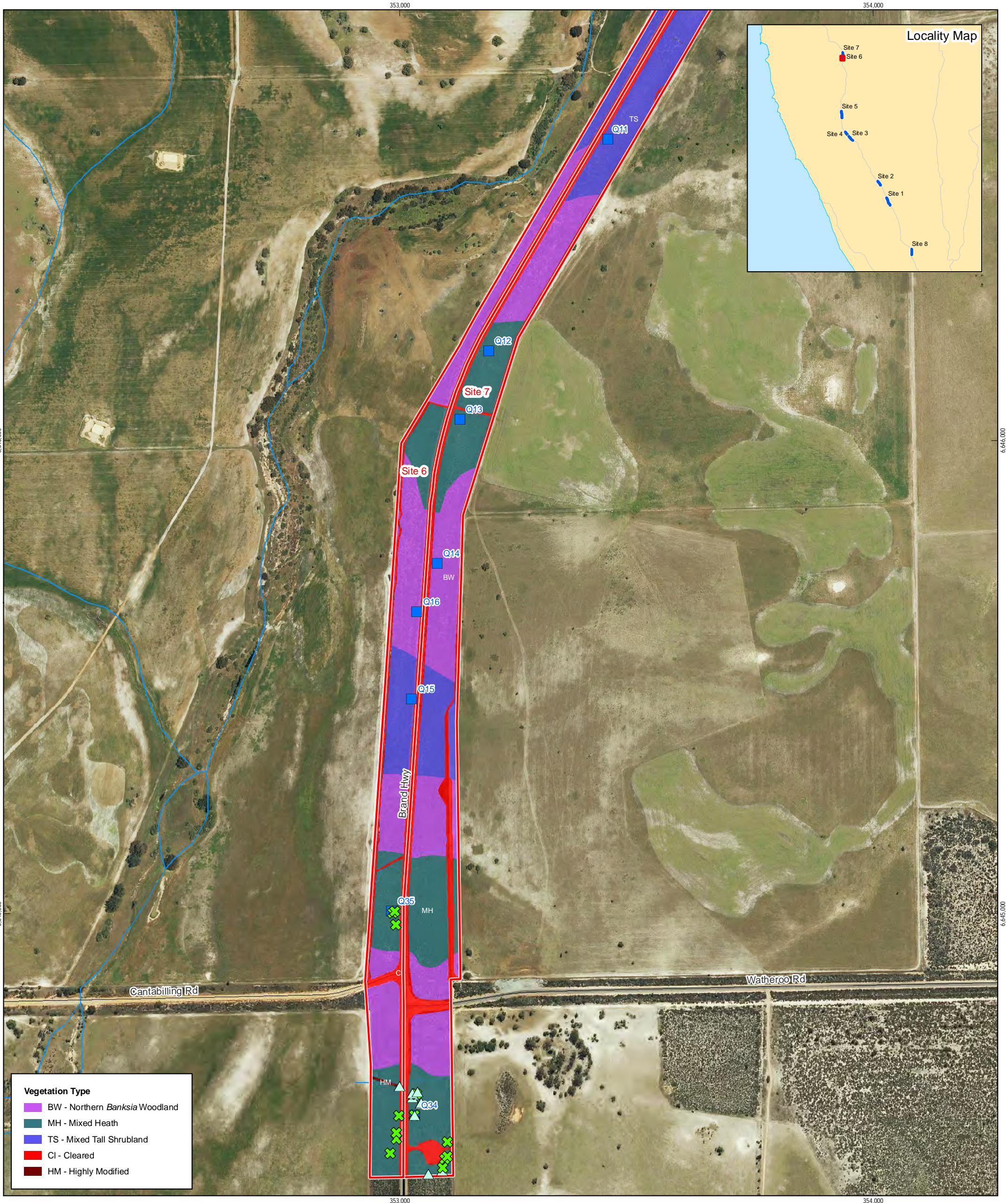
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Vegetation Types, Quadrat Locations and Conservation Significant Flora Species Sheet 01 of 10
Figure 3

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Data source: GHD: Survey Area - 20160215, Vegetation Type - 20160128, Quadrats - 20160218, Significant Flora Species - 20160219; Landgate: Rivers, Wetlands - 20150323; Landgate - Imagery (Virtual Mosaic). Created by:mmkkonen



LEGEND	<ul style="list-style-type: none"> Survey Area State Road Local Road Quadrat River Wetland 	Priority Flora (GHD 2014 & 2015 Survey) <ul style="list-style-type: none"> ▲ P1 - <i>Grevillea synaphea</i> subsp. <i>minuylo</i> ▼ P1 - <i>Lyginia excelsor</i> ▲ P2 - <i>Chordifex ?reseinans</i> 	<ul style="list-style-type: none"> ▲ P3 - <i>Guichenotia alba</i> ▼ P3 - <i>Phlebocarya pilosissima</i> subsp. <i>pilosissima</i> ◊ P3 - <i>Stylidium hymenocraspedum</i> ▲ P4 - <i>Banksia dallanneyi</i> subsp. <i>pollostia</i> 	<ul style="list-style-type: none"> ▼ P4 - <i>Conostephium magnum</i> ◊ P4 - <i>Desmocladus elongatus</i> + P4 - <i>Diuris recurva</i> 	<ul style="list-style-type: none"> ✕ P4 - <i>Grevillea rudis</i> ◊ P4 - <i>Grevillea saccata</i> ★ P4 - <i>Hibbertia ?helianthemoides</i>
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Paper Size A3

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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Main Roads Western Australia
Brand Highway Passing Lanes

Job Number | 61-32011-00
Revision | 1
Date | 23 May 2016

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353,000

354,000

6,615,000

6,614,000

6,613,000

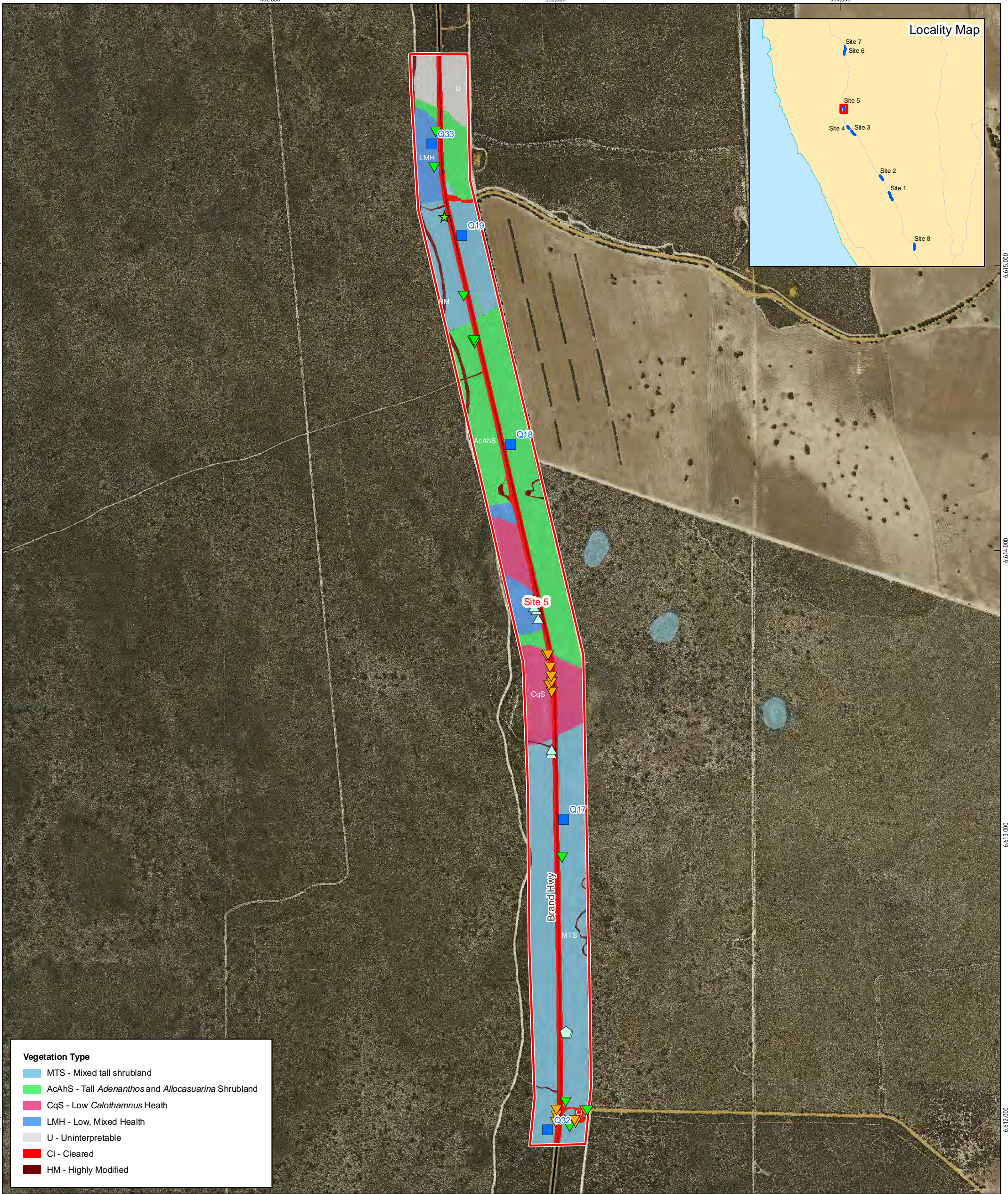
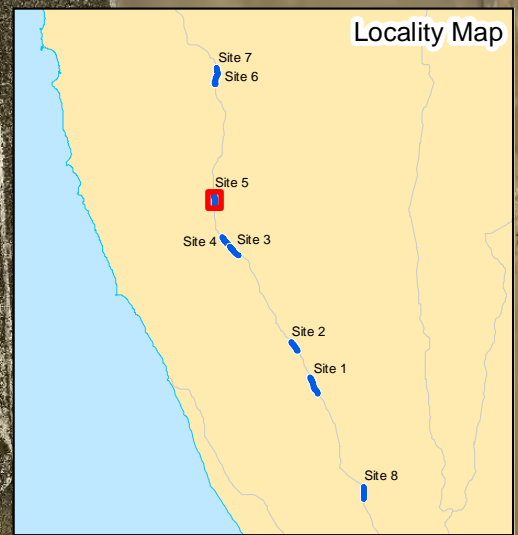
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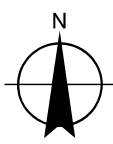
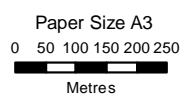
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Vegetation Type	
■	MTS - Mixed tall shrubland
■	AcAhS - Tall <i>Adenanthos</i> and <i>Allocasuarina</i> Shrubland
■	CqS - Low <i>Calothamnus</i> Heath
■	LMH - Low, Mixed Health
■	U - Uninterpretable
■	CI - Cleared
■	HM - Highly Modified

LEGEND

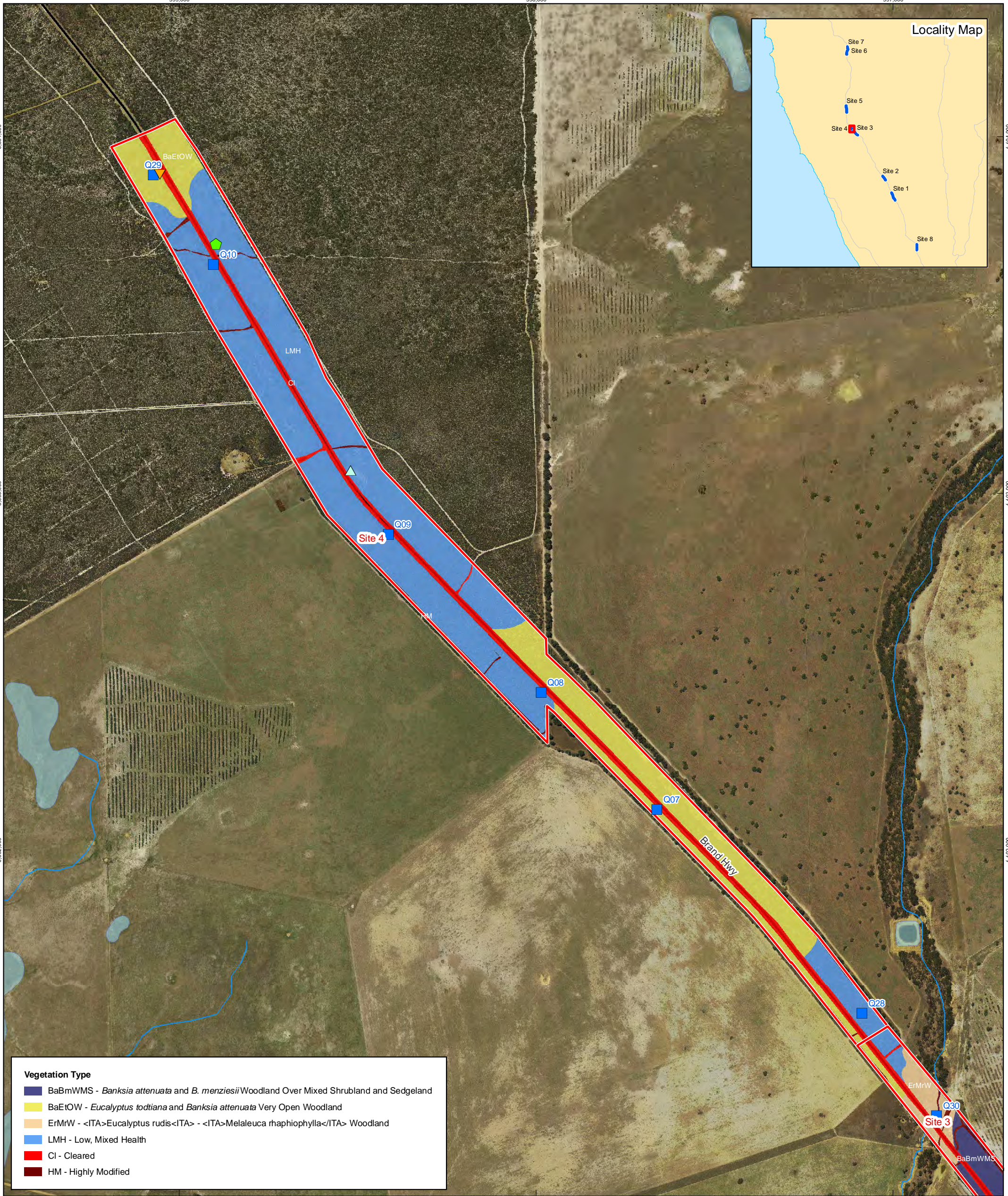
▭ Survey Area	— State Road	Priority Flora (GHD 2014 & 2015 Survey)	▲ P3 - <i>Guichenotia alba</i>	▼ P4 - <i>Conostephium magnum</i>	✕ P4 - <i>Grevillea rudis</i>
■ Quadrat	— Local Road	▲ P1 - <i>Grevillea synaphea</i> subsp. <i>minuylo</i>	▼ P3 - <i>Phlebocarya pilosissima</i> subsp. <i>pilosissima</i>	◆ P4 - <i>Desmocladius elongatus</i>	◆ P4 - <i>Grevillea saccata</i>
— River		▼ P1 - <i>Lyginia excelsor</i>	◇ P3 - <i>Stylidium hymenocraspedum</i>	+ P4 - <i>Diuris recurva</i>	★ P4 - <i>Hibbertia ?helianthemoides</i>
■ Wetland		▲ P2 - <i>Chordifex ?reseinans</i>	▲ P4 - <i>Banksia dallanneyi</i> subsp. <i>pollostia</i>		



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Vegetation Types, Quadrat Locations and Conservation Significant Flora Species **Sheet 03 of 10**
Figure 3



Vegetation Type

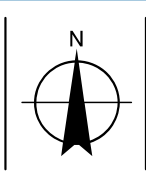
- BaBmWMS - *Banksia attenuata* and *B. menziesii* Woodland Over Mixed Shrubland and Sedgeland
- BaEtOW - *Eucalyptus totidiana* and *Banksia attenuata* Very Open Woodland
- ErMrW - <ITA>*Eucalyptus rudis*</ITA> - <ITA>*Melaleuca raphiophylla*</ITA> Woodland
- LMH - Low, Mixed Health
- CI - Cleared
- HM - Highly Modified

LEGEND

 Survey Area	 State Road	Priority Flora (GHD 2014 & 2015 Survey)	▲ P3 - <i>Guichenotia alba</i>	▼ P4 - <i>Conostephium magnum</i>	✕ P4 - <i>Grevillea rudis</i>
 Quadrat	 Local Road	▲ P1 - <i>Grevillea synaphea</i> subsp. <i>minuylo</i>	▼ P3 - <i>Phlebocarya pilosissima</i> subsp. <i>pilosissima</i>	◆ P4 - <i>Desmocladius elongatus</i>	◆ P4 - <i>Grevillea saccata</i>
 River		▼ P1 - <i>Lyginia excelsor</i>	◇ P3 - <i>Stylidium hymenocraspedum</i>	+ P4 - <i>Diuris recurva</i>	★ P4 - <i>Hibbertia ?helianthemoides</i>
 Wetland		▲ P2 - <i>Chordifex ?reseinans</i>	▲ P4 - <i>Banksia dallanneyi</i> subsp. <i>pollostia</i>		

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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

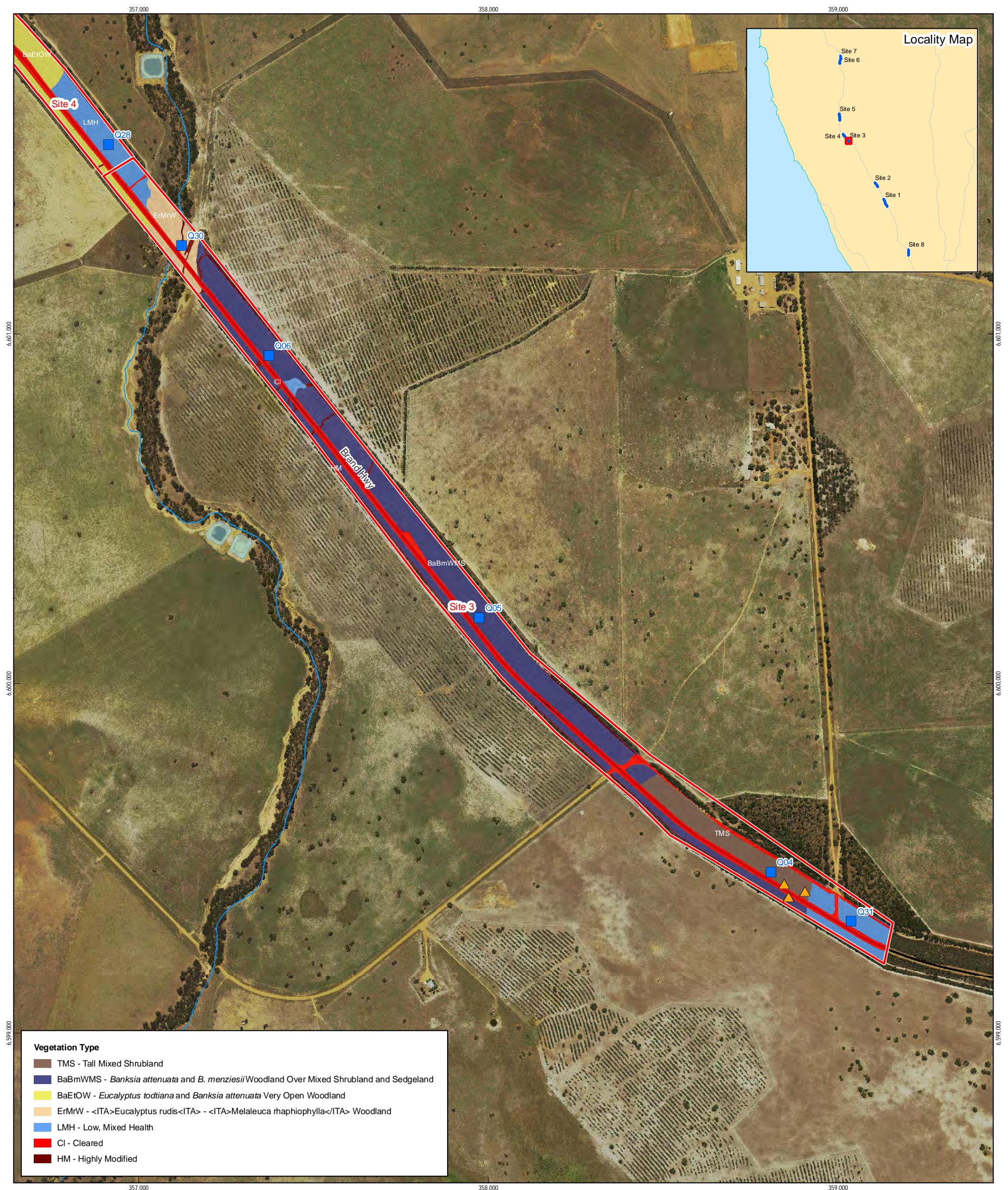


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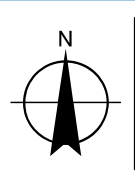
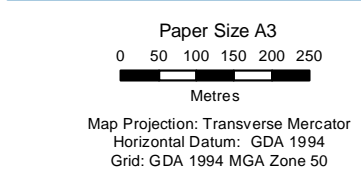
Vegetation Types, Quadrat Locations and Conservation Significant Flora Species Sheet 04 of 10
Figure 3

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Data source: GHD: Survey Area - 20160215, Vegetation Type - 20160128, Quadrats - 20160218, Significant Flora Species - 20160219; Landgate: Rivers, Wetlands - 20150323; Landgate - Imagery (Virtual Mosaic). Created by:mmkkonen



Vegetation Type	
	TMS - Tall Mixed Shrubland
	BaBmWMS - <i>Banksia attenuata</i> and <i>B. menziesii</i> Woodland Over Mixed Shrubland and Sedgeland
	BaEtOW - <i>Eucalyptus totidiana</i> and <i>Banksia attenuata</i> Very Open Woodland
	ErMrW - <i>Eucalyptus rudis</i> - <i>Melaleuca raphiophylla</i> Woodland
	LMH - Low, Mixed Health
	CI - Cleared
	HM - Highly Modified

	Survey Area		State Road	Priority Flora (GHD 2014 & 2015 Survey)		P3 - <i>Guichenotia alba</i>		P4 - <i>Conostephium magnum</i>		P4 - <i>Grevillea rudis</i>	
	Quadrat		Local Road		P1 - <i>Grevillea synaphea</i> subsp. <i>minuylo</i>		P3 - <i>Phlebocarya pilosissima</i> subsp. <i>pilosissima</i>		P4 - <i>Desmocladius elongatus</i>		P4 - <i>Grevillea saccata</i>
	River				P1 - <i>Lyginia excelsor</i>		P3 - <i>Stylidium hymenocraspedum</i>		P4 - <i>Diuris recurva</i>		P4 - <i>Hibbertia ?helianthemoides</i>
	Wetland				P2 - <i>Chordifex ?reseinans</i>		P4 - <i>Banksia dallanneyi</i> subsp. <i>pollostia</i>				



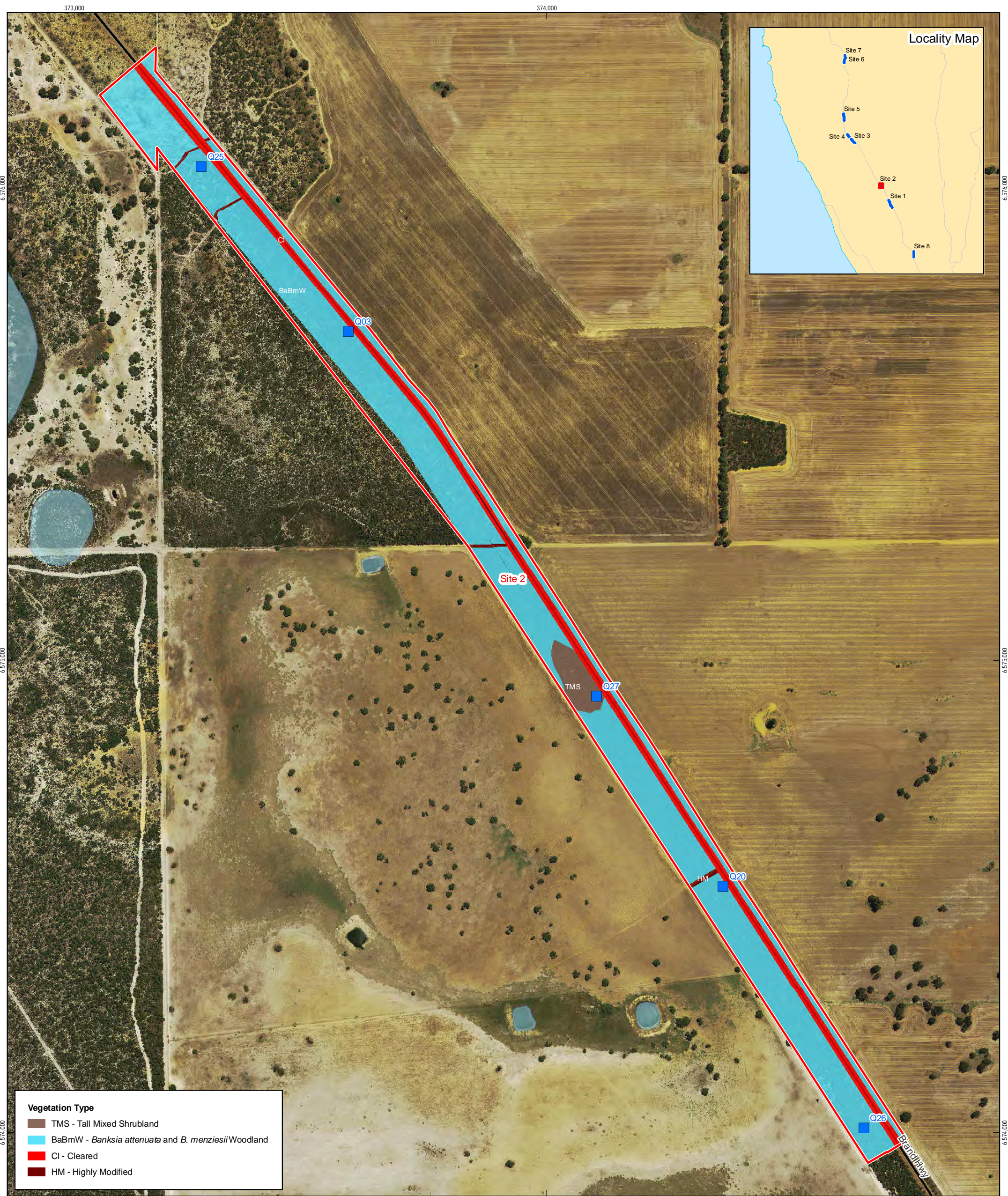
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Job Number | 61-32011-00
Revision | 1
Date | 23 May 2016

Vegetation Types, Quadrat Locations and Conservation Significant Flora Species

Sheet 05 of 10
Figure 3

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Data source: GHD: Survey Area - 20160215, Vegetation Type - 20160128, Quadrats - 20160218, Significant Flora Species - 20160219; Landgate: Rivers, Wetlands - 20150323; Landgate - Imagery (Virtual Mosaic). Created by:mmkkonen

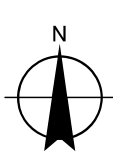
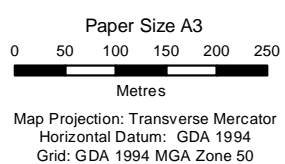


Vegetation Type

- TMS - Tall Mixed Shrubland
- BaBmW - *Banksia attenuata* and *B. menziesii* Woodland
- CI - Cleared
- HM - Highly Modified

LEGEND

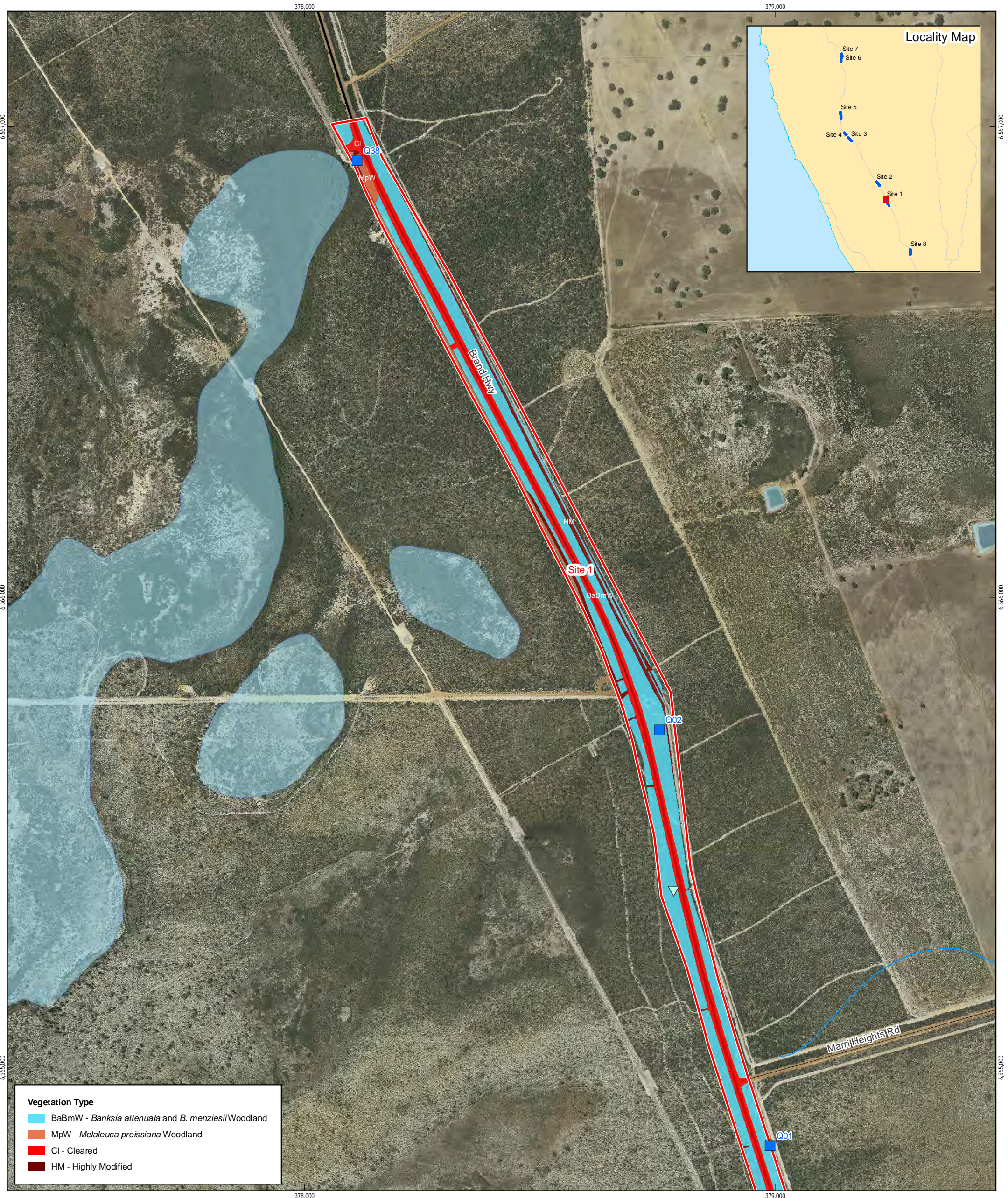
Survey Area	State Road	Priority Flora (GHD 2014 & 2015 Survey)	P3 - <i>Guichenotia alba</i>	P4 - <i>Conostephium magnum</i>	P4 - <i>Grevillea rudis</i>
Quadrat	Local Road	P1 - <i>Grevillea synaphea</i> subsp. <i>minuylo</i>	P3 - <i>Phlebocarya pilosissima</i> subsp. <i>pilosissima</i>	P4 - <i>Desmocladius elongatus</i>	P4 - <i>Grevillea saccata</i>
River		P1 - <i>Lyginia excelsor</i>	P3 - <i>Stylidium hymenocraspedum</i>	P4 - <i>Diuris recurva</i>	P4 - <i>Hibbertia ?helianthemoides</i>
Wetland		P2 - <i>Chordifex ?reseinans</i>	P4 - <i>Banksia dallanneyi</i> subsp. <i>pollostia</i>		



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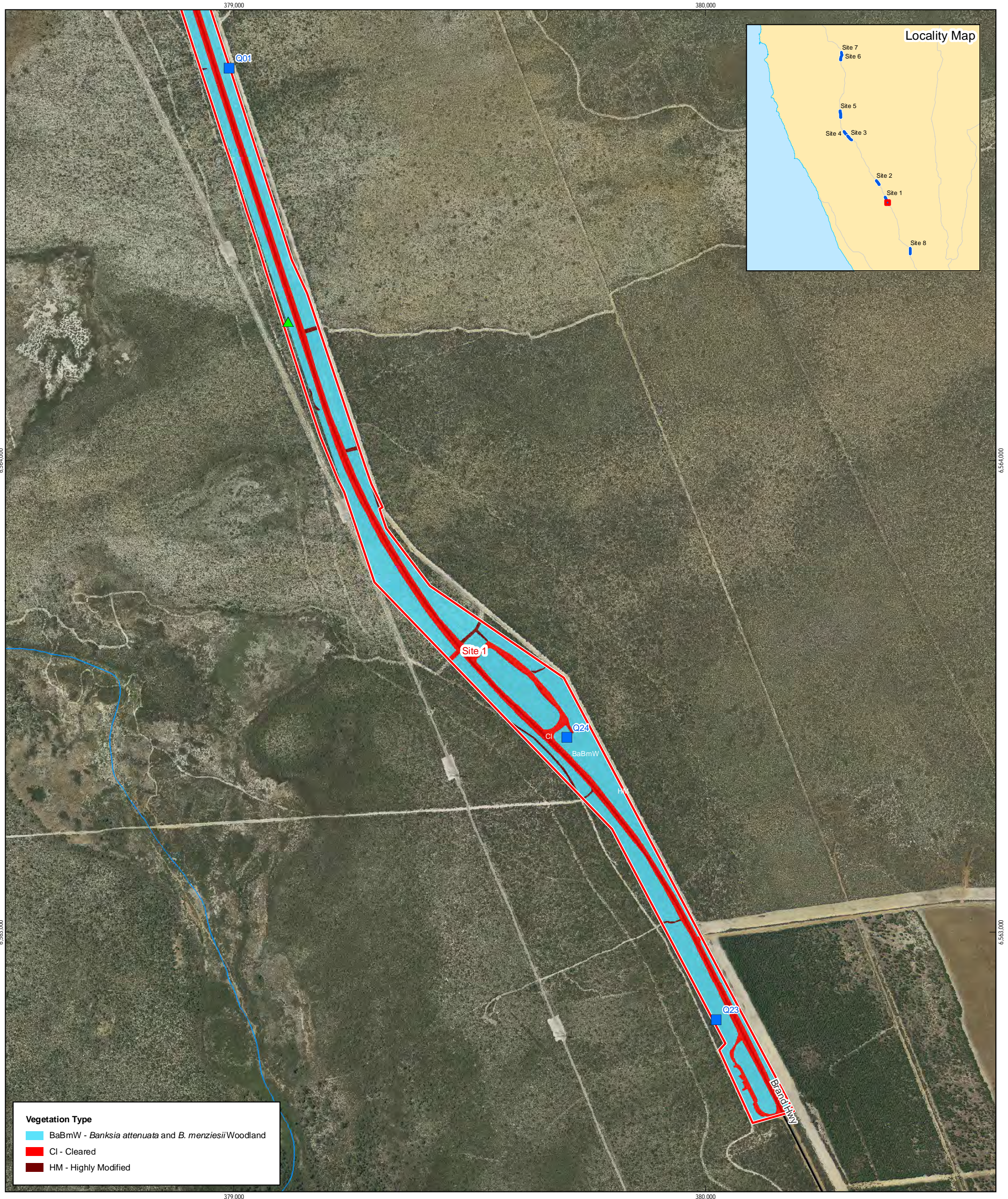
Job Number | 61-32011-00
Revision | 1
Date | 23 May 2016

Vegetation Types, Quadrat Locations and Conservation Significant Flora Species Sheet 06 of 10
Figure 3



LEGEND		Priority Flora (GHD 2014 & 2015 Survey)			
Survey Area	State Road	P1 - <i>Grevillea synaphea</i> subsp. <i>minuylo</i>	P3 - <i>Guichenotia alba</i>	P4 - <i>Conostephium magnum</i>	P4 - <i>Grevillea rudis</i>
Quadrat	Local Road	P1 - <i>Lyginia excelsor</i>	P3 - <i>Phlebocarya pilosissima</i> subsp. <i>pilosissima</i>	P4 - <i>Desmocladius elongatus</i>	P4 - <i>Grevillea saccata</i>
River		P2 - <i>Chordifex ?reseinans</i>	P3 - <i>Stylidium hymenocraspedum</i>	P4 - <i>Diuris recurva</i>	P4 - <i>Hibbertia ?helianthemoides</i>
Wetland			P4 - <i>Banksia dallanneyi</i> subsp. <i>pollostia</i>		

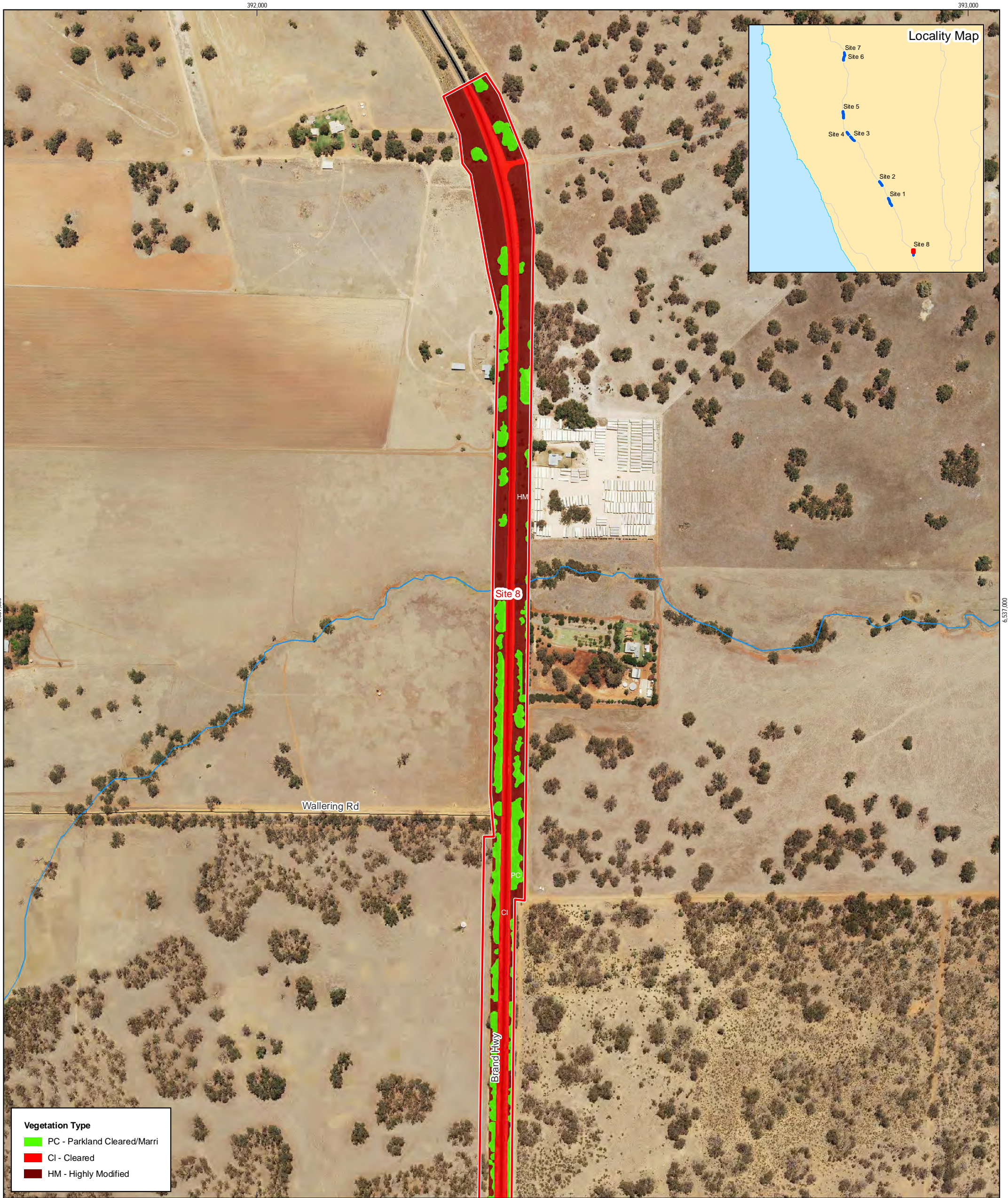
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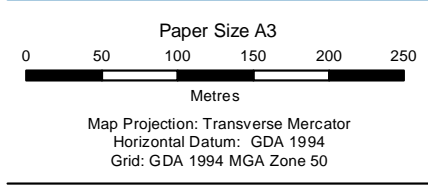
LEGEND	<ul style="list-style-type: none"> Survey Area State Road Local Road Quadrat River Wetland 	Priority Flora (GHD 2014 & 2015 Survey) <ul style="list-style-type: none"> P1 - <i>Grevillea synaphea</i> subsp. <i>minuylo</i> P1 - <i>Lyginia excelsor</i> P2 - <i>Chordifex ?reseinans</i> P3 - <i>Guichenotia alba</i> P3 - <i>Phlebocarya pilosissima</i> subsp. <i>pilosissima</i> P3 - <i>Stylidium hymenocraspedum</i> P4 - <i>Banksia dallanneyi</i> subsp. <i>pollostia</i> 	<ul style="list-style-type: none"> P4 - <i>Conostephium magnum</i> P4 - <i>Desmocladius elongatus</i> P4 - <i>Diuris recurva</i> P4 - <i>Grevillea rudis</i> P4 - <i>Grevillea saccata</i> P4 - <i>Hibbertia ?helianthemoides</i>
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				<p>Sheet 08 of 10 Figure 3</p>	

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LEGEND	Priority Flora (GHD 2014 & 2015 Survey)	Priority Flora (GHD 2014 & 2015 Survey)	Priority Flora (GHD 2014 & 2015 Survey)
Survey Area	State Road	P3 - <i>Guichenotia alba</i>	P4 - <i>Conostephium magnum</i>
Quadrat	Local Road	P3 - <i>Phlebocarya pilosissima</i> subsp. <i>pilosissima</i>	P4 - <i>Desmocladius elongatus</i>
River	P1 - <i>Grevillea synaphea</i> subsp. <i>minuylo</i>	P3 - <i>Stylidium hymenocraspedum</i>	P4 - <i>Diuris recurva</i>
Wetland	P1 - <i>Lyginia excelsor</i>	P4 - <i>Banksia dallanneyi</i> subsp. <i>pollostia</i>	P4 - <i>Grevillea rudis</i>
	P2 - <i>Chordifex ?reseinans</i>		P4 - <i>Grevillea saccata</i>
			P4 - <i>Hibbertia ?helianthemoides</i>

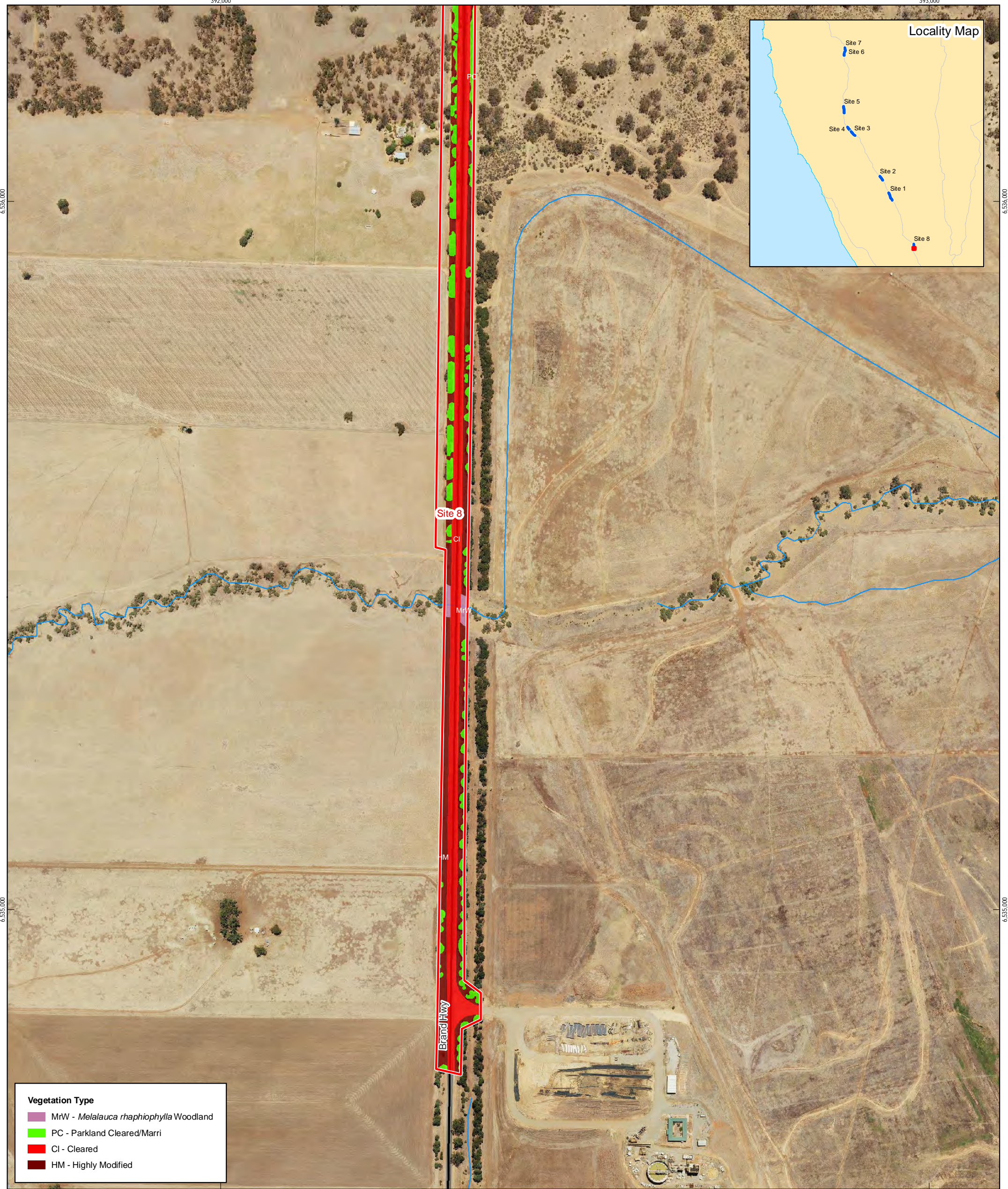


Main Roads Western Australia
Brand Highway Passing Lanes

Job Number 61-32011-00
Revision 1
Date 23 May 2016

Vegetation Types, Quadrat Locations and Conservation Significant Flora Species

Sheet 09 of 10
Figure 3



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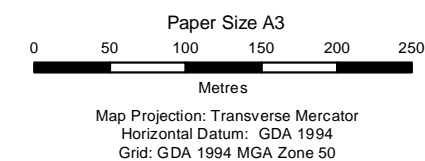
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LEGEND

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| Quadrat | Local Road | P1 - <i>Grevillea synaphea</i> subsp. <i>minuylo</i> | P3 - <i>Phlebocarya pilosissima</i> subsp. <i>pilosissima</i> | P4 - <i>Desmocladus elongatus</i> | P4 - <i>Grevillea saccata</i> |
| River | | P1 - <i>Lyginia excelsor</i> | P3 - <i>Stylidium hymenocraspedum</i> | P4 - <i>Diuris recurva</i> | P4 - <i>Hibbertia ?helianthemoides</i> |
| Wetland | | P2 - <i>Chordifex ?reseinans</i> | P4 - <i>Banksia dallanneyi</i> subsp. <i>pollostia</i> | | |

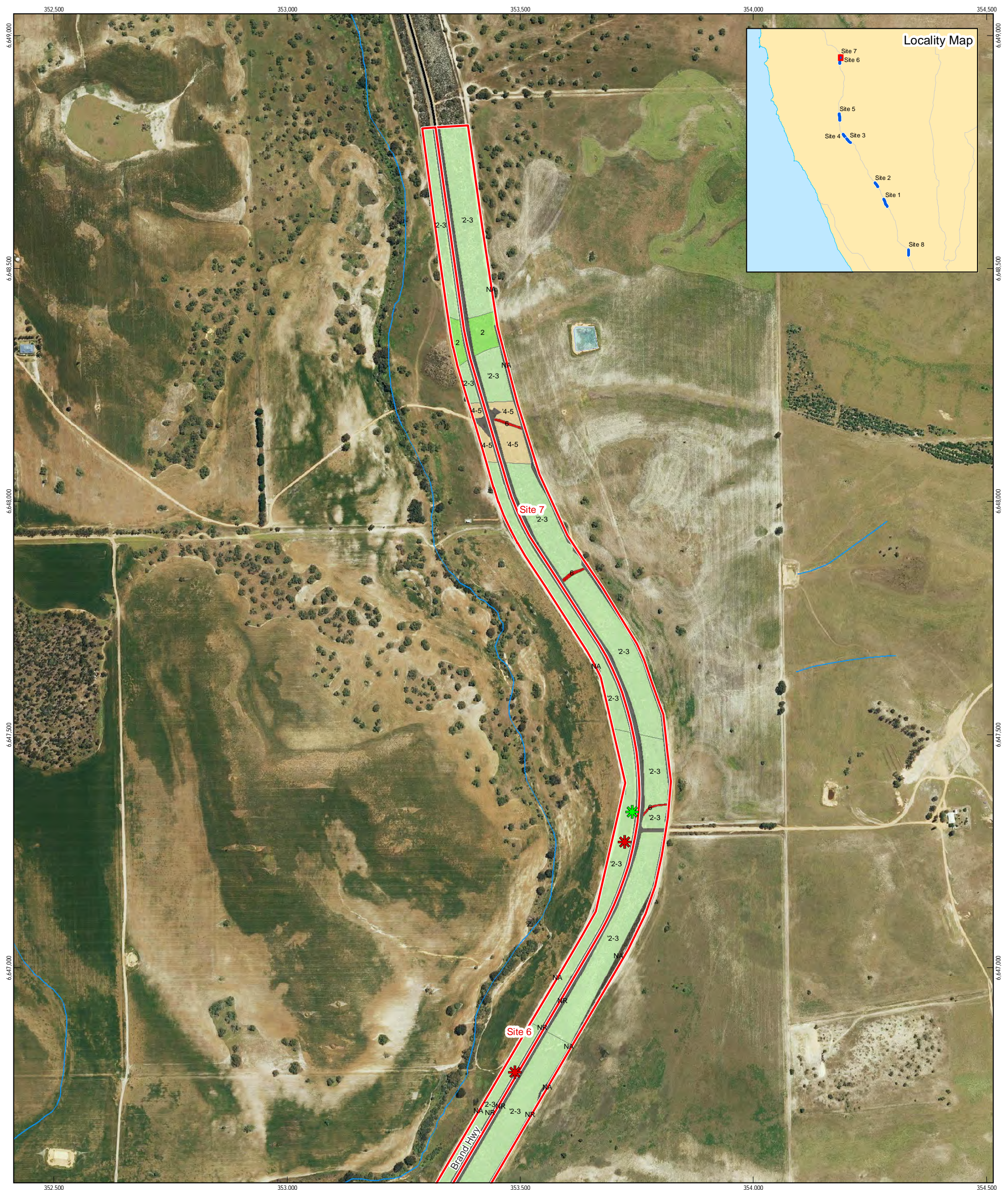


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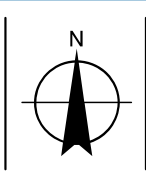
Vegetation Types, Quadrat Locations and Conservation Significant Flora Species
Sheet 10 of 10
Figure 3

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Data source: GHD: Survey Area - 20160215, Vegetation Type - 20160128, Quadrats - 20160218, Significant Flora Species - 20160219; Landgate: Rivers, Wetlands - 20150323; Landgate - Imagery (Virtual Mosaic). Created by:mmkkonen



Survey Area	Vegetation Condition	3 - Very Good	5-6 - Completely Degraded to Degraded	Significant Weed Species (GHD 2014 & 2015)	<i>Leptospermum laevigatum</i>
River	1 - Pristine or Nearly So	3-4 - Good to Very Good	6 - Completely Degraded	<i>Echium plantagineum</i>	<i>Moraea flaccida</i>
Wetland	1-2 - Excellent to Pristine	4 - Good	NR - Not Rated	<i>Emex australis</i>	
State Road	2 - Excellent	4-5 - Degraded to Good	U - Uninterpretable		
Local Road	2-3 - Very Good to Excellent	5 - Degraded			

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 Grid: GDA 1994 MGA Zone 50



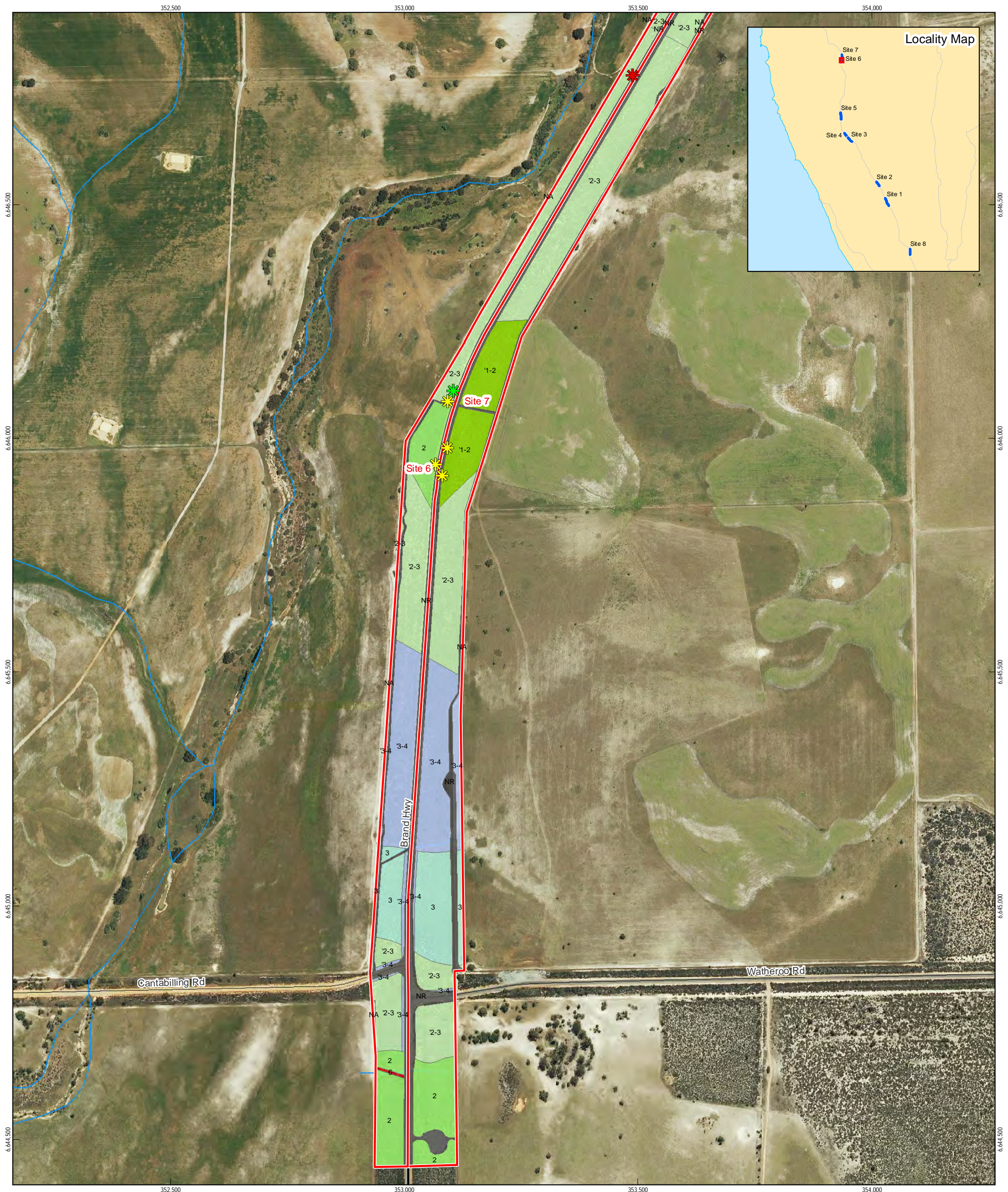
Main Roads Western Australia
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Vegetation Condition and Significant Weed Locations

Job Number 61-32011-00
 Revision 1
 Date 23 May 2016

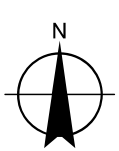
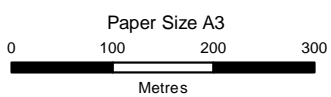
Sheet 01 of 10
Figure 4

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 Data source: GHD: Survey Area - 20160215, Vegetation Condition - 20160128, Significant Weed Species - 20160219; Landgate: Imagery (Virtual Mosaic), Rivers, Wetlands - 20150323. Created by:mmikkonen



LEGEND

- | | | | | | |
|-------------|------------------------------|-------------------------|---------------------------------------|---|--------------------------------|
| Survey Area | Vegetation Condition | 3 - Very Good | 5-6 - Completely Degraded to Degraded | Significant Weed Species (GHD 2014 & 2015) | <i>Leptospermum laevigatum</i> |
| River | 1 - Pristine or Nearly So | 3-4 - Good to Very Good | 6 - Completely Degraded | <i>Echium plantagineum</i> | <i>Moraea flaccida</i> |
| Wetland | 1-2 - Excellent to Pristine | 4 - Good | NR - Not Rated | <i>Emex australis</i> | |
| State Road | 2 - Excellent | 4-5 - Degraded to Good | U - Uninterpretable | | |
| Local Road | 2-3 - Very Good to Excellent | 5 - Degraded | | | |

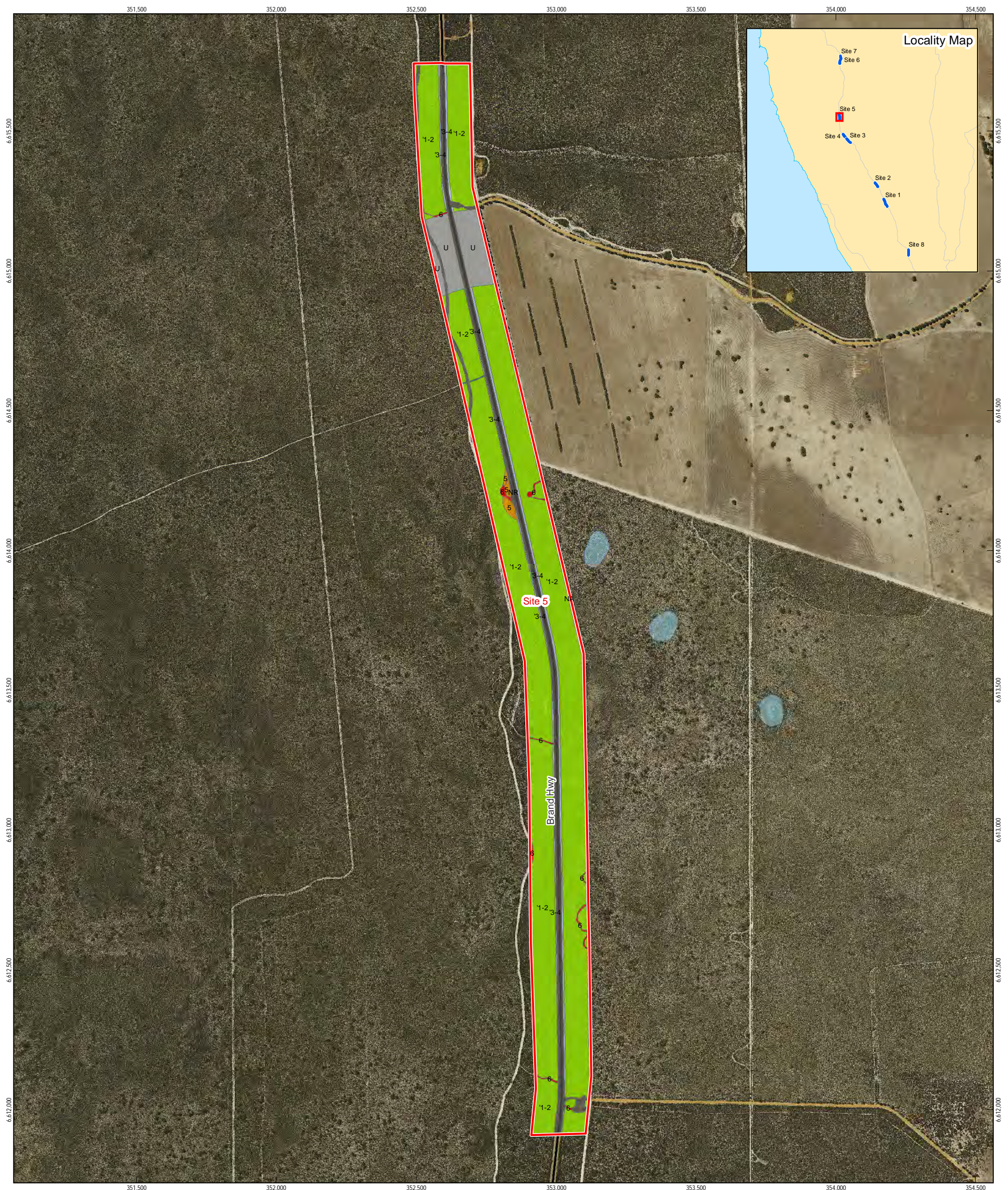


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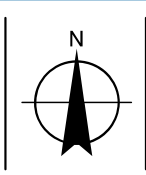
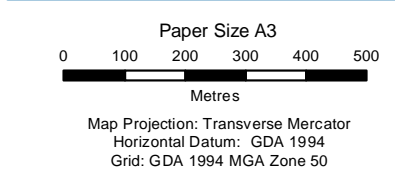
Vegetation Condition and Significant Weed Locations

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Figure 4



LEGEND

Survey Area	Vegetation Condition	3 - Very Good	5-6 - Completely Degraded to Degraded	Significant Weed Species (GHD 2014 & 2015)	<i>Leptospermum laevigatum</i>
River	1 - Pristine or Nearly So	3-4 - Good to Very Good	6 - Completely Degraded	<i>Echium plantagineum</i>	<i>Moraea flaccida</i>
Wetland	1-2 - Excellent to Pristine	4 - Good	NR - Not Rated	<i>Emex australis</i>	
State Road	2 - Excellent	4-5 - Degraded to Good	U - Uninterpretable		
Local Road	2-3 - Very Good to Excellent	5 - Degraded			



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Figure 4

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