Appendix D:

Hatfield Flora Report

Ogyris
Ecological Research

Flora Report on Cristal Mining Australia's Hatfield West Gravel Pit EIS Project.

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All photographs used in this report have been supplied courtesy of Ogyris Pty. Ltd.

Cover Image: **Rabbit-tails (*Ptilotus seminudus*), an uncommon perennial component of the groundflora of Belah-Rosewood Woodlands at the Hatfield West Gravel Pit Project Area.**

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CHAPTER 1 INTRODUCTION AND BACKGROUND

1.1 Context for the Atlas-Campaspe Mine Gravel Pit EIS

In 2013, Cristal Mining Australia Ltd., hereon referred to as Cristal Mining, submitted an EIS proposal to the Government of New South Wales concerning the establishment of two mineral sands mines named Atlas and Campaspe at a location approximately 75 km north-north-west of Balranald in the states southwest. Cristal Mining's Atlas-Campaspe EIS addressed a suite of environmental and socio-economic factors requested by the New South Wales Government. In 2014, with Commonwealth Government Dept. of Environment approvals given pertinent to *Environment Protection and Biodiversity Conservation Act* 1999, the New South Wales Government, after a period of exhibition, receipt of submissions, responses to submissions, and subsequent assessment, Cristal Mining were notified through an affirmative determination from the Dept. of Planning and Environment (DPE), that the Atlas-Campaspe Project could proceed.

The Atlas-Campaspe Project failed to provide for the need to upgrade and maintain the road alignment identified for transport of the mineral concentrate to the Balranald-Ivanhoe Road. The road route identified, hereon referred to as the Mineral Concentrate Transport Route or MCTR, incorporating part of the existing road network, as well as two new sections of alignment, apart from one small sealed section, will be constructed from calcrete gravel. All sections of the alignment, old and new, would need to be substantially wider than the existing road width in order to cater for the large haul trucks that would ultimately use the road. It is estimated that approximately 800,000 tonnes of calcrete road-base will need to be used to maintain the MCTR over the 25-30 year life of the Atlas-Campaspe Mines.

On the 20th November 2015, the New South Wales Office of Environment and Heritage (OEH), responding to a DPE request, provided EIS requirements to Cristal Mining for an investigation concerning "Atlas-Campaspe Mine Gravel Pits". This report addresses the DPE Secretary's Environmental Assessment Requirements or SEAR's as they pertain to the flora and fauna of the gravel pit sites identified.

1.2 Location of the Atlas-Campaspe Gravel Pit EIS Investigation

Three potential gravel pit sites have been identified for investigation as part of this study. The three sites are all situated in the Hatfield West Locality of southwest New South Wales (see Figure 1-01). They include:

1. Site A on Iona Station on the Wampo-Langleydale Road, approximately 3 km east of the Atlas-Campaspe ML boundary;
2. Site B on Langleydale Station on the Langleydale-Balranald Road, 1 km west of the intersection with the Langleydale-Magenta Road; and
3. Site C on Iona Station south of the Wampo-Langleydale Road, approximately 3.5 km east of the Atlas-Campaspe ML boundary.

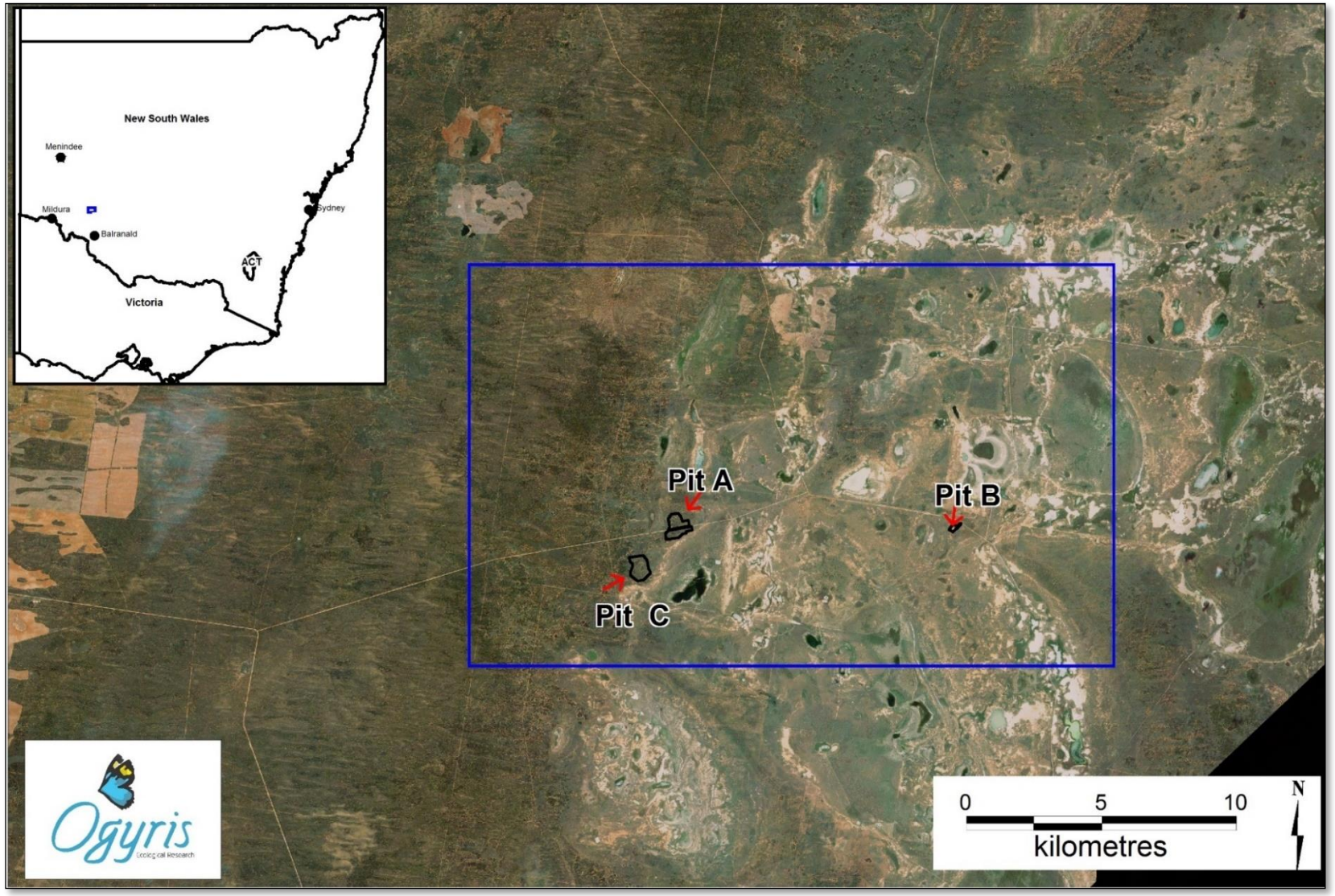

Figure 1-01 **Hatfield West Gravel Pit EIS southwest New South Wales. Locality Map, showing the location of the three proposed Cristal Mining Australia Ltd. gravel pits in southwest New South Wales.**

The regional geographic, environmental and landscape context to the Project Locality is summarized in Table 1-01.

Table 1-01: Regional Geographic Environmental and Landscape Context

Hatfield West Gravel Pit Project Area	Description
Bioregion	Murray-Darling Depression
Botanical Subregion	South Far Western Plains
Local Land Services Region	Western
Local Government Area	Balranald Shire Council (NSW)
Nearby Conservation Areas	Mungo National Park, Mungo State Conservation Area, Boree Plains Conservation Offset (conserved in perpetuity as offset for vegetation loss from the Atlas-Campaspe Mines.
Surrounding Land Use	Mostly agricultural (grazing) land consisting of Belah-Rosewood Woodlands, saltbush and bluebush plains, mallee, Sandhill Pine Woodlands with some grain cropping. The approved Atlas-Campaspe Mines will be situated approximately 3-10 km to the west. Nature conservation (see above) is a major land-use within the surrounding area.

1.3 Compliance with Regulatory Authority Requests

1.3.1 Biodiversity

The NSW OEH have outlined a series of biodiversity requirements as they pertain to statutory matters relating to the application of the *National Parks and Wildlife Act* 1974 and the *Threatened Species Conservation Act* 1995. OEH have advised Cristal Mining that the biodiversity requirements of the Atlas-Campaspe Gravel Pit study can be addressed either by a) the NSW BioBanking Assessment Methodology; or b) a Detailed Biodiversity Assessment. Cristal Mining have adopted for the latter assessment type. In accordance with this, OEH have requested the information contained within the left-hand column of Table 1-02 below, be addressed. Responses to these requests and where they exist within this report have been provided in the right-hand column of Table 1-02.

Table 1.02: Statement of Compliance with OEH Requests Pertaining to Biodiversity and Rehabilitation.

OEH Biodiversity and Rehabilitation Requests of Cristal Mining Pertaining to the Gravel Pit EIS Investigation.	Responses to the OEH Requests and Where they can be Found in this Report (where required).
Request 1 - Biodiversity Mapping and Description	
Request 1A - Geo-referenced mapping of spatial data and sites within the Study Area.	Response 1A - All mapping and site description geo-referenced using UTM coordinates in Map Datum GDA94, Zone 54.
Request 1B - Vegetation mapping, survey locations at an appropriate scale.	Response 1B - Mapping and survey conducted at an appropriate scale (see Section 4.2).
Request 1C - Vegetation plant communities aligned with NSW Plant Community Database through VIS Classification (including methodology used to classify).	Response 1C - NSW Plant Community Database/VIS Classification utilized, steps enunciated, informed by Benson et a. 2006 plant community descriptions (see Section 4.2).
Request 1D - key habitat features described.	Response 1D - vegetation structure and habitat database provided (see Section 4.2).
Request 1E - threatened species, populations and endangered ecological communities present in the Subject Site and Study Area provided as separate spatial (ESRI .shp format files).	Response 1E - All mapping of Subject Site and Study Area threatened species or communities provided as separate ESRI shape files in dedicated appendix.
Request 1F - all report project files (project site, impact footprint, vegetation mapping/classification, offset delineation provided as ESRI shape files. Project metadata provided to OEH.	Response 1F - all project files and metadata provided in a dedicated appendix of this report.
Request 2 - Description of Survey Methodology	
Request 2A - Description of survey methodologies used.	Response 2A - provided in methods part of Chapter 3 (Section 3.1).
Request 2B - Survey effort aligned with "Guidelines for Developments and Activities - Working Draft (DEC 2004).	Response 2B - provided in methods part of Chapter 3 (Section 3.1).
Request 3 - Vegetation Community Description and Data-basing	
Request 3A - Detailed description of vegetation communities (including classification method)	Response 3A - Vegetation mapping methodology outlined in Section 3.1
Request 3B - plot data entered to Vegetation Information System (VIS) via BioNet	Request 3B - plot data entered to BioNet (as per scientific license requirements)

Request 4 - Provide Details of Qualifications and Experience	
Request 4 - Provide Details of Qualifications and Experience	Response 4 - Provided in Section 1.3.
Request 5 - Identify National and State Listed Threatened Biota	
Request 5 - Identify National and State Listed Threatened Biota	Response 5 - Outlined in Chapters 4 and 5.
Request 6 - Description of Biodiversity and Wildlife Corridor Impacts	
Request 6 - Description of Biodiversity and Wildlife Corridor Impacts	Response 6 - The impacts to biodiversity and wildlife corridors, direct and indirect, are outlined for flora and fauna in Chapters 4 and 5 respectively.
Request 7 - Identify how the Project Avoids and Minimizes Impacts	
Request 7 - Identify how the Project Avoids and Minimizes Impacts	Response 7 - The basic mantra of avoidance, minimization and measurement of impact is addressed throughout the report.
Request 8 - Describe the Residual Impacts of the Proposal.	
Request 8A - Describe the Residual Impacts of the Proposal.	Response 8A - Physical impacts of designated gravel pits described in Chapter 4.
Request 8B - Outline Intent to Offset if Impact to Biodiversity Cannot be Avoided	Response 8B - Offset is deemed to be required, and has been done in accordance with OEH Principle's for Biodiversity Offsetting.
Request 9 - Undertake an Assessment of Significance	
Request 9A - An "Assessment of Significance", including direct and indirect impacts must be undertaken taking into account the *Environmental Planning and Assessment Act* 1979.	Response 9A - Undertaken in the Main Report of the EIS.
Request 9B - An "Assessment of Significance", including direct and indirect impacts must be undertaken taking into account the DECCW (2007) "Threatened Species Assessment Guideline - The Assessment of Significance".	Response 9B - Undertaken in Chapters 4 and 5.
Request 10 - Provide Offset Provisions	
Request 10 - Provide Offset Provisions	Response 10 - see Response 8B above. This will be done as per OEH principles and guidelines, but is not part of this report.

1.4 Authority to Conduct the Study

The Principal Investigator and primary author of this report is Dr. Ian Sluiter from Ogyris Ecological Research. Dr. Sluiter was assisted in the field and with office based activities including database searches, compilation of existing information, mapping and report writing by Ogyris P/L staff Heather Sluiter, Karin Sluiter and Geoffrey Allen. Ian Sluiter, Karin Sluiter and Geoffrey Allen work on ecological projects in New South Wales pursuant to OEH National Parks and Wildlife Scientific Licence Number SL101035.

1.5 Definition of Terminology

1.5.1 Geographic Terminology

Consistent descriptions and assessments of the land to be directly or indirectly affected by the development require boundaries to be defined. Definitions for a number of geographic terms including Region, Locality, Study Area and Subject Site – all of which have been adopted for use in this study, are outlined in turn below.

Region

There have been various attempts over the years to define the notion of what constitutes a 'region' in south-western New South Wales. Several authors have attempted to categorize the area into 'regions' based on criteria such as geology, geomorphology and vegetation – often with differing degrees of weighting. Published 'regions' of relevance to biological studies which have encompassed the Hatfield West study area include:

- **'Murray Lowlands Province'** - Jennings and Mabbutt (1977); modified by Wasson (1989) and termed **'Mallee Dunefields'**. *An area characterised by "fixed east-west longitudinal and parabolic dunes; lakes, pans with lunettes."*

- **'Murray Mallee Region'** - Noble and Mulham (1980). Based on the fact that the aeolian landform dominated area lies north and south of the Murray River between Swan Hill and Murray Bridge and is dominated by Mallee vegetation.

- **'Western New South Wales'** - Pressey (1990). A regional assessment of rare or threatened flora in Western New South Wales.

- **'South Far Western Plains'** - Harden (1990). *A botanical subdivision used in the* Flora of New South Wales *(Harden 1990).*

- **'Murray Basin Sands'** Sub-Region - Morgan and Terrey (1992). Giving priority to the fact that the area lies mostly to the west of Willandra Lakes - a relict river system of narrow channels, large lakes and fringing lunettes - and is dominated by sandplains and dunefields that appear to have been influenced by the Darling River.

- **'Murray Darling Depression'** Interim Biogeographic Regionalisation for Australia (IBRA) region - Thackway and Cresswell (1995); and revised by Environment Australia (2000). *IBRA bioregions represent a landscape based approach to classifying the land surface as the basis for understanding and explaining ecological patterns and processes which in turn are responsible for driving the observed patterns of biodiversity. Specialist ecological knowledge, combined with regional and continental scale data on climate, geomorphology, landform, lithology and characteristic flora and fauna were interpreted to describe these patterns. The Murray Darling Depression IBRA region is an extensive gently undulating sand and clay plain of Tertiary and Quaternary age frequently overlain by aeolian dunes;*

vegetation consists of semi-arid woodlands of Black Oak/Belah, Bullock Bush/Rosewood and Acacia spp., mallee shrublands and heathlands and savanna woodlands (Environment Australia 2000).

- **'Southern Mallee Region'** - DLWC (2000); Mazzer et al. (1998); Val et al. (2000). A region recognised by former New South Wales Government Departments (DLWC and NPWS), which has been utilized for the purposes of assessment of vegetation clearance applications and regional biological studies by DLWC and NPWS.

The comprehensive definition of biogeographic regions within the IBRA system (Thackway and Cresswell 1995; Environment Australia 2000) is considered to be one of the more ecologically meaningful ways of recognising natural regions in which to assess ecological processes across Australia. Use of the IBRA bioregions has been enshrined within the NSW *Environmental Planning and Assessment Act* 1979, as the geographic basis within which ecological values should be assessed.

Consequently, the IBRA Murray-Darling Depression Bioregion is considered the broad 'Region' within the context of which the relative importance of those ecological values recognised during the Hatfield West gravel site study should be examined. The Murray-Darling Depression Bioregion in NSW is extensive, covering some 84,396 km^2, with a further 47,103 km^2 and 65,981 km^2 occurring in adjacent parts of South Australia and Victoria respectively.

Locality

A Locality refers to the area within approximately a 20 km radius of the Study Area. In this study, the Locality as defined, would cover parts of four 1:100,000 Map Sheet areas. In essence, however, the project locality is primarily located on the Turlee (7530) and Hatfield (7630) 1:100,000 Map Sheet areas. The Locality of the project is shown in Figure 1-01.

Subject Site and Study Area

A **Subject Site** means "the area which is proposed for development/activity", delineated for purposes of this study as the area of direct disturbance caused by gravel extraction activities including pit site and ancillary facilities (primary crusher, gravel screening plants, materials stockpiles, water dams and gravel pit internal access roads). The **Study Area** is "the Subject Site" and any additional areas that are likely to be affected by the proposal, either directly or indirectly".

The areas of disturbance of the Subject Site are:
Site A = 53.24 Ha
Site B = 5.25 Ha
Site C = 54.16 Ha

The combined area of disturbance of the Subject Site is 113.41 Ha.

The Subject Site for each of the three gravel pits and their geographic position in relation to each other is shown in Figure 1-02.

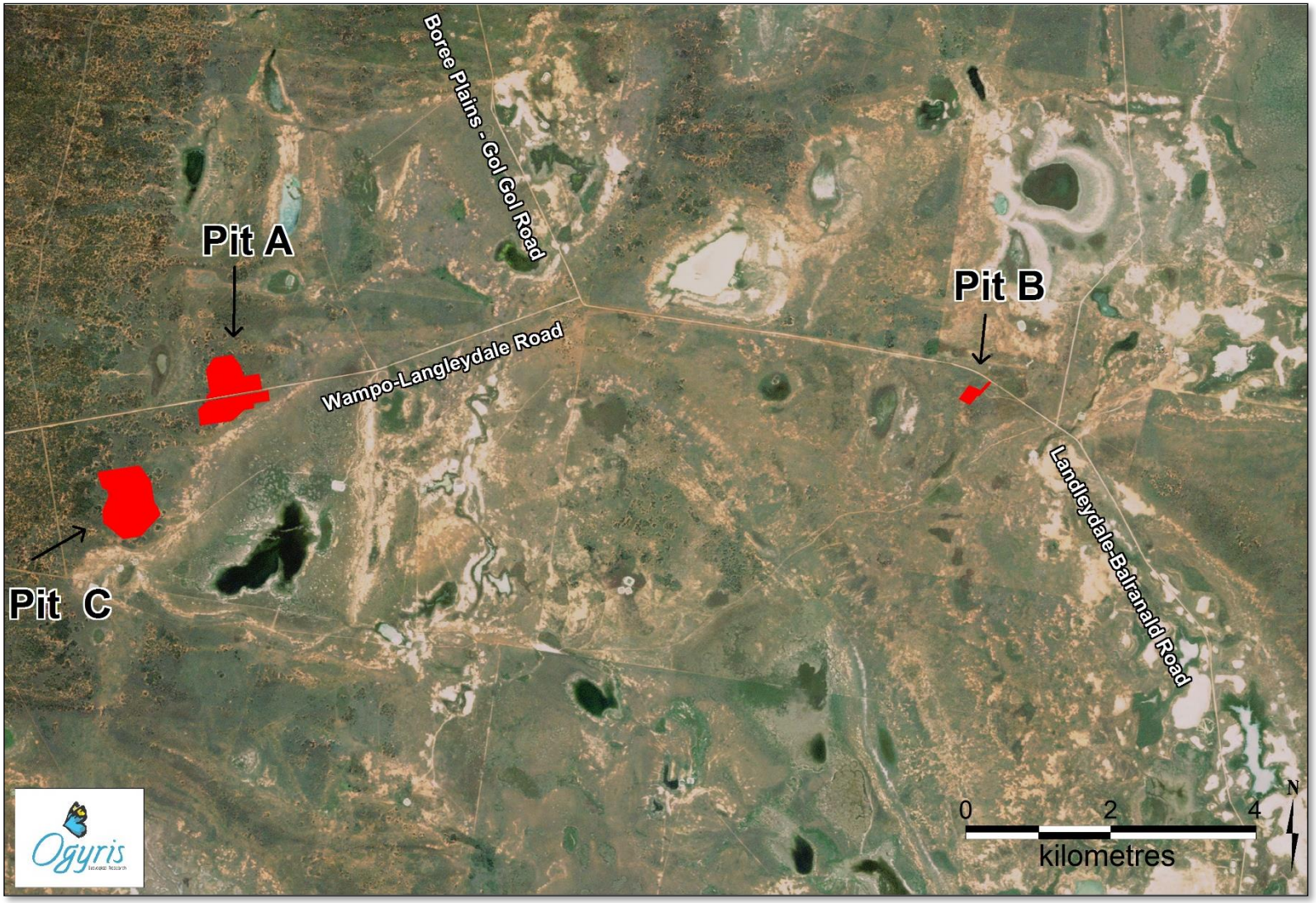

Figure 1-02: **Cristal Mining Australia Ltd. Subject Site for Pits A, B and C at Hatfield West.**

1.5.2 Abbreviations Used in this Report

A number of acronyms and terms have been used in this report. These are explained below, but in the main, these follow the same definitions as outlined in the Atlas-Campaspe EIS Report.

Atlas-Campaspe Gravel Pit Study Area – this includes the three areas provided to the survey team as potential gravel source sites within close proximity to the designated Atlas-Campaspe Mineral Concentrate Transport Route (MCTR).

Atlas-Campaspe Gravel Pit Footprint – the extent of proposed surface development associated with gravel pit construction, including any access roads.

Balranald SC – Balranald Shire Council

Centroid of Study Area – the geographic location marking the centroid point between proposed Gravel Pit Site A, B and C.

Clearing – the destruction of remnant vegetation resulting in complete loss of all layers of vegetation.

Cristal – refers to the mining company Cristal Mining Australia Ltd.

Pit A – the physical location of proposed Gravel Pit A on the Wampo-Langleydale Road, at Iona Station, approximately 3 km east of the Atlas-Campaspe ML boundary.

Pit B– the physical location of proposed Gravel Pit B on the Langleydale-Balranald Road, 1 km west of the intersection with Magenta Road.

Pit C– the physical location of proposed Gravel Pit C south of the Wampo-Langleydale Road, approximately 3.5 km east of the Atlas-Campaspe ML boundary.

Subject Site – the combined area which is proposed for development/activity at Pits A, B and C.

1.6 Purpose of this Report

Ogyris Ecological Research has been commissioned by Cristal to undertake a biodiversity flora assessment for the Atlas-Campaspe Gravel Pit Project. The assessment has been carried out accordance with the SEARs outlined in Table 1-02 (Section 1.3) and controlling provisions for the EPBC Act.

The primary objective of this report is to describe and assess the flora baseline values within the project area and surrounds and determine whether the Hatfield West Gravel Pit Project is likely to have a significant impact on threatened flora listed on the NSW TSC Act and Commonwealth EPBC Act. The report also defines mitigation and offset measures that will reduce and manage ecological impacts from the Hatfield West Gravel Pit Project. The approach adopted in this assessment includes the following:

1. Undertake a background review of relevant literature, mapping and databases.
2. Conduct a flora field survey using recognised methods to assess the ecological values of the site.
3. Describe the ecological values of the site in regard to flora and vegetation communities.
4. Describe the potential flora impacts of the Hatfield West Gravel Pit Project
5. Assess impacts of the Atlas-Campaspe Gravel Pit Project on threatened flora as listed on the TSC Act and EPBC Act.
6. Outline mitigation measures to reduce ecological impacts.

1.7 Existing Recent Mineral Sands EIS Flora and Fauna Baseline Studies

The Atlas-Campaspe EIS (Resource Strategies 2013) included a major baseline assessment of the flora and fauna values (AMBS 2013) of land approximately 4 km west of Pits A and C. This report provides the primary background biodiversity information from the Atlas-Campaspe Project seen as relevant to this study. Some information has also been taken from the draft EIS from the Iluka Resources Ltd. Balranald Mineral Sands Project (NEH 2016). The proposed Nepean Mine component of the Balranald Mineral Sands Project is situated approximately 9 km southwest of Pits A and C and some information from that EIS is relevant to this study. The location of the proposed Hatfield West gravel pits in relation to the nearby Atlas-Campaspe ML's and the proposed Nepean Mine is shown in Figure 1-03.

1.8 Gravel Extraction in the Murray-Mallee

Gravel used for road construction in the Murray-Mallee Region of southeastern Australia is typically the B-horizon carbonate layer existing below the reddish-brown surface topsoil layer known as the Woorinen Formation (Lawrence 1966). The carbonate type used varies by location, often depending on what resource is actually available. Topsoil has been traditionally pushed to the extremities of pits, the gravel extracted with front-end loaders and the pit left to rehabilitate through natural means. This has led to substantial areas being left with virtually no active rehabilitation undertaken.

In December 2015, the New South Wales Government (DPI 2015) recognized this problem and produced a Fact Sheet titled "*Crown Land Extractive Industry Licence in the Western Division*" which outlines a new and detailed process for obtaining permission to extract gravel from Crown Land in the west of the state. The extractive Industry Licence is issued pursuant to provisions of the *Western Lands Act* 1901 and the *Crown Lands Act* 1989, but in all circumstances, there is a requirement to produce either a Statement of Environmental Effects or in some cases, an Environmental Impact Statement. In the case of the Hatfield-West Gravel Pits, DPI have requested that an EIS be produced and submitted to the Balranald SC, which must be accompanied by an Environmental Management and Rehabilitation Plan.

Cristal Mining have identified a number of areas adjacent or nearby to the Atlas-Campaspe MCTR areas where sheet calcrete or the Bakara Pedoderm exists close to the surface. It is these sites (Pits A, B and C) as defined in Section 1.2 where the Extractive Industry Licence will be sought. Unlike many past gravel pit extraction sites, Cristal plan to fully rehabilitate the gravel pits after extraction of the gravel required. The rehabilitation sequence is explained conceptually below.

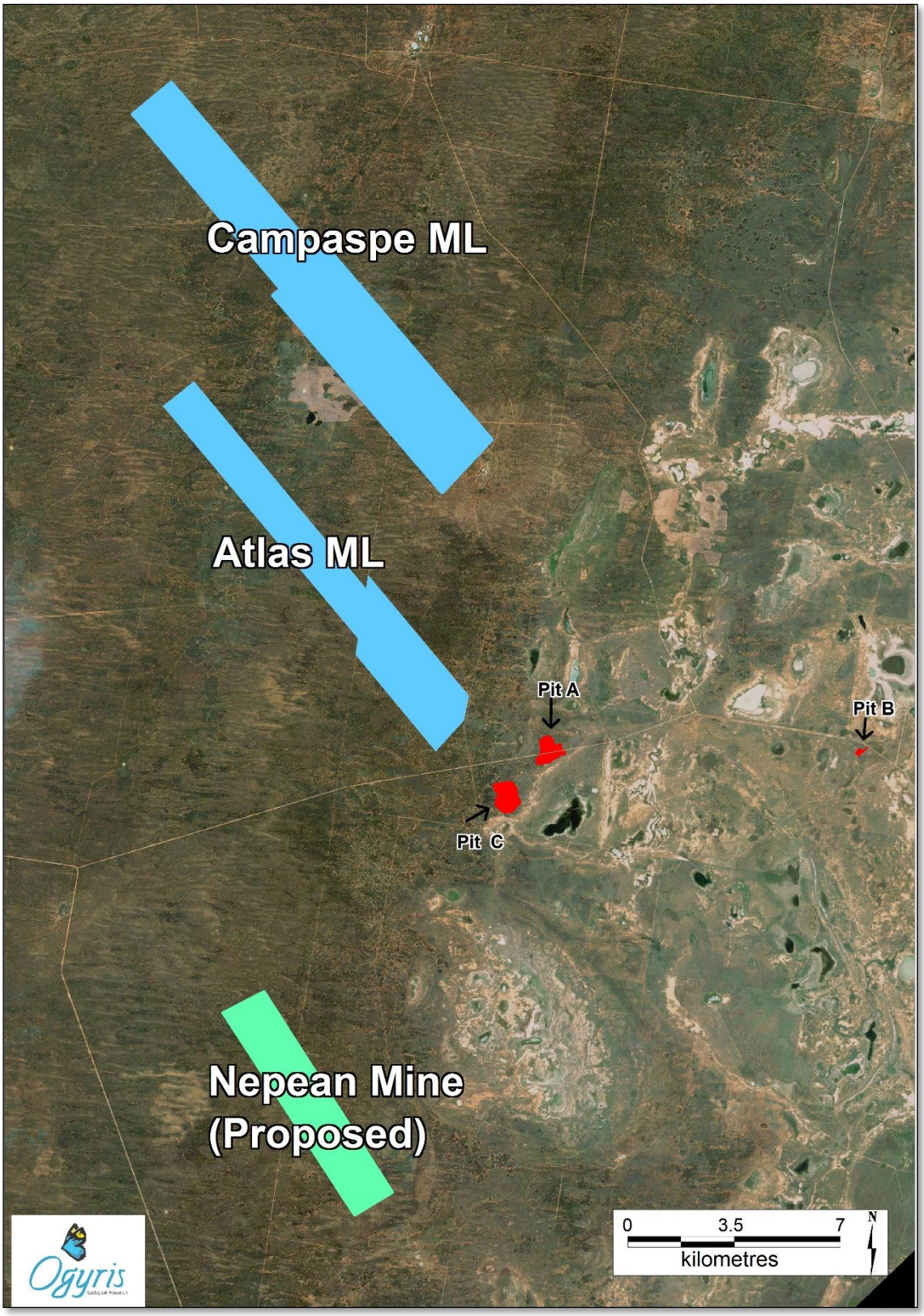

Figure 1-03: **Location of Cristal Mining Australia's Atlas and Campaspe ML's as well as the location of Iluka Resources proposed Nepean Mine.**

1.9 Rehabilitation

Rehabilitation of any site approved for gravel extraction will occur with the same processes as currently occur at existing mine sites operated by Cristal Mining within the Pooncarie West Mining Precinct where the Ginkgo and Snapper Mines exist.

Topsoil Stripping and Stockpiling Topoil stripping operations at the Snapper Mine over the past eight years have followed a three-step process involving 4WD tractors towing laser scoop buckets (see Plate 1-01). The first step involves removal and capture of the surface topsoil which contains the soil cryptogamic crust and soil seed bank, to a depth of approximately 10cm. This layer is removed first and then placed over existing topsoil stockpiles to aid in stabilization of these with indigenous vegetation. The second step involves removal of further topsoil to the top of the underlying carbonate layer or Bk horizon (see Plate 1-02). Topsoil is stored in typically elongated stockpiles no higher than 5m in height with batters prepared at low angles and complemented by contour ripping to prevent erosion. Topsoil is also only allowed to be stored on natural topsoil areas. The laser scoop buckets have the capacity for control of topsoil capture to 2cm accuracy through the aid of GPS units fitted to each towed laser scoop (see Plate 1-01).

Subsoil Stripping and Stockpiling The third stage of soil stripping operations involves the removal of the wanted gravel resource. In the cases where the Bakara Pedoderm is present, front-end loaders would need to be used to extract the sheet calcrete. Where the calcrete layer exits as carbonate layer material in clay, the same laser scoop buckets may be used to extract the calcareous subsoil. Stockpiles of Bakara Pedoderm and other carbonate subsoil gravel would only be stored on land that has subsoil exposed.

Plate 1-01: **A 4wd tractor towing a laser scoop bucket with differential GPS mounted on-board undertaking topsoil stripping at the Ginkgo Mine. These machines have accurate control in soil stripping operations, but care has to be taken to avoid stripping of underlying calcareous subsoil in topsoil stripping operations.**

Plate 1-02: **Topsoil stripping at the Snapper Mine. At this location the 'white' of the B horizon carbonate layer can be seen emerging in the middle of the laser-scoop cut at the mapped depth and planned cutting depth of 30cm.**

Return of Subsoil and Topsoil Subsoil and topsoil are 'returned' in reverse order of stripping on to shaped former mined areas with the land stabilized through ripping to a depth of approximately 20-30 cm.

CHAPTER 2 THE STUDY AREA

2.1 Geological Setting

Geological Summary The Hatfield West Study Area and study area lies within the Murray Lowlands Province (Jennings and Mabbutt 1977) an area dominated by low surface relief overlying thick Murray Basin sedimentary accumulations of Early Tertiary to Recent age (60 Ma to present). This sedimentary sequence overlies Palaeozoic and Proterozoic basement rocks (Wasson 1989). The major landform and geological features at the present day are dominated by the events of the last 5 million years, a time when Late Miocene-Pliocene high-stand sea levels retreated (Brown and Stephenson 1985) leaving sheets of quartzitic sands (e.g. Parilla Sands) over formerly marine and fluvio-lacustrine sediments of Palaeocene to Miocene age. On the Pliocene strand-plain the step-wise retreating of the sea left behind a series of beach ridges (Lawrence 1966) of generally northwest-southeast trending alignment. These ridges have weathered, mineralised and consolidated over time, and represent the target mineral sands in the Balranald North area.

With the retreat of the sea, drainage lines were activated and these manifested themselves as ancient Murray and Darling River floodplains and other palaeodrainage lines such as the now dry watercourse of the Willandra Creek and associated lakes. Episodes of tectonism and related uplift and faulting blocked these watercourses at around 3.2 Ma (An *et al*. 1986) resulting in the formation of a large inland waterbody through the Late Pliocene to Mid-Pleistocene period named Lake Bungunnia (Stephenson 1986). The lake resulted in the deposition of lacustrine sediments termed the Blanchetown Clay (Firman 1965). As lake waters gradually becoming more saline with age, a deposit termed the Bungunnia Limestone was deposited. A combination of tectonic activity and increasing aridity from 700,000 years BP resulted in the end of Lake Bungunnia and the onset of a phase of dune-building and palaeosol development (Wasson 1989).

Two principal dune types are recognised in the Murray-Darling Basin, although only one occurs within the Study Area. This dune type consists of short, low-linear dunes of east-west alignment and moderately high clay and calcareous contents. They represent the Woorinen Formation of Lawrence (1966) and occur mostly in the southern and eastern portion of the MLA. The second type consists of steep and high-crested parabolic or sub-parabolic dunes of curved to irregular shape. Sediments are primarily siliceous with very small clay and calcareous contents. These represent the Lowan Sands of Lawrence (1966) and are best represented as Mandelman Land System (Walker 1991) in areas to the east of Mungo National Park as well as to the north and west around Pooncarie, and within the Scotia Country of southwest NSW.

Geology of the Hatfield West Area The local geology within the Murray Mallee Region of southeastern Australia's Murray Darling Basin is complex and is dominated in any one area by the complex interplay of depositional and erosional processes combined with the influence of underlying structural characteristics such as geological troughs and ridges. The dominant structural feature of the Hatfield West Study Area is the Neckarboo Ridge of the Ivanhoe Block (Brown 1981). To the west of the Study Area, the present and ancient course(s) of the Willandra Creek have cut a swathe through the Ivanhoe Block. The complex suite of geomorphological features present within the WLWHP have been recognized as being of international significance through the World Heritage Listing process.

A highly variable climate, especially over the past 5 million years, has seen major switches from warmer and wetter to drier and more arid conditions. These variations in climate have determined the geomorphological influences present at any particular time, which in turn has influenced the process of soil formation. The surficial geology of the Hatfield West Study Area is dominated by two main types. The red-brown earths of the Woorinen Formation (Lawrence

1966) as well as the relict playa lake country and associated clayey basins and accompanying lunettes. Numerous landforms are present, the most important of which include:

- east-west aligned sandy dunefields (with dunes and interdune corridors or swales)
- sandplains of predominantly sandy loam
- clayey to loamy plains of undulating to almost flat relief
- run-on depressions
- relict playa lakes and
- small areas of gypseous plains and rises

A feature of Woorinen Formation soils is the presence of a 'B' horizon zone of accumulation within the soil profile which is rich in calcium carbonate. As with other Murray Mallee areas, the 'carbonate layer' as it is known, is typically the Loveday Soil, however, in the Hatfield West area, some subsoils also contain a cemented carbonate named the Bakara Pedoderm. The carbonate layer is the soil horizon that typically restricts root growth within Mallee Region soils and is the single largest influence governing the natural distribution of plant species and communities. Also present at a number of locations across the Study Area is the Callabonna Clay – a pedal structured reddish light clay which is typically present immediately below a shallow layer of Woorinen Formation soil.

Underlying the surficial regolith at localized places within and around the Study Area – particularly in the Willandra Lakes area and surrounds – previously active saline groundwater discharge complexes have seen gypseous sediments deposited into a complex mixture of dunes, swales, hummocks and plains which are collectively referred to as the Yamba Formation. Because of the genesis of this sedimentary deposit in a saline setting, the gypsum or 'copi' can often be characterized by a high salt content.

Underlying the Woorinen and Yamba Formations is the Shepparton Formation (Lawrence 1966) a facies equivalent of the Blanchetown Clay (Firman 1965) which occurs to the west of Mungo National Park. The Shepparton Formation formed in a shallow freshwater lake or lacustrine environment. The Shepparton Formation is often an impervious layer, which when present close to the surface can cause localized drainage problems. Underlying the Shepparton Formation and locally confined by it, is the regional groundwater aquifer known as the Loxton-Parilla Sand (Firman 1973). This aquifer represents the hydrogeological unit which will be utilized to float the mine dredge at the Atlas-Campaspe Mines during mineral sands extraction activities.

2.2 Hydrology

Aside from artificial water points, there is no free standing water within the Hatfield West Study Area. The nearest free standing water occurs within the Murray River 80 km to the southwest and the Murrumbidgee River 60 km to the southeast. The Willandra Creek, a drainage line linking a series of relict lake beds exists immediately to the west of the Study Area, although this system is effectively inactive with run-off generally flowing to localized areas such as flats and run-on depressions.

2.3 Rainfall Temperature and Moisture Balance

The mean annual rainfall (MAR) for the Hatfield West Study Area is predicted to be 285 mm as calculated from Bureau of Meteorology weather stations from near Hatfield township. Rainfall seasonality as measured by a coefficient of variation of rainfall is 14, which reflects a relatively even distribution of rainfall. A comparison of average rainfall in the wettest quarter (77mm) vs average rainfall in the driest quarter (64mm) confirms this.

The mean annual temperature (MAT) predicted for the above location is 17.1°C. The site falls within, but at the 'driest' end of the semi-arid climate classification of Bailey (1979). The Bailey's Moisture Index (BMI) for the Hatfield West Study Area and other sand mine prospects and mines within the Murray Darling Basin is shown in Table 2.01 below.

Table 2.01: Bailey's Moisture Index (BMI) values for various sand mine prospects and locations within the Murray-Darling Basin of southeastern Australia.

Dry sub-humid climate 6.37-4.7 BMI

Semi-arid climate 4.69-2.5 BMI

Arid climate <2.49 BMI

Mine Prospect/Location	Bailey's Moisture Index	Climate Type
Ginkgo – via Pooncarie, NSW	2.07	Arid
Prungle – via Euston, NSW	2.55	Semi-arid
Wemen – via Robinvale, VIC	2.81	Semi-arid
Kiamal – via Ouyen, VIC	2.86	Semi-arid
Douglas – via Balmoral, VIC	5.7	Dry sub-humid

BMI increases linearly with increases in precipitation but decreases exponentially with increases in temperature. The climate of the Hatfield West Study Area is semi-arid with a cool winter period and hot, dry summer period.

2.4 Wind

The nearest wind recording stations to the Hatfield West are the Bureau of Meteorology Weather Stations located at Mildura and Wentworth. In this analysis, we have used data from both to compile a profile of the prevailing winds across the Hatfield West Study Area.

An analysis of wind direction from the Wentworth station indicates prevailing winds are received in a compass arc from southeast to northwest with the greatest individual incidence being from the southwest (approximately 27.0%). Conversely wind directions were much less commonly received from the east, northeast and north (total of <20%). Although individual wind strength data were not available at this time from this station, a Wind Frequency Analysis (WFA) highlighted that, on average, wind speed is greater than 30 kph for a little over 2% of the time in mid-afternoon (1500 hours) at this site. The figure of 30-32 kph is considered by soil conservationists as the speed at which significant soil loss is likely to be experienced on unprotected, poorly vegetated or unconsolidated soils (J. Leys, personal communication). It should be noted that this average increases to a little over 4% in the spring months of September, October and November in tandem with an increasingly intensified evapotranspiration regime. The significance of average wind speeds over 30 kph is least in the months of December to April although occasional high wind from the north, north-west and southwest are recorded in February.

Data from the Bureau of Meteorology Station at Mildura indicates an average incidence of two gale-force winds (>75 kph) per year. Normally, average monthly wind speeds 10m above ground at 1500 hrs indicate that the percentage occurrence of speeds greater than 21 kph is between 25 and 43 percent. The months of March to June are close to or at the lower part of the range, and as observed at Wentworth, August to November at the upper part of the range. For wind speed greater than 30kph, the percentage occurrence decreases to levels similar to those recorded at Wentworth. Winds with an easterly vector are relatively insignificant at Mildura. There is also a seasonal shift in direction of strong winds from northwest-north during

July to September to west-southwest during August to January. Overall west-southwest winds dominate over directions from other quarters (Lawrence 1980).

2.5 Climate Summary

The climate of the Hatfield West Study Area is at the 'dry' end of the semi-arid climate classification system of Bailey (1979). The area experiences low (MAR = 285 mm), relatively evenly distributed rainfall with a cool winter period and hot, dry summer period. Mean annual temperature averages 17.1°C which is comparable, although slightly warmer than that occurring at the former Wemen Sand Mine in northwest Victoria. An analysis of wind data from Mildura and Wentworth indicates a prevalence of wind in an arc from southeast to northwest with the highest incidence arising from the southwest. Winds are typically strongest in the Spring (September to November) period and lightest over summer and early autumn.

2.6 The Natural Environment

The Vegetation Map of the Pooncarie 1:250,000 Sheet (Porteners *et al*. 1997) includes seven primary vegetation types in the Hatfield West Study Area. These include:

- Sandplain Mallee (dominated by mallee eucalypts with a shrubby chenopod dominated understorey);
- Callitris Woodland (dominated by Callitris glaucophylla);
- Belah-Rosewood Woodland (dominated by *Casuarina pauper* and *Alectryon oleifolius* subsp. *canescens*);
- Yarran Woodland (dominated by *Acacia melvillei*);
- Pearl Bluebush Shrublands;
- Black Bluebush Shrublands; and
- Open Area Grasslands (which are open areas of land dominated by grasslands).

All of these vegetation types were sampled during the flora survey. The Hatfield West Study Area is composed entirely of Western Land Leases administered by the NSW Department of Primary Industries – Catchment and Lands Division under the NSW *Western Lands Act, 1901*.

CHAPTER 3 METHODS

This chapter provides an outline of all protocols used to extract the flora baseline of the Hatfield West Gravel Pit Study Area. The protocols used include desk-top extraction of information from all of the data sources requested by OEH (see Table 1.2 in Chapter). This includes interrogation of the New South Wales OEH BioNet database, as well as a Commonwealth EPBC Act "Protected Matters Search". The Hatfield West Gravel Pit biodiversity assessment is located within the broader Study Area assessed for the Cristal Mining Australia Ltd. Atlas-Campaspe Mineral Sands EIS. Previous flora findings from that report are considered relevant to this study, especially as the proposed Atlas Mine lies just 3km to the northwest of the Hatfield West Study Area. We have also drawn heavily from the Iluka Resources Ltd. Balranald North Mineral Sands EIS study where the proposed Nepean Mine is located approximately 9 km south of the Hatfield West Study Area. This study also includes a field study of the proposed gravel pit sites. The location of the proposed gravel pit sites in relation to the Atlas-Campaspe and Nepean mineral sand s deposits is shown in Figure 1-03 (Chapter 1).

3.1 Literature Review of Biodiversity Known from the Hatfield West Locality

3.1.1 New South Wales BioNet Database Search

A review of the records of all flora species occurring within the Hatfield West Study Area known to be present on the NSW BioNet database were collated from a search undertaken on 27th January 2016.

3.1.2 EPBC Act Protected Matters Search

An EPBC Act "Protected Matters Search" for a 50 km area around the Hatfield West Study Area was conducted on the 1st June 2016. The search identified threatened species and ecological communities plus other listed species that could potentially be impacted by the Hatfield West Gravel Pit Project.

3.1.3 Review of Previous Reports

A number of previous reports are considered relevant with respect to the flora of the Hatfield West Study Area. These include:

- Atlas-Campaspe Mineral Sands Project – EIS Biodiversity Assessment (AMBS 2013).
- Balranald Mineral Sands Project – EIS Biodiversity Assessment (NEH 2016)
- Biodiversity Summary for Natural Resource Management Regions (DoE 2011)
- Val, J., Foster, E. and LeBreton, M. (2001). *Biodiversity Study of the Lower Murray-Darling.* Dept. of Land Water Conservation, New South Wales.
- Bowen, P.F. and Pressey, R.L. (1993). *Localities and Habitats of Plants with Restricted Distributions in the Western Division of New South Wales.* NSW National Parks & Wildlife Service Occasional Paper No. 17.
- Ayers, D., Nash, S. and Baggett, K. (1996). *Threatened Species of Western New South Wales.* NSW National Parks & Wildlife Service, Sydney.
- Porteners, M.F., Ashby, E.M. and Benson, J.S. (1997). The natural vegetation of the Pooncarie 1:250,000 map. *Cunninghamia* **5(1):** 139-231.

The information contained within each of these reports was scrutinized for relevance with respect to the Hatfield West Study Area.

3.2 Field Assessment

3.2.1 Flora

Rationale Behind and Timing of the Gravel Pit Flora Survey The Cristal flora gravel pit survey was originally proposed to occur in late January 2016 based around the locations of two potential pits selected by that company's geologists. Surveys were conducted at these two proposed pit sites in late January-early February 2016, which have subsequently been termed Pits A and B. After calculation of the potential gravel present in Pits A and B, it became clear later in 2016 that further gravel resources would be required to maintain roads along the MCTR from Atlas-Campaspe to Hatfield over the life of the two mines. A further location, Pit C was added to the study in September 2016, along with an expanded area at Pit A. Baseline flora surveys of Pit C as well as the new area at Pit A were surveyed in October 2016. In addition, targeted rare plant surveys of all three pit locations were also undertaken at this time.

Conditions of the Vegetation Survey The initial field assessment of vegetation at Pits A and B were conducted over two days on the 28th January 2016 and the 3rd February 2016. The ground and shrub layer condition of the vegetation at this time was poor, with little or no herbs present and low groundflora biomass. The vegetation survey in October 2016 was conducted in optimal conditions for flora survey. In excess of 100mm of precipitation in September 2016 ensured that the herbaceous groundflora layer was in peak condition.

Site Selection Survey sites were selected so as to sample all vegetation plant communities present as well as any variation present within them, at each proposed gravel pit site. Survey effort, as advised by OEH in correspondence provided to Cristal Mining of 20/11/2015, was guided by DEC (2004) "*Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft*" (see table 5.2 for quadrat sampling stratification). The DEC (2004) guidelines for quadrat based sampling are:

- at least 1 quadrat per stratification unit <2 hectares
- 2 quadrats per 2 – 50 hectares of stratification unit
- 3 quadrats per 51 – 250 hectares of stratification unit
- 5 quadrats per 251 – 500 hectares of stratification unit
- 10 quadrats per 501 – 1000 hectares of stratification unit, plus 1 additional quadrat for each extra 100 hectares thereof.

The relatively small size of each proposed gravel pit (Pits A and C at ~ 50 Ha; Pit B at ~5Ha) meant that quadrat replication was mostly low, but in all circumstances, met the DEC requirements. A total of 13 quadrat sites were assessed at Pit A (see Figure 4-02), 3 at Pit B (see Figure 4-03) with a further 11 sites surveyed at Pit C (see Figure 4-04).

Vegetation Description The vegetation quadrats measured 50 x 20 m (0.1 Ha). All species recorded in the (1,000m²) fixed area quadrats were allocated a cover-abundance scaling as outlined below:

+ = few individuals, with small cover
1 = numerous individuals but < 5% cover, or scattered individuals and cover to 5%
2 = 5-25% cover
3 = 25-50% cover
4 = 50-75% cover
5 = 75-100% cover

A structural assessment was also undertaken at a subset of the treed sites as well. This involved quantitatively describing the structural parameters that characterized the selected quadrat sites. Information was collected on tree, shrub and groundflora height and cover as well as the number of live trees and large shrubs in each 0.1 Ha area. The latter assessment facilitated a calculation of the density of trees and shrubs per hectare. The number of dead trees, fallen logs, tree hollows, bird nests, lizard burrows and spider holes were also counted.

Plant Nomenclature Botanical nomenclature used in this report follows the *Flora of New South Wales* (Harden 1990; 1991; 1992 and 1993), except where more recent taxonomic revisions as outlined on the Atlas of Living Australia (ALA 2016) apply.

Data Collection and Compliance Ian Sluiter and Geoffrey Allen, the two botanists that undertook the surveys, are licenced to undertake plant biodiversity assessments and ecological surveys under New South Wales *National Parks and Wildlife Act,* 1974 Scientific Licence number SL101035.

Data Curation All floristic data has been entered to the NSW BioNet, as per scientific license requirements.

VIS Classification Plant community types were allocated to Benson *et al.* (2006) New South Wales vegetation communities and later with the new VIS plant community type or PCT's.

Vegetation Mapping The vegetation map produced for the Hatfield West gravel pit locations (see Chapter 4) used the same orthophotographic image used for Cristal's 2011 Atlas-Campaspe EIS study, combined with detailed 'ground truth' notes taken whilst at the sites. The vegetation communities reflect the VIS terminology as derived from BioNet (OEH 2016).

Targeted Threatened Flora Searches Targeted threatened flora searches were undertaken at each proposed gravel pit site in accordance with DEC (2004) guidelines whereby meandering traverses were undertaken according to the following replication:

- 1 x meandering 30 minute traverse per stratification unit <2 hectares
- 2 x meandering 30 minute traverses per stratification unit 2 - 50 hectares.

In reality, considerably more time than this was dedicated to rare plant searches, with approximately 4 hours at each of Pits A (53.24 Ha) and C (54.16 Ha), and 1 hour at Pit B (5.25 Ha).

Limitations The initial flora survey in late summer 2016 was far from ideal. Conditions across all sites were extremely dry with virtually no herbaceous component present. The inclusion of Pit C to the study in spring 2016 allowed all sites to be re-assessed in October 2016. This facilitated targeted rare plant surveys at the appropriate time of the year under optimal seasonal conditions. Whilst the field conditions for this study were considered to be very good, it should also be mentioned that the baseline EIS surveys of the nearby Atlas-Campaspe and Balranald minerals sands projects were both undertaken during spring months during years of good rainfall. This would have increased the chances of finding threatened plant species at these locations.

CHAPTER 4 FLORA OF THE HATFIELD WEST STUDY AREA

This chapter outlines the flora baseline of the Hatfield West Study Area. The assessment includes information provided in recent mineral sands EIS investigations (Section 4.1), as well as the vegetation occurring at the potential gravel pit sites assessed (Section 4.2). Section 4.3 provides an assessment of potential threatened species and plant communities.

4.1 Flora of the Broader Study Area

The Hatfield West Study Area lies within the south-central part of the New South Wales 1:250,000 Pooncarie Map Sheet. The vegetation of this map sheet was described by Porteners *et al.* (1997), from which 18 plant communities were described. Other relevant vegetation assessments with attendant mapping within the region include:

- Westbrooke and Miller (1995) who described and mapped the vegetation of nearby Mungo National Park;
- Australian Museum Business Services (AMBS 2013) who described and mapped the vegetation of the proposed Atlas-Campaspe Mineral Sands Mines, as well as adjoining vegetation to the east of Mungo National Park in part of the Boree Plains Station property; and
- Niche Environment and Heritage (NEH 2016) who described and mapped the vegetation of the proposed nearby Nepean Mineral Sands Mine.

Both the AMBS (2013) and NEH (2016) studies are considered the most relevant to this study as the vegetation described and mapped occurs within 10 km of the gravel pits sites. The plant taxa recorded from these studies, as well as those recorded on the NSW BioNet database are outlined in Appendix 1.

4.2 Hatfield West Vegetation Community Delineation and Mapping

The vegetation occurring at the proposed gravel pit sites was initially aligned in the field with the southwest New South Wales plant community types described by Benson *et al.* (2006). Six plant community types were recognized as occurring across the three gravel pit locations. These were subsequently aligned with the BioMetric Vegetation Types for the Lower Murray-Darling CMA (with relevant reference codes), as well as with the New South Wales Vegetation Formations and Classes of Keith (2004). The six vegetation community types described below have been aligned with the validated vegetation community types in Table 4-01. Vegetation community mapping for each proposed gravel pit has been shown as Figure 4-01 (Pit A), Figure 4-02 (Pit B) and Figure 4-03 (Pit C). A seventh vegetation unit has also been mapped. This is Rosewood Woodland which is a sub-community type of Belah-Rosewood Woodland. The vegetation maps were compiled from field notes taken whilst walking through the Subject Site area and surrounds and from detailed assessments made at the surveyed quadrat sites. The surveyed quadrat sites are shown for each gravel pit site within the three vegetation maps and have been classified within Table 4-01. Some vegetation from the surrounding Study Area has also been shown. These mapped areas represent plant community types that are threatened NSW Endangered Ecological Communities or EEC's and have been shown to provide context as well as to show how the proponent has attempted to avoid disturbance where possible.

The plant communities recognized in this study are described in turn within Sections 4.2.1 to 4.2.6 below.

Table 4-01: Vegetation communities present within the Cristal Mining Australia Ltd. proposed gravel pits at Hatfield West. The area of each vegetation community potentially disturbed has been shown.

Vegetation Formation (Keith 2004)	Vegetation Class (Keith 2004)	BioMetric Vegetation Type (OEH 2011)	Benson *et. al.* (2006) ID No.	Vegetation Community (abbreviated name in this study)	Pit A Area (Ha)	Pit B Area (Ha)	Pit C Area (Ha)	TOTAL (Ha)	Vegetation Quadrat Sites
Semi-arid Woodlands (shrubby sub-formation)	Semi-arid Sand Plain Woodlands	LM108 Black Oak - Western Rosewood open woodland on deep sandy loams of the Murray-Darling Depression and Riverina Bioregions.	58	Belah-Rosewood Woodland (Belah-Rosewood sub-community)	21.85	0	7.10	**53.93**	A-01, A-02, A-03, A-08, A-11, C-04, C-09, C-11
		LM108 Black Oak - Western Rosewood open woodland on deep sandy loams of the Murray-Darling Depression and Riverina Bioregions.	58	Belah-Rosewood Woodland (Rosewood sub-community)	13.36	0	11.62		A-05, A-06, A-07, A-10, C-06, C-08
	Riverine Sandhill Woodlands	LM159 White Cypress Pine open woodland of sandplains, prior streams and dunes of the semi-arid (warm) climate zone.	28	Sandhill Pine Woodland	1.43	2.22	1.24	**4.89**	A-07, B-01, B-02, B-03, C-03
Semi-arid Woodlands (shrubby sub-formation)	Sandplain Mallee Woodlands	LM116 Chenopod sandplain mallee woodland/shrubland of the arid and semi-arid (warm) zones.	170	Chenopod Sandplain Mallee	0.37	0	0.65	**1.02**	A-04
Arid Shrublands	Not specifically recognized by Keith (2004)	LM160 Yarran shrubland of the semi-arid (warm) and arid zones.	23	Yarran Shrubland	0	0	0.53	**0.53**	C-01, C-02
Arid Shrublands (Chenopod sub-formation)	Aeolian Chenopod Shrublands	LM138 Pearl Bluebush low Open Shrubland of the arid and semi-arid plains.	154	Pearl Bluebush Shrubland	0	0	2.70	**2.70**	C-05
Arid Shrublands (Chenopod sub-formation)	Aeolian Chenopod Shrublands	LMW122 Derived corkscrew grass grassland/forbland on sandplains and plains in the semi-arid (warm) climatic zone.	165	Bluebush-Grassland Mosaic	15.98	0.87	28.86	**45.71**	A-12, C-07, C-10
N/A	N/A	N/A	N/A	Cleared Areas	1.01	2.16	1.46	**4.63**	

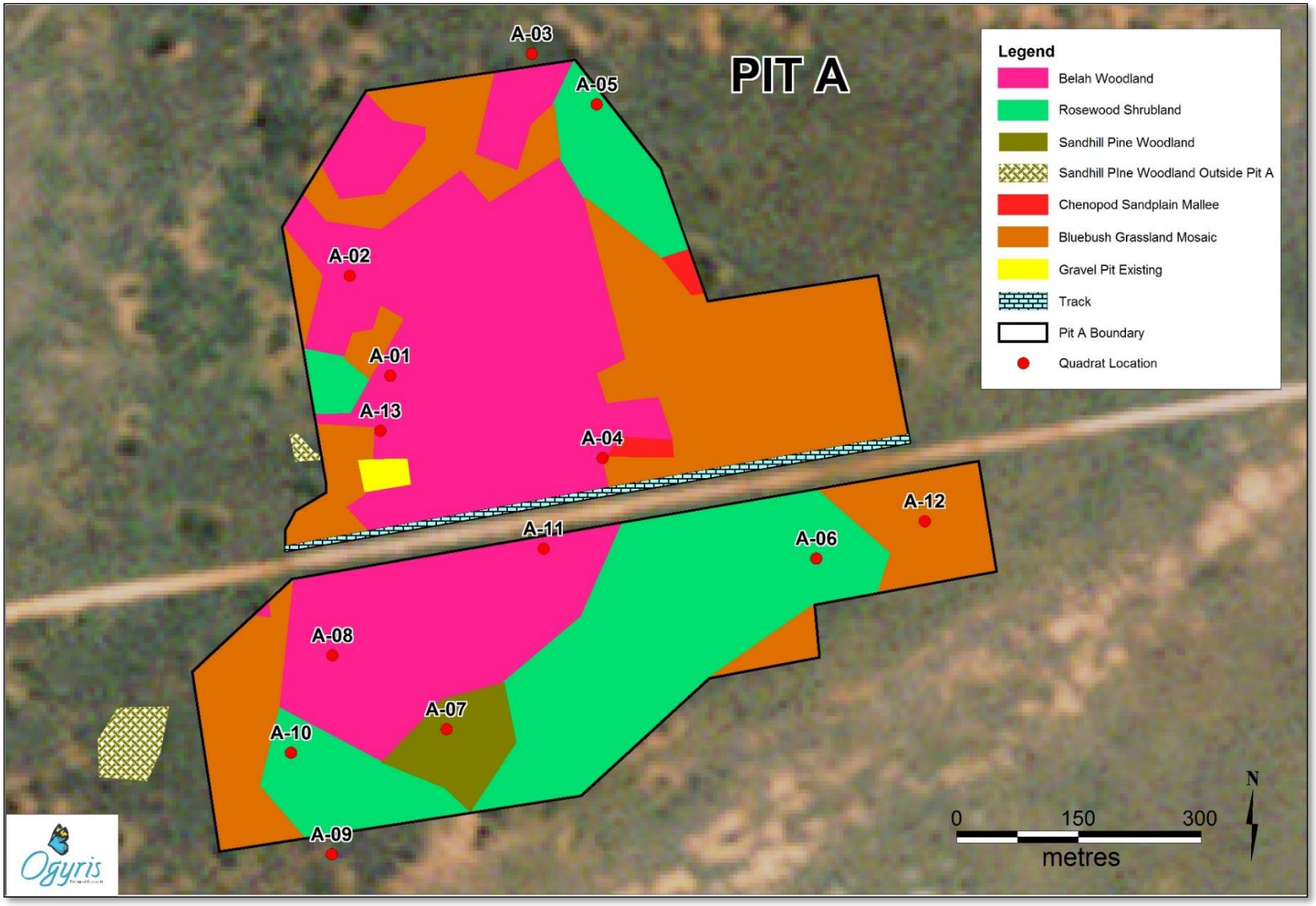

Figure 4-01: **Vegetation Map of the Pit A proposed gravel pit location. Five vegetation community types are present, along with a very small area where gravel has been extracted in the past.**

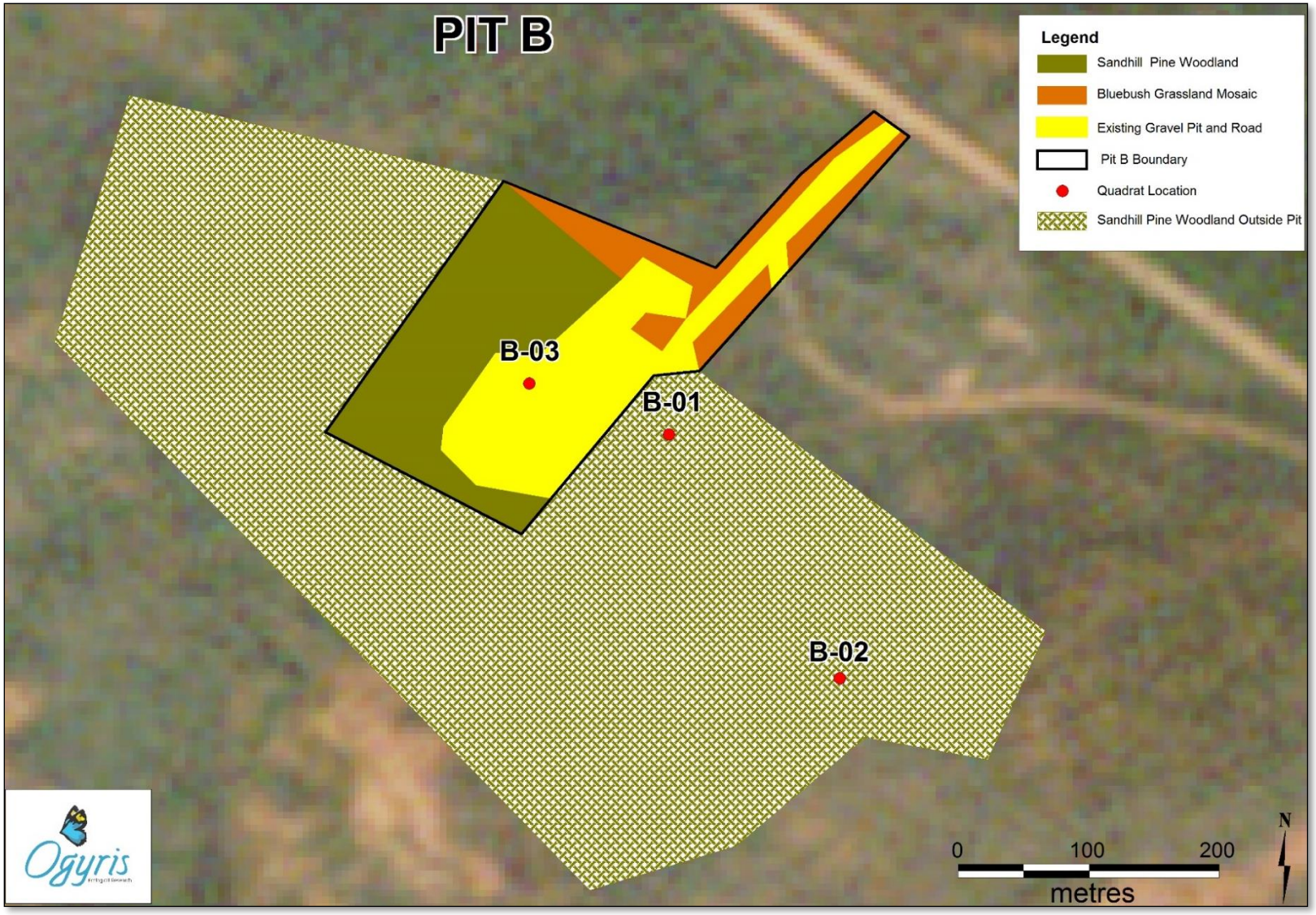

Figure 4-02: **Vegetation Map of the Pit B proposed gravel pit location. Two vegetation community types are present, along with an area where gravel has been extracted in the past. The location of a surrounding EEC named Sandhill Pine Woodland has been shown.**

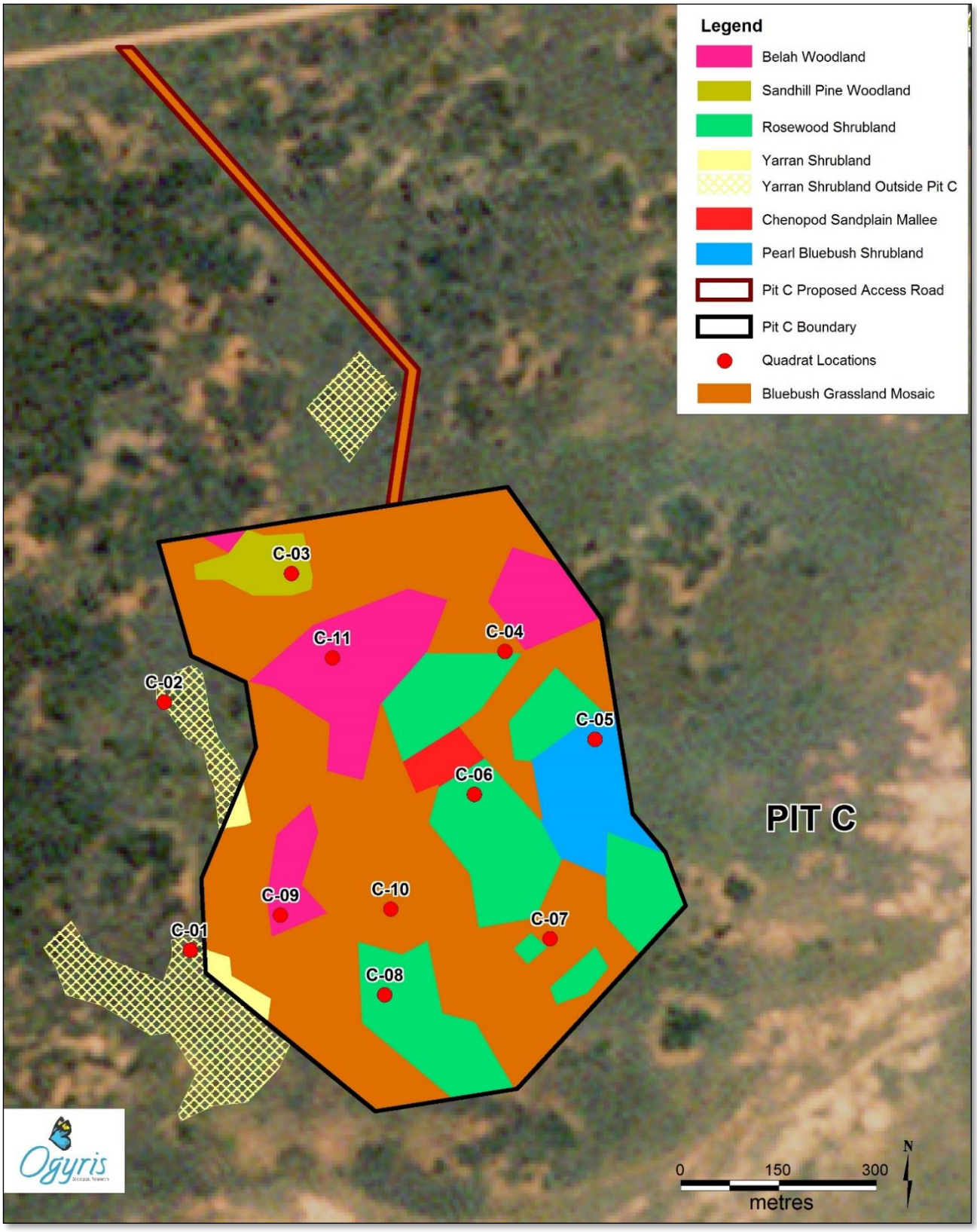

Figure 4-03: **Vegetation Map of the Pit C proposed gravel pit location. Six vegetation community types are present. The location of a surrounding EEC named Yarran Shrubland has been shown.**

4.2.1 Belah-Rosewood Woodland

Habitat Belah-Rosewood Woodland (see Plate 4-01) was present on flat to undulating plains comprised of Woorinen Formation reddish-brown clay loam and sandy clay loam Calcarosol soils with topsoil depths varying from 25-40 cm.

Structure and Primary Character Species Woodland and open woodland overwhelmingly dominated by Belah (*Casuarina pauper*) from 5-9m tall. Also present at most locations was a small tree stratum of 3.5-5m in height of Rosewood (*Alectryon oleifolius* ssp. *canescens*). Another occasional canopy tree taxon present was Sugarwood (*Myoporum platycarpum* ssp. *platycarpum*). In some circumstances, Rosewood formed mono-specific stands of small trees to 5m tall, generally surrounded by open grasslands, but sometimes ecotonal with Belah-Rosewood Woodland. An example of the Rosewood Woodland sub-community of Belah-Rosewood Woodlands is shown in Plate 4-02. Tree density of Belah-Rosewood Woodland varied from 200-260 trees per Ha in well treed areas, which were spread across several size classes. The dominant size classes were 10-20 cm DBH (40% of trees) and 20-30cm DBH (35% of trees), although smaller (<10cm DBH) and larger trees (30-45cm DBH) were also present. Tree hollows averaged 170 hollows per Ha and most (80%) were in the small (<5cm) size class with lesser numbers in the size class 5-10cm. Rosewood trees occasionally contained small hollows <5cm in size. The shrub layer of Belah-Rosewood Woodlands was dominated by Black Bluebush (*Maireana pyramidata*) which was present at an average density of 1,950 mature shrubs per Ha. Densities of Black Bluebush across Pit A and Pit C Belah-Rosewood Woodlands were quite variable which reflects a long history of grazing impact upon the site.

Presence at the Gravel Pit Sites Belah-Rosewood Woodland was absent from the Pit B site, but was the dominant vegetation community of Pit A where it comprised 35.21Ha of the total pit area of 54Ha. Belah-Rosewood Woodland was also common at the Pit C location as well where it comprised 11.62Ha of the total area of 54.16Ha. In total, Belah-Rosewood Woodland comprised 53.93Ha or 47.6% of the total Subject Site area of 113.41Ha. Sampled at 9 locations including quadrats A-01, A-02, A-03, A-08, A-11 in Pit A and quadrats C-04, C-09 and C-11 in Pit C.

Vegetation Condition The vegetation condition of Belah-Rosewood Woodlands at Pit A in late summer 2016 was moderate only with heavily browsed Black Bluebush shrubs and very little groundflora vegetation. This contrasted sharply with the vegetation condition in October 2016 when the vegetation at Pits A and C were considered to be in good condition with a healthy Black Bluebush large shrub layer and common chenopod shrubs and sub-shrubs such as Ruby Saltbush (*Enchylaena tomentosa*), Hedge Saltbush (*Rhagodia spinescens*) and Limestone Copperburr (*Sclerolaena obliquicuspis*) present along with common herbs as well. The presence, however, of common Arabian Grass (*Schismus barbatus*), Smooth Mustard (*Sisynmbrium erysimioides*), Mediterranean Turnip (*Brassica tournefortii*) and Little Medic (*Medicago minima*) at most sites detracted from the vegetation condition of the Pit A and C overall. The presence of moderately common African Boxthorn (*Lycium ferocissimum*) was also noted.

Conservation Status Not listed by NSW or Commonwealth legislation. Benson et al. (2006) have the Belah-Black Bluebush Woodlands (ID: 58) listed within the threat category ‘Near Threatened’.

Plate 4-01: Belah-Rosewood Woodland at quadrat site C-11, at Pit C on 13th October 2016.

Plate 4-02: Mono-specific tree stand of Rosewood (*Alectryon oleifolius* ssp. *canescens*) at Pit C. This plant association is considered to be a sub-community of Belah-Rosewood Woodland.

4.2.2 Chenopod Sandplain Mallee

Habitat Chenopod Sandplain Mallee (see Plate 4-03) was extremely restricted in occurrence (see below) and was present on plains comprised of Woorinen Formation reddish-brown sandy clay loam Calcarosol soils with shallow topsoil depths of 30 cm.

Structure and Primary Character Species A low woodland from 5-6m dominated by Pointed Mallee (*Eucalyptus socialis*) and White Mallee (*E. gracilis*) with a chenopod understorey containing Black Bluebush (*Maireana pyramidata*), Hedge Saltbush (*Rhagodia spinescens*) and Limestone Copperburr (*Sclerolaena obliquicuspis*).

Presence at the Gravel Pit Sites Chenopod Sandplain Mallee was absent from the Pit B site, and was present at extremely small locations at both Pits A and C where the total area was just 1.02ha or 0.9% of the total Subject Site area of 113.41Ha. Sampled at one location in Pit A (quadrat A-04).

Vegetation Condition The vegetation condition of Chenopod Sandplain Mallee at Pit A in late summer 2016 was moderate only with only 11 indigenous species present along with common African Boxthorn (*Lycium ferocissimum*).

Conservation Status Not listed by NSW or Commonwealth legislation. Benson *et al.* (2006) have Chenopod Sandplain Mallee (ID: 170) listed within the threat category 'Near Threatened'.

Plate 4-03: Chenopod Sandplain Mallee at quadrat site A-04, at Pit A on 28th January 2016. The vegetation at this site was in moderate condition only with low indigenous plant diversity and a common presence of African Boxthorn (*Lycium ferocissimum*).

4.2.3 Sandhill Pine Woodland

Habitat Sandhill Pine Woodland was originally described by Benson *et al.* (2006) as "White Cypress Pine open woodland of sandplains, prior streams and dunes mainly of the semi-arid

(warm) climate zone". At the Hatfield West Study Area, Sandhill Pine Woodland is found on Woorinen Formation sandy loam and light sandy clay loam dunes and sandplains which surround the margins of relict lake beds associated with the Willandra Lakes palaeo drainage outflow. Within and immediately surrounding the Subject Site of all three proposed gravel pits, Sandhill Pine Woodland is always found associated with sandy soil profiles, typically with topsoil depth of > 60cm above the carbonate layer.

Structure and Primary Character Species Sandhill Pine Woodland is an open woodland containing scattered trees of White Cypress Pine (*Callitris glaucophylla*) to 10-12m tall (see Plate 4-04), although at some locations tree cover is almost absent and all that remains are stumps cut for fence posts or burnt remains of old trees previously killed by wildfire.

Plate 4-04: **Sandhill Pine Woodland at quadrat site C-03 within the Pit C gravel pit Subject Site. A** Wedge-tailed Eagle (Aquila audax) nest appears in the crown of the large tree at right of the photograph.

The understorey within and immediately surrounding the Subject Site at each proposed gravel pit location is composed of a large shrub cover of sparse to moderately dense Black Bluebush (*Maireana pyramidata*) shrubs at a cover density varying from 1-10%, with a sub-shrub layer dominated by Limestone Copperburr (*Sclerolaena obliquicuspis*) and a groundflora layer characterized by Balcarra Speargrass (*Austrostipa nitida*), Flannel Cudweed (*Actinoble uliginosum*), Flat Spurge (*Chamaesyce drummondii*) and Native Caltrop (*Tribulus micrococcus*). Weeds such as Arabian Grass (*Schismus barbatus*), Smooth Mustard (*Sisynmbrium erysimioides*), Mediterranean Turnip (*Brassica tournefortii*), Common Barley Grass (*Hordeum leporinum*), Small Medic (*Medicago minima*) and Wild Sage (*Salvia verbenaca*) are also common at each site

Presence at the Gravel Pit Sites Sandhill Pine Woodland was found to occur within all three proposed gravel pit sites as small occurrences varying from 1-2Ha in size. The largest

contiguous presence of the plant community occurs around the proposed Pit B site, where >15Ha occurs juxtaposed to vegetation within the Pit B site which can also be ascribed to this plant community. At Pit A, Sandhill Pine Woodland occurs as a small patch at the southern end of the southern section of the Subject Site as well as with a minute occurrence on the western side of the northern section of the Subject Site, nearby to an old abandoned quarry site. At Pit C, a small area is located near the northeastern corner of the Subject Site. Sampled at 5 locations including quadrat A-07 in Pit A, quadrats B-01, B-02 and B-03 at Pit B and quadrat C-03 at Pit C.

Vegetation Condition In every occurrence within the Subject Site and immediate surrounds, Sandhill Pine Woodland occurs as degraded remnants with vastly diminished tree density compared to remnants approximately 10km to the north occurring within Cristal Mining Australia's Boree Plains property where remnants in good condition are found.

Conservation Status Sandhill Pine Woodland is listed on Schedule 1 (Part 3) of the NSW *Threatened Species Conservation Act* 1995 as an endangered ecological community or EEC. The formally listed name is "Sandhill Pine Woodland in the Riverina, Murray-Darling Depression and NSW South Western Slopes Bioregions' Benson *et al.* (2006) estimate that approximately 27% of the pre-European extent still exists within NSW, with <6% currently conserved within secure conservation reserves.

4.2.4 Yarran Shrubland

Habitat Yarran Shrubland (see Plate 4-05) is a tall open to very open shrubland from 3-6m tall, typically with a chenopod shrub dominated understorey. Within the broader Study Area, including the Pit C Subject Site, Yarran Shubland ubiquitously occurs on reddish-brown clay loam Calcarosol soils with shallow Woorinen Formation topsoil depth of 25-35cm, often with gilgai soil depressions and cracks present. The shrubland is also found within the lowest parts of the aeolian landscape, generally surrounded by open grassland and/or Belah-Rosewood Woodland.

Structure and Primary Character Species The dominant canopy species is Yarran (*Acacia melvillei*) which at the Pit C Subject Site and surrounds occurred with diminished shrub density due to the impact of past wildfire (see below). Sugarwood (*Myoporum platycarpum* ssp. *platycarpum*) and Rosewood (*Alectryon oleifolius* ssp. *canescens*) are also present as a component of the canopy layer. The shrub layer is dominated by Black Bluebush (*Maireana pyramidata*), usually along with Three-wing Bluebush (*Maireana triptera*), whilst Balcarra Speargrass (*Austrostipa nitida*) is also common within the inter-shrub spaces. Herbs such as Flannel Cudweed (*Actinoble uliginosum*), Hard-headed Daisy (*Brachyscome lineariloba*), Desert Purslane (*Calandrinia eremaea*), Desert Spinach (*Tetragonia moorei*) and Native Leek (*Bulbine semibarbata*) dominate the groundflora layer, along with weed taxa including Smooth Mustard (*Sisymbrium erysimoides*), Little Medic (*Medicago minima*) and Cut-leaf Medic (*Medicago laciniata*).

Plate 4-05: **Yarran (*Acacia melvillei*) Shrubland at quadrat site C-01. This site was just outside the Pit C Subject Site, but the plant community extends to the east or left hand side of the photograph to be present within the Subject Site as well. The shrub layer is dominated by Black Bluebush (*Maireana pyramidata*) with a diverse herbaceous component as well.**

Presence at the Gravel Pit Sites Yarran Shrubland occurs at two locations totalling just 0.53Ha on the western side of the Pit C Subject Site where it is also contiguous with larger patches of this shrubland. Sampled at 2 locations near Pit C, at quadrats C-01 and C-02.

Vegetation Condition Yarran Shrubland is in moderate-poor condition at the Pit C site and surrounds. Shrub density of Yarran is considered to be 1-5% of pre-European density, with most large shrubs having been killed by past wildfire, and then prevented from regenerating by a high browsing presence from sheep and Feral Goats. Despite the diminished canopy presence, the plant community is characterized by a healthy large shrub layer of Black Bluebush as well as a high diversity of indigenous herbs within the groundflora layer.

Conservation Status Yarran Shrubland is listed on Schedule 1 (Part 3) of the NSW *Threatened Species Conservation Act* 1995 as an endangered ecological community or EEC. The formally listed name is "*Acacia melvillei* Shrubland in the Riverina and Murray-Darling Depression Bioregions' Benson *et al.* (2006) estimate that approximately 42% of the pre-European extent still exists within NSW, with no areas currently conserved within secure conservation reserves at that time (2006). A private conservation reserve on the Cristal Mining Australia Ltd. property at Boree Plains contains Yarran Shrubland, but AMBS (2013; p.60) consider this to be in "moderate to poor condition, lacking structural integrity and having higher numbers of weed species than other (vegetation) map units in the (Atlas-Campaspe) study area".

4.2.5 Pearl Bluebush Shrubland

Habitat Pearl Bluebush Shrubland are a treeless chenopod shrubland from 0.8-1.4m in height occurring on clay loam Calcarosol soils with shallow (20-30cm) topsoils and a weakly developed gilgai presence along with a strong sub-soil carbonate presence dominated by calcrete nodules. The shrublands occur in the lowest part of the eastern side of the Pit C Subject Site, bordering a relictual lakebed.

Structure and Primary Character Species Pearl Bluebush Shrubland (see Plate 4-06) was dominated by Pearl Bluebush (*Maireana sedifolia*), with an appreciable presence of Black Bluebush (*Maireana pyramidata*) as well. The inter-shrub spaces in October 2016 were characterized by a high cover of the annual weeds Hairy Rupture-wort (*Herniaria cinerea*), Little Medic (*Medicago minima*) and Cut-leaf Medic (*Medicago laciniata*), along with native perennial grasses including Balcarra Speargrass (*Austrostipa nitida*) and Common Wallaby Grass (*Rytidosperma caespitosa*).

Plate 4-06: Pearl Bluebush Shrubland at quadrat site C-05 within the Pit C Subject Site on 12th October 2016.

Presence at the Gravel Pit Sites Pearl Bluebush Shrubland was restricted to just 2.7 Ha on the eastern side of Pit C. The vegetation community was described at quadrat site C-05.

Vegetation Condition The condition of the vegetation was moderate with a diminished bluebush shrub density, but with high indigenous species diversity (n=36 taxa) as well as weed diversity (n=16 taxa).

Conservation Status Not listed by NSW or Commonwealth legislation. Benson *et al.* (2006) have Pearl Bluebush Shrubland (ID: 154) listed within the threat category 'Near Threatened'.

4.2.6 Bluebush-Grassland Mosaic

Habitat Undulating aeolian plains of shallow Woorinen Formation clay loam topsoils 25-35cm thick characterized by the presence of a native perennial grass sward of Speargrass (*Austrostipa* spp.) interspersed with Black Bluebush shrubs (see below) with variable density (see Plates 4-07 and 4-08) of cover.

Structure and Primary Character Species Native perennial grassland dominated by Balcarra Speargrass (*Austrostipa nitida*) and Rough Speargrass (*Austrostipa scabra* ssp. *falcata*) with a variable presence of Black Bluebush (*Maireana pyramidata*) shrubs varying from 0-10% large shrub cover. Benson *et al.* (2006) have indicated they believe this plant community is likely to be derived from other woody plant communities including Bluebush Shrublands and possibly Belah-Rosewood Woodlands.

Presence at the Gravel Pit Sites Present at all three proposed gravel pit locations, but most extensive at Pit C where this plant community made up 53% of the Subject Site of 54.16Ha. Also well represented at Pit A where the plant community made up 30% of the Subject Site of 54Ha. Collectively, Bluebush-Grassland Mosaic comprises 45.71Ha or 40.3% of the total Subject Site of 113.41Ha. Sampled at three quadrat locations (A-12/Pit A; and C-07 and C-10/Pit C)

Vegetation Condition In October 2016, this plant community contained relatively low indigenous plant diversity (n=16-22 taxa) but high weed diversity (n=7-11 taxa)

Conservation Status Not listed by NSW or Commonwealth legislation. Benson *et al.* (2006) have Bluebush-Grassland Mosaic (ID: 165) listed within the threat category 'Least Concern'.

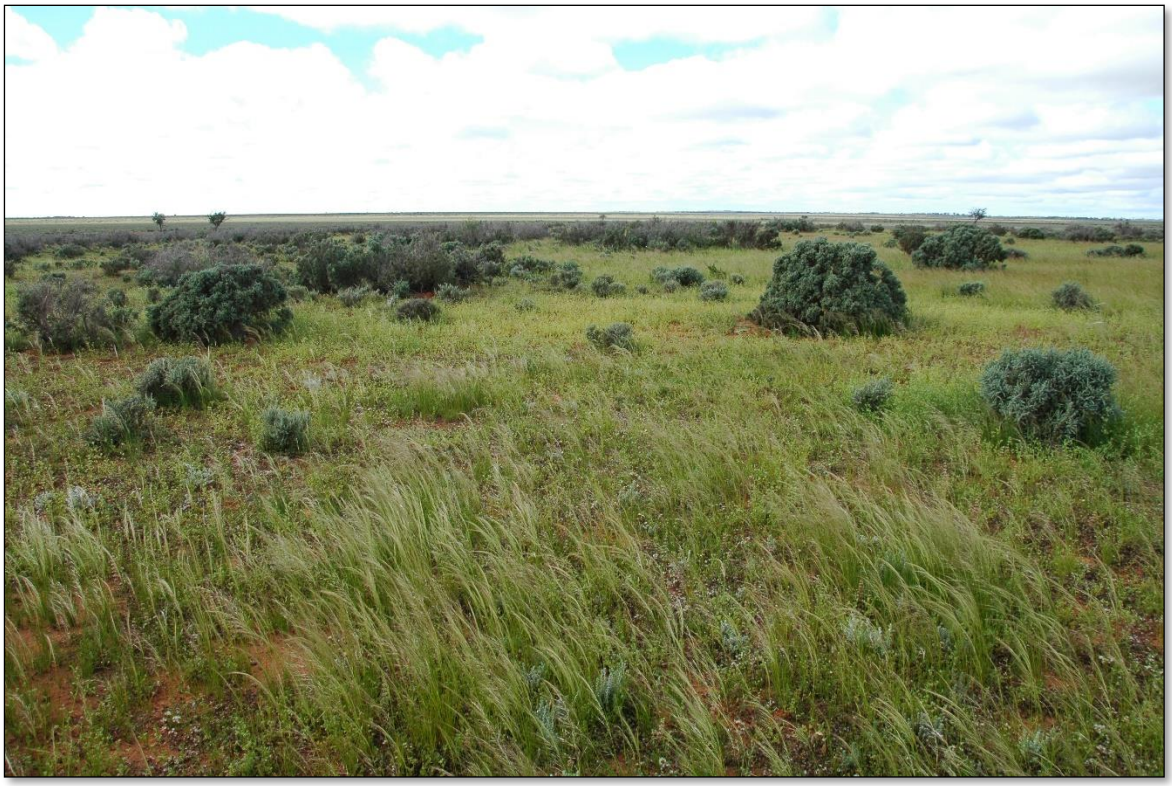

Plate 4-07: Bluebush-Grassland Mosaic at quadrat site A-12 – showing an example of this plant community with the higher end of near 10% shrub cover of Black Bluebush.

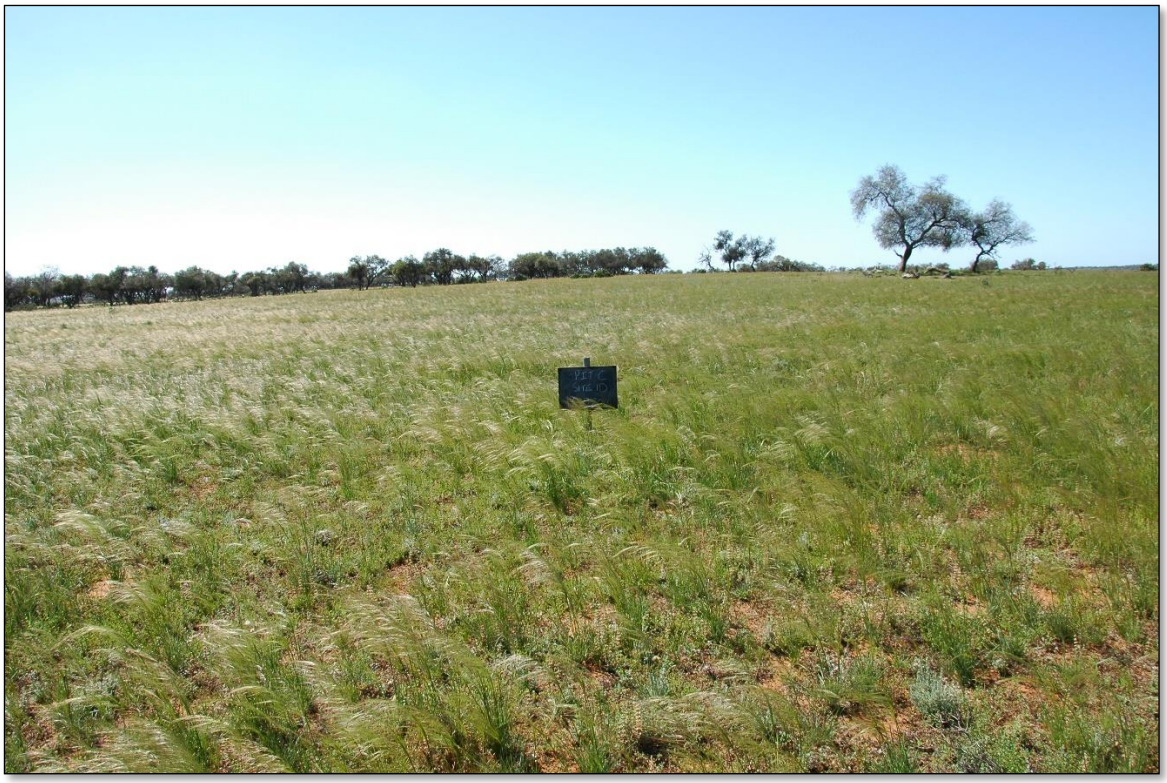

Plate 4-08: Bluebush-Grassland Mosaic at quadrat site C-10 – showing an example of this plant community with the lower end of 0% shrub cover of Black Bluebush.

4.3 Flora of the Hatfield West Study Area

During the course of the field work program, 157 plant taxa were recorded from the Hatfield West Study Area. This includes 120 indigenous plant taxa and 37 alien plant taxa.

4.3.1 Indigenous Plant Taxa Recorded from the Hatfield West Study Area

The 120 indigenous plant taxa recorded in this study from the Hatfield West Study Area and Subject Site have been outlined in Table 4-02. The most important of these records is the NSW and Australian vulnerable species Mossgiel Daisy (*Brachyscome papillosa*). Also of interest is the presence of Large-flowered Annual Blue-bell (*Wahlenbergia victoriensis*), one of less than 10 records for NSW and less than 100 records for Australia, and only the second record for the the state's component of the Murray-Darling Depression Bioregion (see ALA 2016; 02 December 2016).

Table 4-02: List of indigenous plant taxa recorded within Hatfield West gravel pit survey EIS flora investigation of the Study Area and Subject Site.

Plant Taxon	Common Name
Acacia melvillei	Yarran
Actinobole uliginosum	Flannel Cudweed
Alectryon oleifolius subsp. *canescens*	Cattle Bush
Amyema linophyllum subsp. orientale	Amyema 001087
Amyema miraculosum subsp. boormanii	Amyema 001096
Angianthus brachypappus	Spreading Angianthus
Arabidella nasturtium	Yellow Cress
arabidella trisecta	Shrubby Cress
Atriplex holocarpa	Pop Saltbush
Atriplex lindleyi subsp. *conduplicata*	Saltbush
Atriplex nummularia	Old Man Saltbush
Atriplex stipitata	Kidney Saltbush
Austrodanthonia caespitosa	Common Wallaby-grass
Austrostipa drummondii	soft Speargrass
Austrostipa nitida	Balcarra Spear-Grass
Austrostipa scabra subsp. *falcata*	Rough Spear-grass
Boerhavia dominii	Tah-vine
brachyscome ciliaris	Variable Daisy
Brachyscome lineariloba	Hard-headed Daisy
Brachyscome papillosa	Mossgiel Daisy
Bulbine semibarbata	Leek Lily
Calandrinia eremaea	Desert Purslane
Callitris glaucophylla	White Cypress-pine
Calotis hispidula	Bogan Flea
Cassytha melantha	Coarse Dodder-laurel
Casuarina pauper	Black Oak
Chamaesyce drummondii	Flat Spurge
Chrysocephalum vitellinum	Yellow Everlasting daisy
Chthonocephalus pseudevax	Ground Heads
Convolvulus clementii	Clement's Bindweed
Convolvulus remotus	Grass Bindweed
Crassula colorata var. *colorata*	Austral Stonecrop
Crassula sieberiana	Sieber Crassula
Daucus glochidiatus	Austral Carrot
Dissocarpus paradoxus	Cannon Balls
Dysphania cristata	Crested Goosefoot
Elachanthus pusillus	Small Elachanth
Enchylaena tomentosa	Ruby Saltbush
Enneapogon avenaceus	Common Bottle-washers
Eremophila sturtii	Narrow-leaf Emu-bush
Eriochiton sclerolaenoides	Wooly-fruit Bluebush
Erodium crinitum	Blue Crowsfoot
Eucalyptus dumosa	Dumosa Mallee
Eucalyptus gracilis	Yorrell
Eucalyptus socialis	Red Mallee
Euchiton sphaericus	Star Cudweed
Exocarpos aphyllus	Leafless Ballart
Geijera parviflora	Wilga
Geococcus pusillus	Earth Cress
Goodenia lunata	Stiff Goodenia

Table 4-02 continued

Plant Taxon	Common Name
Goodenia pusilliflora	Small-flower Goodenia
Hakea tephrosperma	Hooked Needlewood
Harmsiodoxa blennodioides	May Smocks
Herniaria cinerea	Hairy raspwort
Hypochaeris glabra	Smooth Cat's Ear
Isoetopsis graminifolia	Grass Heads
Lactuca serriola	Wild Lettuce
Lysiana exocarpi	Harlequin Mistletoe
Maireana brevifolia	Short-leaf Bluebush
Maireana georgei	Slit-wing Bluebush
Maireana pentatropis	Erect Bluebush
Maireana pyramidata	Black Bluebush
Maireana sedifolia	Pearl Bluebush
Maireana triptera	Three-wing Bluebush
Maireana turbinata	Satiny Bluebush
Marsdenia australis	Austral Doubah
Marsilea drummondii	Nardoo
Millotia perpusilla	Tiny Bow-flower
Minuria cunninghami	Bush Minuria
Myoporum platycarpum subsp. *platycarpum*	Sugarwood
Nicotiana velutina	Wild Tobacco
Nitraria billardierei	Nitre-bush
Olearia pimeleoides	Pimelea Daisy-bush
Omphalolappula concava	Burrstick
Onopordum acaulon	Stemless Thistle
Osteocarpum acropterum var. *deminuta*	Babbagia
Oxalis perennans	Wood Sorrel
Parietaria cardiostegia	Desert Nettle
Pimelea trichostachya	Annual Rice-flower
Pittosporum angustifolium	Weeping Pittosporum
Plantago turrifera	Small Sago-weed
*Podolepis aristata*subsp. *affinis*	Copper-wire Daisy
Podolepis muelleri	Small Copper-wire Daisy
Pogonolepis muelleriana	Stiff Cup-flower
Pycnosorus pleiocephalus	Soft Billy-buttons
Rhagodia spinescens	Hedge Saltbush
Reichardia tingitana	Reichardia
Rhodanthe moschata	Musk Sunray
Rhodanthe pygmaea	Dwarf Sunray
Rhodanthe stuartianum	Clay Sunray
Rytidosperma caespitosa	Common Wallaby Grass
Salsola tragus subsp. tragus	Prickly Saltwort
Schenkea australis	Pink Gentian
Sclerochlamys brachyptera	Short-wing Bluebush
Sclerolaena diacantha	Grey Copperburr
Sclerolaena eriacantha	Wooly-fruit Copperburr
Sclerolaena intricata	Poverty Bush
Sclerolaena obliquicuspis	Limestone Copperburr
Sclerolaena patenticuspis	Spear-fruit Copperburr
Senecio glossanthus	Slender Groundel
Senecio pinnatifolius var. pinnatifolius	Mallee Groundsel

Table 4-02 continued

Plant Taxon	Common Name
Senna artemisioides subsp. x coriacea	Broad-leaf Desert Senna
Sida intricata	Twiggy Sida
Solanum esuriale	Quena
Spergularia brevifolia	Native Sand-spurrey
Stenopetalum lineare	Slender Thread-petal
Tetragonia moorei	Desert Spinach
Tribulus micrococcus	Spineless Caltrop
Vittadinia cervicularis	Annual New Holland Daisy
Vittadinia gracilis	Hairy New Holland Daisy
Wahlenbergia gracilenta	Annual Bluebell
Wahlenbergia graniticola	Tufted Bluebell
Wahlenbergia victoriensis	Large-flowered Annual Bluebell
Wurmea dioica subsp. *brevifolia*	Early Nancy
Zygophyllum apiculatum	Pointed Twinleaf
Zygophyllum aurantiacum	Shrubby Twinleaf
Zygophyllum crenatum	Notched Twinleaf
Zygophyllum iodocarpum	Violet Twinleaf
Zygophyllum ovatum	Dwarf Twinleaf
Zygophyllum simile	White Twinleaf

4.3.2 Alien Plant Taxa Recorded from the Hatfield West Study Area

A total of 37 alien plant taxa were recorded in the Hatfield West gravel pit flora survey. They have been listed in Table 4-03 below. Of these, only African Boxthorn (*Lycium ferocissimum*) is listed under the *Noxious Weeds Act* 1993 as Class 4 noxious weed for control within the Balranald Shire Council Control Area. African Boxthorn "must be managed in a manner that continuously inhibits the ability of the plant to spread and the plant must not be sold, propagated or knowingly distributed". African Boxthorn was recorded at numerous sites and was present at all three proposed pit locations. Although found within the Hatfield West Study Area, Onion Weed (*Asphodelus fistulosus*) and Bathurst Burr (*Xanthium spinosum*), are not Category 4 noxious weeds for control within the Balranald SC Control Area, as listed by AMBS (2013).

Table 4-03: List of introduced plant taxa recorded within Hatfield West gravel pit survey EIS flora investigation.

Introduced	Weed Species Name	Common Name
*	*Alyssum linifolium*	Flax-leaf Alyssum
*	*Arctotheca calendula*	Cape Weed
*	*Asphodelus fistulosus*	Onion Weed
*	*Brassica tournefortii*	Mediterranean Turnip
*	*Bromus rubens*	Red Brome
*	*Carthamus lanatus*	Saffron Thistle
*	*Centaurea melitensis*	Malta Thistle
*	*Chenopodium murale*	Nettle-leaf Goosefoot
*	*Chondrilla juncea*	Skeleton Weed
*	*Cirsium vulgare*	Spear Thistle
*	*Citrullus colocynthis*	Camel Melon
*	*Emex australis*	Three-corner Jack
*	*Erodium cicutarium*	Pink Storksbill
*	*Herniaria cinerea*	Hairy Rupture-wort
*	*Hordeum leporinum*	Common Barley-grass
*	*Hypocharis glabra*	Smooth Cats-ear
*	*Lactuca serriola*	Wild Lettuce
*	*Limonium lobatum*	Winged Sea Lavender
*	*Lycium ferocissimum*	African Box-thorn
*	*Malva parviflora*	Marshmallow
*	*Marrubium vulgare*	Horehound
*	*Medicago laciniata*	Cut-leaf Medic
*	*Medicago minima*	Little Medic
*	*Onoprdum acaulon*	Stemless Thistle
*	*Psilocaulon granulicaule*	Wiry Noon-flower
*	*Reichardia tingitana*	Reichardia
*	*Rostraria pumila*	Small Bristle-grass
*	*Salvia verbenaca*	Wild Sage
*	*Schismus barbatus*	Short-tooth Arabian Grass
*	*Silene apetala* var. *apetala*	Catchfly
*	*Silene nocturna*	Mediterranean Catchfly
*	*Sisymbrium erysimoides*	Smooth Mustard
*	*Solanum nigrum*	Deadly Nightshade
*	*Sonchus oleraceus*	Common Sow-thistle
*	*Spergularia diandra*	Small Sand-spurrey
*	*Vulpia myuros*	Rats-tail Fescue
*	*Xanthium spinosum*	Bathurst Burr

4.3.3 Threatened Plant Taxa of the Hatfield West Study Area and Surrounds

Table 4-04 lists the threatened plant taxa either known, considered likely or which may possibly occur within the Hatfield West Study Area. The list has been derived from similar considerations in the Atlas-Campaspe EIS (AMBS 2013) and Balranald North EIS (NEH 2016) flora assessments. Thirty plant taxa have been listed and considered within Table 4-04, but realistically only two plant species were considered possibly likely to occur within the Hatfield West gravel pit Study Area based on detailed rare or threatened plant searches over much wider areas in the two previous EIS investigations undertaken from surrounding land within 10km from the Study Area. These were Mossgiel Daisy (*Brachyscome papillosa*) and Cobar Greenhood (*Pterostylis cobarensis*). Targeted searches for these plants were conducted at

the opportune time for observation of these species, in mid-late October 2016 in a season of well above average rainfall. Only one threatened plant species, Mossgiel Daisy (*Brachyscome papillosa*) was found to occur within or immediately surrounding the Hatfield West Subject Sites of Pits A and C. Herbarium specimens of Mossgiel Daisy were collected for verification purposes and the identification to Mossgiel Daisy was confirmed at the Melbourne Royal Botanic Gardens (MEL) by Mr. Neville Walsh (Senior Conservation Botanist) in email correspondence on the 19th October 2016. Mossgiel Daisy (see Plate 4-09 and 4-10) is a New South Wales endemic species and is considered to be vulnerable in NSW as well as Australia. The species is listed under the NSW *Threatened Species Conservation Act* 1995 as well the Commonwealth's *Environment Protection and Biodiversity Conservation Act* 1999. Cobar Greenhood was not detected during the targeted rare plant surveys of the Hatfield West Study Area despite extensive searches for this species.

The occurrences of Mossgiel Daisy at and around the Pit A and Pit C sites has been shown in Figure 4-04. At Pit A, Mossgiel Daisy was found at eight locations within the Subject Site. At Pit C, Mossgiel Daisy was found to occur at one location within the Subject Site. At every site within both Pits A and C, Mossgiel Daisy was found as single plants, with the only occurrence with multiple plants being the location immediately north of Pit C. Mossgiel Daisy was found most commonly within Belah-Rosewood Woodland (see Plate 4-11)), but was also found in Yarran Shrubland (see Plate 4-12). The plants found were also always present with white ray florets and not mauve ray florets as suggested in Harden (1992). Both the habitat in which the species was found at Hatfield West as well as the occurrence of white ray florets on the flowers differs from the threatened species profile of OEH (2016) which is in need of amendment based on the information found within this study.

Plate 4-08: Mossgiel Daisy (*Brachyscome papillosa*) flowers showing the white ray florets.

Plate 4-09: Mossgiel Daisy has distinctive pinnatisect leaf with flowers held singularly on an extended peduncle.

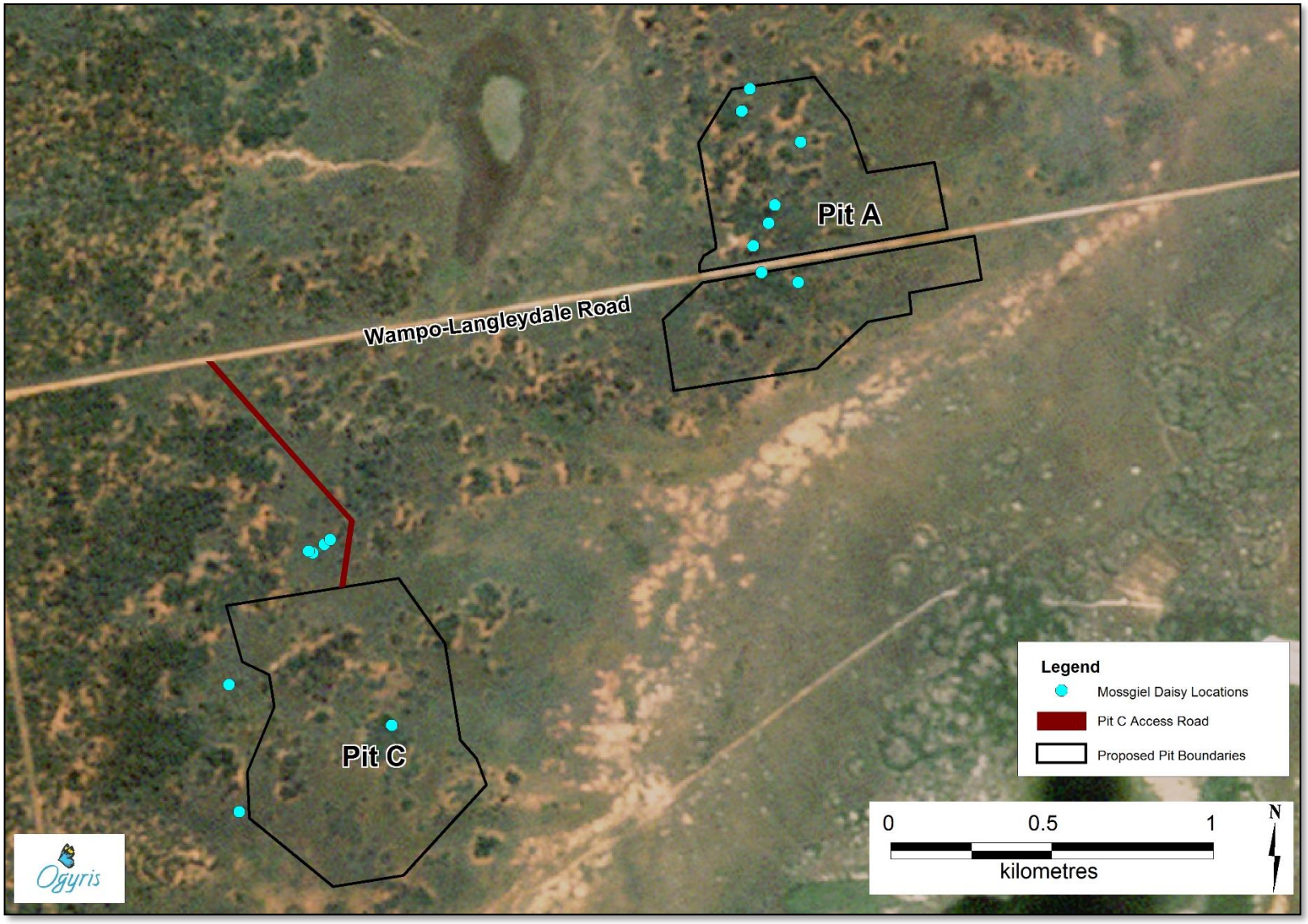

Figure 4-04: **Map showing the location of the NSW and Australian vulnerable Mossgiel Daisy (*Brachyscome papillosa*) at Pits A and C and surrounds.**

Plate 4-11: **Mossgiel Daisy location in Belah-Rosewood Woodland, just north of the Wampo-Langleydale Road in Pit A.**

Plate 4-12: **Mossgiel Daisy location in Yarran Shrubland, south of the Wampo-Langleydale Road at quadrat site C-02, immediately west of Pit C.**

A targeted search for Mossgiel Daisy was also conducted along the known MCTR location at the Langleydale-Magenta Road (see AMBS 2013). This was undertaken initially to ensure that the species was correctly identified within the Hatfield West Study Area, but also to understand the context for any plants found in our study. The distribution of this species along the MCTR was also mapped in greater detail than was presented by AMBS (2013), although that information is not presented here. At the MCTR site, the habitat is closely aligned with the published (PlantNet 2016) saltbush shrubland. Here the species was found in Bladder Saltbush (*Atriplex vesicaria*) Shrubland as well as Black Bluebush (*Maireana pyramidata*) Shrubland and ecotones grading between the two primary plant communities. The population of Mossgiel Daisy at the Langleydale-Magenta Road section of the MCTR has been estimated at greater than 200,000 plants, with the largest numbers occurring on the western side of the road. Plate 4-13 illustrates a Black Bluebush Shrubland with more than 50 plants per m². The population of Mossgiel Daisy at the Langleydale-Magenta Road location is considered a meta-population in optimal habitat for the species. The population is quite possibly the largest in New South Wales and is highly significant.

Plate 4-13: Mossgiel Daisy at the Langleydale-Magenta Road section of the Atlas-Campaspe MCTR on the 28th October 2016. At this location, plant densities were more than 50 plants per m². The population location is considered to be a meta-population in optimal habitat for the species.

The occurrences of Mossgiel Daisy within the Hatfield West Gravel Pit site are very small in comparison and probably represent outlier occurrences in sub-optimal habitat in an exceptional year for observation of this species. Well above average precipitation through late August and September 2016 must have led to a massive germination event for Mossgiel Daisy in chenopod shrublands along the Langleydale-Magenta Road section of the MCTR, as well as the occasional germination event in woodland vegetation away from this core meta population.

4.3.4 Threatened Plant Communities of the Hatfield West Area and Surrounds

The Atlas-Campaspe EIS flora investigation (AMBS 2013) found two threatened ecological plant communities occurred within the Study Area of that investigation. These were

- "Sandhill Pine Woodland in the Riverina, Murray-Darling Depression and NSW South Western Slopes Bioregions", known in this report as Sandhill Pine Woodland; and
- *Acacia melvillei* Shrubland in the Riverina and Murray-Darling Depression Bioregions, known in this report as Yarran Shrubland.

Both of these plant communities were found to occur within the Hatfield West Study Area, including within the Subject Site of the proposed gravel pit sites. Figure 4-05 shows the location of both of these plant communities at the Pit A and C location.

Sandhill Pine Woodland Sandhill Pine Woodland occurs over 1.43 Ha and 1.24 Ha at Pit A and C respectively. At Pit A, Sandhill Pine Woodland also occurs at four locations surrounding the Subject Site comprising an appreciably greater distribution of 14.1 Ha. Figure 4-02, from earlier in this chapter, shows the location of Sandhill Pine Woodland both within, and immediately surrounding the Pit B Subject Site. A dis-used quarry has been excavated into a dune at this location and has removed approximately 2 Ha of Sandhill Pine Woodland. The Pit B Subject Site also includes 2.22 Ha, but a further 19.5 Ha also surrounds this proposed area of disturbance. All of the Sandhill Pine Woodland at the Hatfield West Subject Site (Pits A, B and C) and surrounds is degraded, with vastly diminished tree and large shrub (Black Bluebush) density.

Yarran Shrubland At Pit C, Yarran Shrubland occurs primarily around the western side of the Pit C Subject Site, but two patches are contiguous with it and total 0.53 Ha. The Yarran Shrubland in this area is all in poor condition with vastly diminished canopy cover.

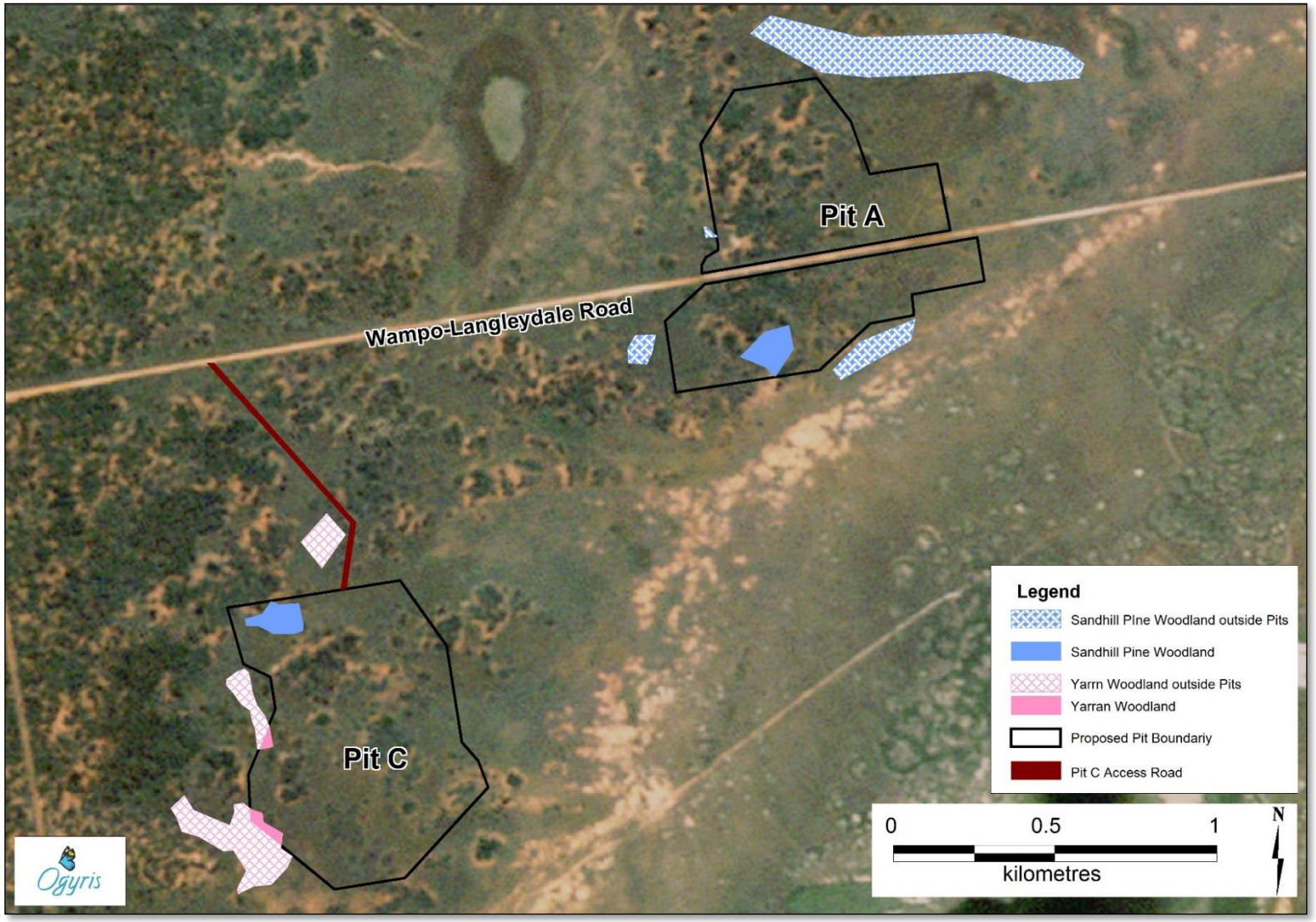

Figure 4-05: **Map showing the distribution of the NSW listed endangered ecological plant communities known as Sandhill Pine Woodland and Yarran Shrubland at Pits A and C and surrounds.**

CHAPTER 5 FLORA IMPACT ASSESSMENT

5.1 Potential Impacts

The Hatfield West gravel pits would impact biodiversity, including threatened biodiversity, through both direct and indirect impacts during construction and operation. The majority of impacts on biodiversity would occur as a result of direct impacts inside the Subject Site through clearing of native vegetation and removal of habitat for a range of flora species and plant communities. Indirect impacts are also considered within the overall assessment of impacts.

Impacts on biodiversity would occur over the operational life of the Hatfield West gravel pits, despite revegetation of the gravel extraction areas taking place concurrently with decommissioning of completed areas. Rehabilitation of the gravel extraction areas will be important in mitigating long-term impacts from removal of native vegetation from the Subject Site, but will also provide the opportunity to re-establish threatened plant communities and the known threatened plant species cleared from the site. This is discussed further in the following 'Chapter 6 Avoidance Management and Mitigation'.

5.2 Direct Impacts

The main impact on biodiversity associated with the Hatfield West gravel pit development is clearing of native vegetation and removal of habitat, including threatened flora species habitat within the disturbance area.

5.2.1 Loss of Remnant Vegetation

The maximum extent of clearing of remnant native vegetation associated with this project would be 108.78 Ha. A further 4.63 Ha of existing cleared vegetation along fencelines and tracks, and within dis-used quarry areas would also form part of the development. Table 5-01 attempts to summarize the loss within the context of the vegetation remaining within the Southern Mallee Region as well as the Lower Murray-Darling Catchment. The two major plant community groupings occurring within the Subject Site of the Hatfield West gravel pits are Belah-Rosewood Woodland and Bluebush-Grassland Mosaic. Together, they comprise ~88% of the vegetation present. Along with Chenopod Sandplain Mallee, Belah Woodlands and Chenopod Shrublands (incorporating the degraded mapping unit Bluebush-Grassland Mosaic as well as Pearl Bluebush Shrubland) comprise the majority of the vegetation in the Southern Mallee Region of NSW. None are threatened, although Chenopod Sandplain Mallee, a very minor component (<1%) of this study, is over-cleared within the lower Murray-Darling Catchment Region.

Table 5-01: Summary table comparing the area proposed for gravel pit clearance with estimated catchment loss of the same vegetation communities. The proportion of those communities occurring within the Southern Mallee Region has also been shown.

Vegetation Community	Community Conservation Status	Area (Ha) to be Cleared by Gravel Pit Development	Location	Estimate (%) of Vegetation Community Cleared in Lower Murray-Darling Catchment (OEH 2012)	Proportion (% of the Total) Existing Within the Southern Mallee
Semi-arid Woodlands					
Belah-Rosewood Woodland	NT	53.93	Pit A and C	20	16.7
Chenopod Sandplain Mallee	NT	1.02	Pit A and C	30	8.9
Belah-Rosewood/Chenopod Mallee Mosaic	None	0	N/A	Unknown	5.0
*Sandhill Pine Woodland	E	4.89	Pit A, B and C	50	NR
Arid Shrublands					
*Yarran Shrubland	E	0.53	Pit C	60	NR
Pearl Bluebush Shrubland	NT	2.70	Pit C	10	36.0
Bluebush-Grassland Mosaic	LC	45.71	Pit A, B and C	Unknown	

Community Conservation Status **E = Endangered**
NT = Near Threatened
LC = Least Concern

5.2.2 Loss of Threatened Species and Plant Communities

Threatened Plant Communities Although degraded, the most significant impact to remnant vegetation associated with this study will be the loss of 4.89 Ha of Sandhill Pine Woodland which has already suffered ~50% clearance from the Lower Murray-Darling Catchment along with >70% from other parts of the plant community's distribution across the Lachlan, Murrumbidgee and Murray Catchments (Benson *et al.* 2006). Of lesser direct impact would be the loss of 0.53Ha of Yarran Shrubland, which is also in poor condition, but also extensively over-cleared within the Lower Murray-Darling Catchment (~60%). Both of these plant communities provide significant opportunity for rehabilitation within the post extraction future of the gravel pits (see Chapter 6), as well as from enhancement of surrounding vegetation.

Threatened Plants Assessments of Significance were completed for 30 plants considered possibilities to be present within the Hatfield West Gravel Pit Project Area (see Table 5-02). Only one species, Mossgiel Daisy (*Brachyscome papillosa*) was actually found in this study, whilst another, Cobar Greenhood (*Pterostylis cobarensis*), was considered a possibility to occur there. A Seven Part Test was conducted on both of these species (see Appendix 2) and neither were predicted to be significantly impacted by the Hatfield West Gravel Pit Project.

Table 5-02: Assessments of Significance for 30 plants considered possibilities to be present within the Hatfield West Gravel Pit Project Area.

SPECIES	COMMON NAME	EPBC STATUS	TSC STATUS	LIKELIHOOD OF OCCURRENCE	POTENTIAL FOR IMPACT	COMMENTS ON KNOWN ECOLOGY
Acacia acanthoclada	Harrow Wattle		e	None - no suitable habitat in Project Area.	None	Found primarily in deep sand mallee community dune crests which do not exist within the Project Area. The nearest plants recorded (NPWS Atlas records) occur on the western side of the Willandra Lakes WHA approximately 80 km to the NNW.
Acacia carneorum	Purple Wood Wattle	V	v	Unlikely to be Present Within the Project Area	None	Although nominally suitable habitat is present as Belah Woodlandcommunity, the Project Area is a considerable distance east of the known distribution of this species.
Acacia notabilis	Stiff Golden Wattle		e	Unlikely to be Present Within the Project Area	None	The few records of this species from the Murray Mallee region of New South Wales and Victoria indicate a preference for mallee communities (Harden 1991; Walsh & Entwisle 1996). An extremely rare plant in both states but may be present in the high quality mallee dune fields that characterize the Prungle MLA. Widespread and occasionally common in South Australia, occurring in areas receiving 200-500mm rainfall (Whibley and Symon 1992). Unlikely to be present within the Project Area.
Acacia rivalis	Creek Wattle		e	None - no suitable habitat in Project Area.	None	Confined to woodland communities near Broken Hill, bordering ephemeral creeks and streams and along watercourses. It grows in a variety of stony soils, often with limestone content.
Atriplex infrequens	Saltbush	V	v	None - no suitable habitat in Project Area.	None	*Atriplex infrequens* is associated with broad drainage tracts (Cunningham et al. 1992), clay flats and possibly occasionally inundated habitats which are not present within the Project Area
Austrostipa metatoris	speargrass	V	v	Unlikely to be Present Within the Project Area	None	Occurs across three of Harden's botanical sub-divisions of New South Wales (viz. SFWP, SWP and CWS). Known from the Euston and Kyalite areas although ecology of the species, apart from a comment by Harden (1993) concerning a preference for sandy sites, is very poorly known. Considered unlikely to occur within the Project Area.
Austrostipa nullanulla	Club Speargrass		e	None - no suitable habitat in Project Area.	None	Exclusively found on gypseous (copi) rises which are widespread in the Willandra Lakes WHA, but are not represented within the Project Area.

SPECIES	COMMON NAME	EPBC STATUS	TSC STATUS	LIKELIHOOD OF OCCURRENCE	POTENTIAL FOR IMPACT	COMMENTS ON KNOWN ECOLOGY
Austrostipa wakoolica	Speargrass	E	e	Unlikely to be Present Within the Project Area	None	Grows on floodplains of the Murray River tributaries, in open woodland on grey, silty clay or sandy loam soils; habitats include the edges of a lignum swamp with box and mallee; creek banks in grey, silty clay; mallee and lignum sandy-loam flat; open Cypress Pine forest on low sandy range; and a low, rocky rise.
Brachyscome papillosa	Mossgiel Daisy	V	v	**Known** to be Present Within the Project Area.	**Low** - will be impacted. See assessment of significance. A significant impact is not likely.	Recorded in clay and clay loam soils in Bladder Saltbush and Black Bluebush shrublands nearby to the Project Area, along the Atlas-Campaspe MCTR in the EIS invesitigation by Cristal Mining Australia. Found within Pit A and Pit C, all as single plants.
Callitriche cyclocarpa	Western Water Starwort	V	v	None - no suitable habitat in Project Area.	None	In NSW only recorded at 'The Gut' near Koraleigh, on the floodway from the Murray to Wakool River, about 26 km NNW of Swan Hill.
Calotis moorei	Moore's Burr-daisy	E	e	Unlikely to be Present Within the Project Area	None	Moore's Burr-daisy occurs on red-brown fine sand in relatively flat areas on upper areas of low sandhills which are not present within the Project Area.
Casuarina obesa	Swamp Sheoak		e	None - no suitable habitat in Project Area.	None	Requires moist, slightly saline soils. Potential habitats include shorelines of permanent, ephemeral or relict lakes. These systems may be freshwater or saline-influenced judging by the present distribution of the species. In NSW, associated species include *Eucalyptus camaldulensis*, *E. largiflorens* and *Acacia stenophylla* with the understorey dominated by grasses and sedges.
Convolvulus tedmoorei	Bindweed		e	None - no suitable habitat in Project Area.	None	Grows in self-mulching grey clay soils on the floodplains of the Darling and Murrumbidgee Rivers. No suitable habitat within the Project area.

SPECIES	COMMON NAME	EPBC STATUS	TSC STATUS	LIKELIHOOD OF OCCURRENCE	POTENTIAL FOR IMPACT	COMMENTS ON KNOWN ECOLOGY
Cratystylis conocephala	Bluebush Daisy		e	Unlikely to be Present Within the Study Area	None	Found in Belah Woodland in Victoria (IRKS personal observation), in bladder saltbush communities in Western Australia (Mitchell and Wilcox 1988) and in Belah Woodland (Ayers et al. 1996) and Chenopod Shrublands (M. Westbrooke personal communication) in western New South Wales (near Wentworth and at Nanya Station). An easily recognizable plant that would have been recorded if present within the Study Area. Unlikely to be present within the Project Area.
Dodonaea stenozyga	Desert Hop-bush		ce	None - no suitable habitat in Project Area.	None	Discovered at Nanya Station in a Scotia Land System broad sandy swale (M. Westbrooke personal communication). No suitable habitat within the Project Area.
Kippistia suaedifolia	Fleshy Minuria		e	None - no suitable habitat in Project Area.	None	Restricted to gypseous (copi) flats and low rises around saline discharge complexes. No suitable habitatis present within the Project Area.
Lasiopetalum behrii	Pink Velvet-bush		ce	None - no suitable habitat in Project Area.	None	Widespread on suitable substrates mostly in mallee communities and heaths in South Australia and Victoria. Single record from New South Wales collected from a mixed Chenopod Mallee-Belah Woodland swale in Mandelman Land System approximately 40 km south of Pooncarie by the lead author in 1997. A lack of suitable sandy substrate precludes any chance of this species being present.
Lepidium monoplocoides	Winged Peppercress	E	e	None - no suitable habitat in Project Area.	None	Recorded from a range of habitats in semi-arid and arid southwest New South Wales (Ayers et al. 1996), although seemingly restricted in semi-arid northwest Victoria to the margins of floodplain woodlands and saline shrublands. A possibility to occur on or around the relict lakebeds to the east of the Project Area, but a lack of suitable substrate and vegetation community types renders the site unsuitable.

SPECIES	COMMON NAME	EPBC STATUS	TSC STATUS	LIKELIHOOD OF OCCURRENCE	POTENTIAL FOR IMPACT	COMMENTS ON KNOWN ECOLOGY
Leptorynchos waitzia	Button Immortelle		e	Old records from within 100 km either side of the Project Area. Unlikely to be present within the Project Area.	Unlikely	Widespread in semi-arid regions of South Australia with a more restricted distribution in western Victoria where the taxon is considered vulnerable. The only recent record known from western New South Wales was collection from Bluebush shrublands at Kinchega National Park with three 19th Century records from the Prungle Lakes on the western side of the the Willandra Lakes World Heritage Area, Buronga and Booligal.
Maireana cheelii	Chariot Wheels	V	v	Unlikely to be Present Within the Project Area	None	Soils include heavy brown to red- brown clay-loams and hard cracking red clay. Tends to grow in shallow depressions, often on eroded or scalded surfaces, and does not extend to elevated well drained soils in the habitat. It has been found on the edges of bare, windswept claypans, in shallow depressions.
Pimelea serpyllifolia ssp serpyllifolia	Thyme Rice-flower		e	None - no suitable habitat in Project Area.	None	Only one record of this plant known from New South Wales where found adjacent to the Sturt Highway 31km west from Euston in mallee. Widespread in Victoria and South Australia where known from numerous coastal locations along with a few Mallee locations (Walsh & Entwisle 1996). No suitable habitat within the Project Area.
Pterostylis cobarensis	Cobar Greenhood		v	Possibility to be present based on occurrence 4 km NNE in Atlas-Camapspe Study Area.	**Low** - but may possibly be impacted. See assessment of significance. A significant impact is not likely.	Habitats are eucalypt woodlands, open mallee or native pine woodlands on sandy-loam soils. Potential habitat for the species within the Project Area includes the very small areas of Chenopod Sandplain/Swale Mallee Woodland (LM116) as well as the White Cypress-pine Woodland.The species is known to be present at a site approximately 4 kms to the north of the Project Area (Resource Strategies 2013).
Santalum murrayanum	Bitter Quandong		e	None - no suitable habitat in Project Area.	None	The few records of this species from New South Wales indicate a preference for sandy mallee communities (Harden 1992). Extremely rare in New South Wales but known to occur in very low numbers in Spinifex-Mallee. Present nearby to the Project Area in Spinifex-Mallee, but no suitable habitat for this species at the Hatfield West site.

SPECIES	COMMON NAME	EPBC STATUS	TSC STATUS	LIKELIHOOD OF OCCURRENCE	POTENTIAL FOR IMPACT	COMMENTS ON KNOWN ECOLOGY
Solanum karsense	Menindee Nightshade	V	v	None - no suitable habitat in Project Area.	None	New South Wales endemic mostly restricted to lakebed herbfields, black box woodland and run-on areas of the Lower Darling and Lower Murrumbidgee River areas of far south-western New South Wales. Habitats are generally lake beds or floodplains of heavy grey clays with a highly self-mulching surface. Also found on sandy floodplains and ridges and in calcareous soils, red sands, red-brown earths and loamy soils.
Swainsona adenophylla	Violet Swainson-pea		e	None - no suitable habitat in Project Area.	None	NSW records for this species indicate a preference for red sandy or stony flats near lake margins (Harden 1991). Herbarium record from Kinchega NP, but no records from within 100km of the Study Area. Unlikely to be present within the Study Area.
Swainsona colutoides	Bladder Swainson-pea		e	None - no suitable habitat in Project Area.	None	Nearest known occurrence to the Study Area is a 1995 collection from east of Trentham Cliffs, approximately 120 km to the south west. Also present in the Scotia Country and nearby Danggali CP, the latter in South Australia. Possibly restricted to mallee woodlands.
Swainsona flavicarinata	Yellow-keeled Swainson-pea		e	None - no suitable habitat in Project Area.	None	Grows in deep red sand, recorded from a roadside on a treeless plain in NSW. In central Australia, the species grows in mulga communities on red earths and on stony soils supporting Bladder Saltbush. Also found on sandy plains and ridges, in grassland, and in watercourses and floodplains near creeks or rock holes.
Swainsona murrayana	Slender Darling Pea	V	v	Unlikely to be present Within the Study Area	Unlikely	Rare but widespread and found in Bluebush Shrublands, bladder saltbush, grassland, inland floodplains, run-on and groundwater discharge areas across the semi-arid to arid parts of South Australia, Victoria and New South Wales. Palatability to stock and kangaroos may restrict chances of finding this taxon.

SPECIES	COMMON NAME	EPBC STATUS	TSC STATUS	LIKELIHOOD OF OCCURRENCE	POTENTIAL FOR IMPACT	COMMENTS ON KNOWN ECOLOGY
Swainsona pyrophila	Yellow Swainson Pea	V	v	None - no suitable habitat in Project Area.	None	Mainly occurring in mallee communities of the Murray Mallee region of South Australia, Victoria and New South Wales. Short-lived and only appears after fire or disturbance (e.g. track construction/grading) which restricts the chances of finding this taxon. Found in primarily Chenopod Mallee vegetation in spring 2002 at Prungle Station on the western side of the Willandra Lakes World Heritage Area Property. Lack of suitable habitat suggests an ulnlikely presence within the Project Area.
Swainsona sericea	Silky Swainson Pea		v	Unlikely to be Present Within the Project Area.	Unlikely	Widespread distribution in New South Wales and Victoria and apparently threatened in both States - and possibly extinct from South Australia. Chances of recording this taxon would be very low due to a lack of suitable habitat, but Sandhill Pine Woodland may provide suitable habitat.

5.3 Indirect Impacts

Indirect impacts will occur within and adjacent to the project area as a result of gravel pit construction and operation. Such impacts will largely be restricted to the short to medium term associated with the life of each gravel pit. These impacts can also be mimimized through a suite of sympathetic management procedures.

A range of indirect impacts are likely to, or could, occur as a result of the Hatfield West gravel pits project. These include:

- increased noise and dust from gravel pit construction and operation;
- loss of connectivity and fragmentation of habitats at a local scale through clearing of intact areas of native vegetation within the project area;
- erosion or sedimentation in areas adjoining the gravel pits;
- increased spread of weed propagules;
- increased edge-effects for surrounding vegetated areas; and
- changes in vegetation composition and structure.

The indirect impacts described above are variable in terms of the distance they may extend from actual disturbance areas. Incorporation of buffer areas would also serve to mute indirect impacts and with respect to this study, a boundary buffer edge of 10 m along roads and tracks and 20m around the Pit perimeters is recommended.

5.3.1 Edge Effects

Edge effects are those changes that may occur to a population or community at the edge of a patch of vegetation or habitat. Developments that create new edges (for e.g. through vegetation clearing) will have edge effects on the surrounding remnant vegetation or habitats. Introduction of disease, weeds and predators, as well as management activities such as weedicide control and fencing are examples of edge effects. The establishment of the Pits A and C and the expansion of Pit B would create a number of new edges.

Alterations to the local habitat condition and flora species composition are likely to occur in habitats adjacent to the new edges. The new edges could facilitate the establishment and spread of introduced plant species and may also lead to a potential increased impact from Feral Goats which are common across the Study Area. The operator of the gravel pits will have to incorporate appropriate management strategies, imbued within a Biodiversity Management Plan to plan for minimal impacts as a result of Edge Effects.

It should be noted the Hatfield West Gravel Pit Project would involve appropriate monitoring and control measures to counter act weed invasion and pest control.

5.3.2 Weeds

Weeds have the opportunity to establish themselves in areas of disturbed vegetation, and although only small in area, 37 alien plant taxa are already known from the Study Area, including the common presence of a weed of National Significance in African Boxthorn (*Lycium ferocissimum*), which is listed for control within the Balranald SC Control Area.

The Hatfield West Gravel Pit Project has the potential to increase or lead to the establishment of weed species where they do not currently exist through the operation of machinery during construction and operation phases, or through the impact of changed stock and Feral Goat movement patterns. New weed species can potentially be introduced as a result and an example from the broader Locality is the first record for NSW of the alien taxon Sprawling Marigold (*Oligocarpus calendulaceus*). This species was recorded by the authors in Yarran Shrubland in the Vegetation Offset study associated with this project from Cristal's' Boree

Plains property. This plant taxon sporadically occurs across the arid zone part of the Nullabor Plain in Western and South Australia from Norseman to Port Augusta, with an occurrence at the NSW-SA border as well. A watch for further spread of this weed species is flagged for the State of NSW and control measures will need to be implemented if the species arrives within the Study Area.

5.3.3 Erosion

The Hatfield West Gravel Pit Project is located in area where undulating flat plains are interspersed with dunes. The dune landscapes are few, but are characterized by sandy loam topsoils which are notorious for their susceptibility to wind erosion once remnant vegetation has been removed. From experience at the Ginkgo and Snapper Mines at Pooncarie West, even plains comprised of clay loam soils will also erode from winds once threshold speeds of approximately 30 kph are achieved (John Leys, *personal communication*). Soil stripping, storage and replacement strategies will need to be cognizant of the potential for wind erosion to valuable topsoil and appropriate management strategies will be required to prevent wind erosion. Such strategies could include, but not be restricted to:

- use of mulch
- use of mulch slurries over newly bare surfaces
- physical wind breaks/barriers
- cover crops

5.3.4 Dust

Dust from the construction and operation of the Hatfield West Gravel Pit Project has the potential to impact the function of plants through reduced photosynthetic activity as well as making the plants susceptible secondary stresses, such as drought, insects and pathogens. Dust impacts will be mitigated through the onsite use of water suppression and the progressive rehabilitation of disturbance across gravel pit areas.

5.3.5 Noise

Impacts of noise generated within the project area are likely to have the greatest impact on fauna biodiversity values with flora values largely unimpeded.

5.3.6 Loss of Connectivity

The Hatfield West Gravel Pit Project would be situated within a large expanse of native vegetation which has been subjected to stock and feral animal grazing and browsing impacts for over 100 years. Connectivity losses would be primarily restricted to fauna, but some minor flora loss of connectivity will occur through an alteration to localized pollination efficiency and function. The progressive rehabilitation of gravel pit sites will assist with mitigation of this impact.

5.3.7 Fire

Historically, bushfires within the Western Division of NSW tend to be associated with rapid growth of Speargrass (*Austrostipa* spp.) following above average rainfall periods. During summer, following rain events usually associated with lightning, dry swards of grasses pose a bushfire hazard (AMBS 2013) for Western Division vegetation of almost all types. Vehicles with hot exhausts driven through Speargrass swards can lead to fires. The Biodiversity Management Plan will need to incorporate bushfire management protocols, due to the serious risk of fire. This is especially relevant to the two endangered ecological communities present, both of which have clearly suffered impact from fire in the past.

5.3.8 Conservation Reserves

The juxtaposition of the site immediately to the east of the Willandra Lakes World Heritage Area Property (WLWHAP) is also of significance, as this formerly active wetland area conserves a diversity of habitats including lakebeds, lunettes and arid woodlands of international significance. The WLWHAP occupies approximately 240,000 Ha or almost 3% of the Murray-Darling Depression Bioregion. Approximately 10% of the WLWHAP is conserved within Mungo National Park. A number of sizable private conservation reserves also exist on nearby properties including Wampo and Boree Plains.

5.4 Cumulative Effects

Cumulative impacts are the successive, incremental and combined impacts (both positive and negative) of an activity on society, the economy and the environment (Franks *et al*. 2010). They can arise from the compounding activities of a single operation given the interaction of that operation with past, current and future activities that may or may not be related to the existing development. Cumulative impacts may also arise through the interaction of one development with other types of activities and industries, such as grazing and broad scale agriculture.

In relation to the Hatfield West Gravel Pit Project, the cumulative impacts are considered to be the total impact on the environment that would result from incremental impacts (including both direct and indirect impacts) from the development, added to other existing impacts and proposed developments in the Locality and Region.

The primary cumulative impacts of the Hatfield West Gravel Pit Project are associated with the direct and indirect impacts outlined in Sections 5.2 and 5.3, respectively above. The condition and composition of the habitat to be cleared as a result of the Hatfield West Gravel Pit Project has been outlined in detail in Chapter 4. Impacts which are likely to be cumulative within the Hatfield West Gravel Pit Project area include the clearing of vegetation, loss of individuals of threatened plants, potential increases in feral animal populations and weed invasion. It is likely that the accumulating impacts would increase with the area of disturbance at any one time, balanced to some degree by progressive rehabilitation of completed sites and enhancement of surrounding remnant vegetation sites. The cumulative impacts listed may not be fully expressed until well after completion of gravel extraction due to the innate character of semi-arid woodlands whereby regeneration is usually dependent on high rainfall events for completion of reproductive success, with seedlings and young plants significantly prone to grazing by stock, Feral Goats and rabbits.

The Hatfield West Gravel Pit Project would add, albeit in a minor way, to the cumulative impacts of the Atlas-Campaspe Mine 3-10 km to the west, as well as, if approved, to the cumulative impacts of the proposed Balranald North Project located to the south. The cumulative impact of the development of both mineral sands mine developments within what can be termed the "Balranald North Mineral Sands Mining Precinct" would total approximately 9,318 Ha and would add a further 1.2% of disturbance to remnant vegetation associated with mining in the Region.

The Atlas-Campaspe Mine will result in impacts to the following threatened flora (*Brachyscome papillosa*, *Lepidium monoplocoides, and Pterostylis cobarensis*) and their habitats which were found within the disturbance areas: (AMBR 2013). The Hatfield West Gravel Pit Project would add further losses to the presence of *Brachyscome papillosa* in the Locality, but the number of plants lost will be infinitesimally small when compared to the size of the meta population of this species present within the margins of the Langleydale-Magenta Road part of the Atlas-Campaspe MCTR. No loss of the other threatened species found within the Atlas-Campaspe Mine area is anticipated to occur. The habitat for *Brachyscome papillosa* present within the Subject Site of this study would be lost, but as was explained in Chapter 4, the woodlands present are considered outlier occurrences in sub-optimal habitat in an exceptional year for observation of this species.

The main industries and land uses in the surrounding locality are cattle, sheep and Feral Goat grazing in remnant native vegetation, some minor cropping as well as nature conservation. The Hatfield West Gravel Pit Project will not disturb any current cropping areas but will lead indirectly, to the expansion of the area set aside in perpetuity for nature conservation through the dedication of a Biodiversity Offset which would be conserved in perpetuity. Measures such as this would mitigate the cumulative effects of the gravel pit development and are discussed further in the following chapter on mitigation measures.

Whilst the Hatfield West Gravel Pit Project will result in an increase in degradation to natural ecosystems within the Murray Darling Depression Bioregion, it should be noted that the Project will also involve an offset that will contribute to managed conservation areas within the Bioregion. Another positive will include an upgraded road access from the Balranald-Ivanhoe Road west towards properties in the Mungo NP area.

CHAPTER 6 AVOIDANCE MANAGEMENT AND MITIGATION

In accordance with OEH Request 7 (see Chapter Table 1-02), the Hatfield West Gravel Pit EIS must demonstrate how the "Project Avoids and Minimizes Impacts" on biodiversity values of the Project area. This chapter of the report outlines the avoidance, management and mitigation measures that Cristal will or has employed for the project to reduce impacts on biodiversity values. Chapter 7 of this report describes the offset strategy for the Hatfield West Gravel Pit Project to account for residual impacts that cannot be avoided or mitigated.

Avoidance, management and mitigation measures associated with each stage of the Hatfield West Gravel Pit Project are outlined in the following sections. The four broad stages of the project include:

Stage 1 Project design

Stage 2 Construction

Stage 3 Operation

Stage 4 Rehabilitation and closure.

It is recognized that some of these stages may actually overlap, such that rehabilitation may actually be occurring at one gravel pit as another is being constructed, although the eventual gravel pit schedule for development has not actually been designed as yet.

A key feature of documenting and carrying out management activities to avoid and mitigate impacts from the Hatfield West Gravel Pit Project will be the formulation of a Biodiversity Management Plan (BMP) for the life of the project. The BMP will also cover management activities for threatened biodiversity (see Section 6.5).

6.1 Project Design

Project design relates to site selection, designing and re-designing elements of the project to minimize vegetation clearing, avoid impacts to significant habitats and vegetated corridors as well as to avoid direct impacts to threatened biodiversity values.

6.1.1 Site Selection

The initial design of the Hatfield West Gravel Pit Project in January 2016 involved two pits – Pit A and Pit B. As the project evolved, it became obvious that the quantity of calcrete resource available at these two pits, particularly Pit B where a large area of the EEC Sandhill Pine Woodland occurred, would be insufficient to maintain the gravel roads along the Atlas-Campaspe MCTR over the life of the project, estimated at 20 years. Pit C was added in September 2016. Calcrete road base of sufficient quality is in short supply in the northern sections of the Balranald SC LGA. Consequently, the location of the gravel pits reflects a compromise between local availability of high quality resource, proximity to the Atlas-Campaspe MCTR, ease of extraction and avoidance of threatened pant communities wherever possible.

6.1.2 Design Considerations

Cristal has aimed to avoid and minimize environmental impacts from the Hatfield West Gravel Pit Project during the design process. Generally, this process has involved:

- Attempts to find existing quarried resources in close proximity to the Atlas-Campaspe MCTR;

- overlay and consideration of the preliminary project footprint on aerial photography to avoid treed remnant vegetation wherever possible;
- consideration of cadastral information, property boundaries, existing roads and utility corridors;
- baseline vegetation surveys to identify and confirm ecological constraints within the project area and surrounds; and
- where significant features could not be avoided, identification of mitigation measures to minimize impacts, or commitment to compensation (i.e. offset measures) if impacts are not able to be sufficiently mitigated.
-

Specific principles adopted to avoid or minimize impacts on biodiversity are discussed below for the combined gravel pit footprint as well as access roads.

Pit A The original design of Pit A included a larger area of Sandhill Pine Woodland to the south of the current proposed footprint. This has conservatively avoided approximately 5 Ha of Sandhill Pine Woodland and minimized the area of impact to the south of the Wampo-Langleydale Road to 1.43 Ha of this plant community type. Further revision of the design may be possible to avoid even more of this EEC.

Pit B The original design of Pit B surveyed in January 2016 included a large proportion of the Sandhill Pine Woodland to the east of the current footprint. The original design included an additional 5 Ha of this plant community which would have increased the total impact at the Pit B location from the current 2.22 Ha to something exceeding 7 Ha. The access road at this site also follows an existing road, and a fence will be constructed on both sides of this road into and out of the site to direct traffic along dedicated road corridors only, thus reducing the impact to the surrounding dune where Sandhill Pine Woodland occurs.

Pit C The Pit C location is not located next to a road. A route was chosen through disturbed grassland habitat which avoids impact to all but a few small Rosewood (*Alectryon oleifolius* ssp. *canescens*) trees, ending up at the Wampo-Langleydale Road 700 m to the north. A small bend in the access road just north of Pit C avoids traversing through a patch of Yarran Shrubland where a number of specimens of the threatened Mossgiel Daisy occur.

6.2 Construction

Impacts arising from the construction of the Hatfield West gravel pits and their associated infrastructure and access roads will primarily relate to vegetation clearing. Cristal proposes to undertake vegetation clearing in accordance with the following mitigation and management actions.

6.2.1 Vegetation Clearance

Pre-clearance Surveys Gravel pit pre-clearance surveys would primarily be undertaken to assess whether threatened bat species were living within the Belah-Rosewood Woodlands present at Pits A and C. With respect to threatened flora, the selected pre-clearance areas would be searched for Mossgiel Daisy prior to clearing and construction works, with any propagules (seed) collected from plants and stored for subsequent use in the rehabilitation program. Pre-clearance surveys for Mossgiel Daisy should be undertaken at an appropriate time of the year such as spring (September-November) when the plants are most likely to be in flower and seeding and can be readily identified. Whole plants should also be removed from pre-clearance areas, on-grown and seed collected from these plants.

Timing of Clearing Timing of clearing again, would largely be driven by avoiding the period during the year when bat species may be present in tree hollows either with live young or

during pregnancy. This means tree clearing should effectively avoid the window from late winter (mid July) to early summer (December).

Clearing Method The clearing method employed would be similar to that used at Cristal's Pooncarie West Mining Precinct where two bulldozers dragging a linked chain literally pull the trees down to ground level. The tree litter is then stored as stockpiles for subsequent use as mulch in the rehabilitation program.

Pre-clearance Protocols A Vegetation Clearance Protocol should be prepared along the lines of that currently in operation at Cristal's Pooncarie West Mining Precinct.

6.2.2 Fencing and Signposting

A combination of fencing and/or the use of highly visibility hazard tape would be used to delineate the boundary of vegetation pre-clearance areas. Signposting will also be used to inform project personnel and site visitors of areas of active extraction and rehabilitation works areas. Speed limit and warning signs would also be erected along the Wampo-Langleydale Road (Pits A and C) as well as the Langleydale-Balranald Road (Pit B) to inform local traffic of the existence of the gravel pits as well as entering and exiting vehicular traffic.

6.2.3 Pest and Weed Management

Pest and weed management activities will be prescribed in the BMP and will include:

- management protocols for feral animals such as foxes, goats, pigs and cats within the rehabilitation area;
- management protocols for the identification of noxious or important environmental weeds within areas to be cleared; and
- avoidance protocols to prevent transporting the weed seeds to rehabilitation areas.

6.3 Operations

The majority of the impacts on biodiversity values will occur in the construction phase of the Hatfield West Gravel Pit Project, however mitigation of direct and indirect impacts which may arise from the operational phase of the project includes the following:

- minimization of dust generation by restricting the extent and time that bare soil is exposed;
- dust suppression activities involving any or all of the use of water carts on roads, sprinklers, vegetation mulch, mulch slurries) where relevant through the project area;
- ensuring vehicles remain on designated roads and tracks through use of signposting and driver education during the induction process and in ongoing project discussions; and
- management and removal of all rubbish from the project area.

6.4 Rehabilitation and Closure

As sections of the gravel pits are decommissioned, progressive rehabilitation will occur. Best practices for rehabilitation, drawing on previous experience as well as from reports and publications (e.g. Squire *et al.* 2012; Sluiter *et* al. 2016) arising from Cristal's Pooncarie West Mining Precinct will guide management with respect to the Closure and Rehabilitation Strategy. An indicative six-step approach is outlined in Table 6-01.

The Closure and Rehabilitation Strategy will be under-pinned by embracing the importance of Step 5: "Restoring self-regenerating vegetation types comprised of indigenous plant taxa in vegetation community types similar to those occurring in surrounding areas".

Table 6-01: Conceptual rehabilitation step-wise model outlining rehabilitation criteria, measurement targets and evidence for completion.

Criteria	Measure/Target	Evidence for Completion
Step 1: Undertake gravel pit pre-clearance flora and fauna surveys in accordance with a Hatfield West 'Vegetation Pre-clearance Protocol'.	Gravel pit pre-clearance surveys undertaken. Threatened flora species recovered where possible for later use in the rehabilitation program. Wildlife captures documented and threatened fauna species managed within the mantra of a 'Threatened Species Management Protocol'. Captured wildlife returned to similar vegetation types in Cristal Offset areas.	Gravel pit pre-clearance survey reports written and included within the Hatfield West Gravel Pit Annual Environmental Report (AEMR).
Step 2: Soil stripping, removal and storage undertaken in accordance with a Gravel Pit Operations Plan (GPOP).	Topsoil and subsoil stockpiles constructed with appropriate batter angles and heights and protected from erosion by appropriate means such as mulch slurries.	Survey control of completed earthwork structures and work programs. Topsoil stockpiles monitored for vegetation cover and weed presence.
Step 3: Subsoil and topsoil retuned in accordance with the Hatfield West GPOP.	Cristal Earthworks Supervisor and Rehabilitation Officer to ensure target sub-soil and topsoil depths achieved and no plant root impeding layers are present.	Survey control of completed earthwork structures and work programs. Amelioration (ripping and/or gypsum application) of root impeding layers undertaken if required.
Step 4: Achieve stable, non-eroding landforms that can support indigenous native vegetation.	Soil profiles reconstructed with no significant limitations to revegetation.	Soil survey assessments undertaken as part of a Hatfield West Vegetation Monitoring Strategy to ensure long-term rehabilitation landscape stability.
Step 5: Restore self-regenerating vegetation types comprised of indigenous plant taxa in vegetation community types similar to those occurring in surrounding areas.	Revegetation undertaken by a combination of seeding and strategic hand-planting of species unable to be successfully direct seeded. Revegetation targeted for appropriate climatic conditions conducive to vegetation establishment. Strategic fauna monitoring of revegetated areas and surrounding vegetation to assess re-colonization.	Rehabilitation flora assessment reports of new areas undertaken annually for three years, then every three years after that until final completion criteria achieved and property hand-over occurs. Fauna studies written up as reports.
Step 6: Maintain and enhance where necessary, vegetation community types similar to those occurring in surrounding areas in readiness for hand-over to owner for light grazing end-use.	Rehabilitation ecological surveys conducted in line with a Hatfield West Gravel Pit Vegetation Monitoring Strategy.	Rehabilitation monitoring flora and fauna survey reports completed and included within the Hatfield West Gravel Pit Annual Environmental Report (AEMR).

6.5 Biodiversity Management Plan

A Biodiversity Management Plan (BMP) would be prepared to inform and manage various activities throughout the life of the Hatfield West Gravel Pit Project in order to protect and manage important biodiversity values. Key commitments to be covered by the BMP would include flora threatened species management, including specific provisions for Mossgiel Daisy,

Sandhill Pine Woodland and Yarran Shrubland, pest and weed management, fire management and site hygiene practices.

6.5.1 Threatened Plant Management

Only one threatened plant species – Mossgiel Daisy (*Brachyscome papillosa*) – will be impacted by construction of the Hatfield West Gravel Pit Project. Pre-clearance surveys of designated new gravel pit areas in the spring of each year will allow any plants present to be located. Any plants found should have seed collected from them which should be appropriately curated for subsequent use in the rehabilitation program. Plants should be grown from this seed for subsequent re-planting back to the site as tubestock. In addition, parent plants should be lifted, potted and on-grown for seed production. Plants should be planted back into the following target revegetation communities:

- Belah-Rosewood Woodland
- Yarran Shrubland
- Black Bluebush Shrubland

6.5.2 Threatened Plant Community Management

A key plank in the threatened plant management approach to be taken at the Hatfield West Gravel Pit Project sites will be the return within rehabilitation pods of greater areas of the threatened plant communities than were cleared prior to gravel pit development. This involves targeted revegetation of Sandhill Pine Woodland at each of Pits A, B and C, as well as Yarran Shrubland at Pits A and C. Table 6-02 outlines a targeted conceptual model for threatened plant community revegetation at the Hatfield West Gravel Pit sites. Sandhill Pine Woodland rehabilitation at Pit B would occur over cleared areas as well as new areas at the current pit site, but also in an enhancement area surrounding the pit. There is a problem at Pit B in that the existing quarry of ~ 2 Ha has not recovered topsoil in a manner sympathetic with recovering all of this vitally important component of the rehabilitation program. In short, topsoil has been pushed to each side of the Pit B area which has mixed subsoil with topsoil. This will inevitably compromise the success of rehabilitation at this site. It is recommended that to achieve the rehabilitation outcome at Pit B, an enhancement area of extremely degraded Sandhill Pine Woodland totalling a minimum of 5 Ha be revegetated with approximately 1000 *Callitris glaucophylla* trees. Similarly, enhancement areas totalling a minimum of 5 Ha are proposed at the Pit C gravel pit site where approximately 2000 *Acacia melvillei* shrubs would be planted. This would include a patch of Yarran Shrubland north of the Pit C Subject Site known to contain Mossgiel Daisy.

Table 6-02: Conceptual model for revegetation of two threatened plant communities at the Hatfield West Gravel Pit sites.

***Denotes that:**

- **an additional 5Ha and 1000 *Callitris glaucophylla* trees would be planted into an enhancement area contiguous with the Pit B gravel pit site; and**
- **an additional 5 Ha and 2000 *Acacia melvillei* shrubs would be planted into enhancement areas contiguous with the Pit C gravel pit site.**

Sandhill Pine Woodland			
	Pit A	***Pit B**	**Pit C**
Area to be Cleared (Ha)	1.43	2.22	1.24
Target Area for Revegetation (Ha)	5.0	2.5	5.0
Replanting Density of *Callitris glaucophylla* Ha^{-1}	200	200	200
Total Target *Callitris glaucophylla* Trees Replanted to Subject Site	1000	500	1000
Additional *Callitris glaucophylla* trees planted to enhancement area	0	1000	0
Yarran Shrubland			
	Pit A	**Pit B**	***Pit C**
Area to be Cleared (Ha)	0	0	0.53
Target Area for Revegetation (Ha)	2.0	0	5.0
Replanting Density of *Acacia melvillei*	400	0	400
Total Target *Acacia melvillei* Trees Replanted to Subject Site	800	0	2000
Additional *Acacia melvillei* shrubs planted to enhancement area	0	0	2000

6.6 Monitoring Mitigation and Management

The BMP will outline monitoring programs to be set up to measure the success of biodiversity management protocols and activities across the Hatfield West Gravel Pit Project such as management actions for threatened plant species, threatened plant communities, pest management activities, and rehabilitation and revegetation activities. Monitoring programs will include goals and performance indicators to measure the success of proposed mitigation measures.

CHAPTER 7 BIODIVERSITY OFFSET STRATEGY

Biodiversity offsets provide benefits to biodiversity to compensate for the adverse impacts of an action. Biodiversity offsets assist in achieving long-term conservation outcomes while providing development proponents with the ability to undertake actions that have unavoidable impacts on biodiversity. This chapter provides the background on Cristal's proposed Biodiversity Offset Package.

7.1 Commonwealth Government Framework for Offset Development

With respect to the Commonwealth Governments position on biodiversity offsetting, offsets are to be determined having regard to the EPBC Act Offsets Policy. Similar to the NSW Framework for biodiversity offsetting (see below), environmental offsets are provided as measures that compensate for the residual adverse impacts of an action under the EPBC Act Offsets Policy. Offsets should counterbalance the impacts that remain after avoidance and mitigation measures have been implemented. For assessments under the EPBC Act, offsets are only required if residual impacts are significant on Matters of National Environmental Significance. With respect to the loss of Mossgiel Daisy, the loss has been assessed as not significant (see Appendix 3), meaning the biodiversity offset can be considered within the NSW 'Framework' only.

7.2 NSW Framework for an Offset Development

The Hatfield West Gravel Pit Project has been designated as a 'Local Development' and as such, it is not a State Significant Development (SSD) Project. For non-SSD projects, the OEH have released a series of guiding principles titled "OEH principles for the use of biodiversity offsets in NSW" (OEH 2016). The Biodiversity Offset Strategy proposed herein, has been devised cognizant of these guiding principles. Table 7-01 outlines the OEH Principles for NSW Biodiversity Offsets and provides, in turn, the proponents response to that principle.

Table 7-01: OEH Biodiversity Offset Principles for non-SSD Developments and the Cristal Response.

OEH Biodiversity Offset Principles for Non-SSD EIS Developments	Cristal Response to OEH Principles for Biodiversity Offsetting
Principle 1. Impacts must be avoided first by using prevention and mitigation measures.	Response: Chapter 6 outlines the avoidance and mitigation measures proposed by Cristal.
Principle 2. All regulatory requirements must be met.	Response: All regulatory requirements requested of Cristal have been addressed.
Principle 3. Offsets must never reward ongoing poor performance (with respect to management of the proposed offset).	Response: The Cristal owned property on which the Biodiversity Offset would be located is in vastly superior condition than the land where the development is proposed. It has already been approved in part as an offset for the Atlas-Campaspe Mines.
Principle 4. Offsets will complement other government programs.	Response: The Cristal owned property on which the Biodiversity Offset would be located is contiguous with an existing conservation offset as well as Mungo National Park.
Principle 5. Offsets must be underpinned by sound ecological principles.	Response: The Cristal approach has been to acknowledge that compensation of habitat is required for the loss of the remnant vegetation at the proposed development. Cristal also proposes a combination of revegetation of the Subject Sites as well as enhancement of a surrounding EEC (Sandhill Pine Woodland) through fencing and supplementary replanting with the canopy dominant (*Callitris glaucophylla*).
Principle 6. Offsets should aim to result in a net improvement in biodiversity over time.	Response: Cristal plan to conserve the Biodiversity Offset in perpetuity, audit the condition of the offset, undertake ongoing pest plant and animal control - all of which will lead to an improvement in biodiversity over time.
Principle 7. Offsets must be enduring – they must offset the impact of the development for the period that the impact occurs.	Response: Cristal will ensure the Biodiversity Offset area selected is conserved in perpetuity.
Principle 8. Offsets should be agreed prior to the impact occurring.	Response: Cristal propose to 'sign-off' on the proposed Biodiversity Offset once an area has been agreed upon between the regulatory authority and the company. This will occur before any impact at the proposed gravel pits occurs.

OEH Biodiversity Offset Principles for Non-SSD EIS Developments	Cristal Response to OEH Principles for Biodiversity Offsetting
Principle 9. Offsets must be quantifiable – the impacts and benefits must be reliably estimated.	Response: Cristal have commissioned a baseline Flora Study of the proposed development areas (the Hatfield West Gravel Pits A, B and C), as well as a botanical survey of potential offset areas owned by the company at a nearby property. The biodiversity values of that property have been documented in a separate report which forms an Appendix of this report.
Principle 10. Offsets must be targeted.	Response: The Biodiversity Offset provides for like-for-like where possible, but in most circumstances vastly exceeds the conservation value of the land lost as part of the proposed development.
Principle 11. Offsets must be located appropriately.	Response: The proposed Biodiversity Offset is located ~20km to the north on land contiguous with Mingo National Park.
Principle 12. Offsets must be supplementary - that is not on land already conserved or having received an incentive to conserve.	Response: The Cristal owned land is not part of an existing reserve.
Principle 13. Offsets and their actions must be enforceable through development consent conditions, license conditions, conservation agreements or contracts.	Response: See response to Principle 7. Cristal also undertake to conduct independent audits of the vegetation condition of the selected Biodiversity Offset.

7.3 Quantifying the Offset Required

Chapter 5 of this report assessed the impacts of the Hatfield West Gravel Pit Project on biodiversity values of the area. Direct impacts will result in the loss of 108.78 Ha of remnant vegetation which incorporates habitat for one threatened flora species and two endangered ecological plant communities. As such the offset strategy must quantify the required offset for the Hatfield West Gravel Pit Project in accordance with the TSC Act. Cristal have chosen to not pursue the BioBanking method for provision of offsets, but instead to offer as compensation, land owned by the company which is in vastly superior ecological condition when compared to the proposed development sites. With no prescribed 'multiplier' provided by the regulatory authority for offsetting land, we have looked to similar recent precedent within the region to provide guidance on what the conservation offset multiplier might be for the plant communities proposed for clearance at the Hatfield West Gravel Pit Subject Site. In a recent EIS investigation for Iluka Resources Ltd. for the Balranald Mineral Sands Project, NEH (2016) devised offset multipliers for four of the six plant communities that occur within the Hatfield West Subject Site, using the NSW/OEH Ecosystem Credit Converter. The plant communities and their offset multiplier include Belah-Rosewood Woodland (7.7:1), Chenopod Sandplain Mallee (6.5:1), Pearl Bluebush Shrubland (4.8:1) as well Open Grasslands-Degraded Shrublands (3.5:1). Table 7-02 outlines the plant communities that would be lost as part of the Hatfield West Gravel Pit development as well as their proposed offset multiplier and eventual offset area in hectares.

The Cristal response has been to increase the multiplier in all circumstances for the four plant communities shared between the Iluka Balranald Project as well as the Hatfield West Gravel Pit Project. Cristal have proposed a multiplier of 15:1 for the two threatened plant communities occurring within the Hatfield West Subject Site which it is argued is generous considering the extremely degraded nature of both threatened EEC's at the Hatfield West Subject Site, combined with the fact that enhancement areas for these EEC's are also proposed. The total Biodiversity Offset package proposed by Cristal is a minimum of 716.2 Ha. This Biodiversity Offset should contain the majority area as Belah-Rosewood Woodland, along with a sizable area of Sandhill Pine Woodland as well, if this can be found. The basic requirements outlined in Table 7-02 can be accommodated at Cristal's property at Boree Plains, ~10 km north of the Hatfield West Gravel Pit Project area. At that location, large areas of Belah-Rosewood Woodland, Sandhill Pine Woodland, Chenopod Sandplain Mallee and Spinifex-Mallee are present, the latter community containing a NSW endangered species in Bitter Quandong (*Santalum acuminatum*). In addition, the Belah-Rosewood plant community present contains an as yet undescribed (Neville Walsh *personal communication*) Greenhood orchid species (*Pterostylis* sp. aff. *biseta*) known only from the Boree Plains property.

Table 7-02: Estimated vegetation offset requirements for the Hatfield West Gravel Pit Project.

Vegetation Formation (Keith 2004)	Vegetation Class (Keith 2004)	BioMetric Vegetation Type (OEH 2011)	Benson *et. al.* (2006) ID No.	Vegetation Community (abbreviated name in this study)	Disturbance Area (Ha)	Indicative Offset Ratio	Target Area of Offset Proposed (Ha)
Semi-arid Woodlands (shrubby sub-formation)	Semi-arid Sand Plain Woodlands	LM108 Black Oak - Western Rosewood open woodland on deep sandy loams of the Murray-Darling Depression and Riverina Bioregions.	58	Belah-Rosewood Woodland (Belah-Rosewood sub-community)	53.93	8:1	431.4
	Riverine Sandhill Woodlands	LM159 White Cypress Pine open woodland of sandplains, prior streams and dunes of the semi-arid (warm) climate zone.	28	Sandhill Pine Woodland	4.89	15:1	73.4
Semi-arid Woodlands (shrubby sub-formation)	Sandplain Mallee Woodlands	LM116 Chenopod sandplain mallee woodland/shrubland of the arid and semi-arid (warm) zones.	170	Chenopod Sandplain Mallee	1.02	7:1	7.1
Arid Shrublands	Not specifically recognized by Keith (2004)	LM160 Yarran shrubland of the semi-arid (warm) and arid zones.	23	Yarran Shrubland	0.53	15:1	8.0
Arid Shrublands (Chenopod sub-formation)	Aeolian Chenopod Shrublands	LM138 Pearl Bluebush low Open Shrubland of the arid and semi-arid plains.	154	Pearl Bluebush Shrubland	2.70	5:1	13.5
Arid Shrublands (Chenopod sub-formation)	Aeolian Chenopod Shrublands	LMW122 Derived corkscrew grass grassland/forbland on sandplains and plains in the semi-arid (warm) climatic zone.	165	Bluebush-Grassland Mosaic	45.71	4:1	182.8
TOTAL					**108.78**		**716.2**

CHAPTER 8 CONCLUSIONS

Cristal Mining Australia Ltd. require approximately 800,000 tonnes of calcrete for road base in order to maintain the Atlas-Campaspe MCTR for up to 30 years which is the stated 'life-of-mine' for the Atlas-Campaspe Mines. The MCTR lies within the Hatfield West area of southwest NSW, in the LGA jurisdiction of Balranald Shire Council. The NSW OEH have requested an EIS investigation of proposed gravel pit sites, with the study to be assessed by the Balranald SC. This report forms part of the broader EIS and describes the flora baseline of the Hatfield West Gravel Pit Project Area and addresses the potential impacts to flora associated with the proposed development.

Where possible, attempts have been made to avoid disturbance to important vegetation types, however after consideration of the lack of the target calcrete resource in the Hatfield West Locality, disturbance to remnant vegetation nearby to the Atlas-Campaspe MCTR will be unavoidable. The Hatfield West Gravel Pit Project would directly impact 113.41 Ha of land of which 108.78 can be considered remnant vegetation. Six NSW BioMetric Vegetation Types were recognized as being present within the proposed disturbance area, two of which, Sandhill Pine Woodland and Yarran Shrubland are Endangered Ecological Communities listed under the TSC Act. The Hatfield West Gravel Pit Project Area would also impact the EPBC Act and TSC Act listed Mossgiel Daisy (*Brachycome papillosa*) which occurs as single plants at nine locations across the Subject Site. A significant impact to Mossgiel Daisy will not occur as the plants existing within the Hatfield West Gravel Pit Project Area are considered to be outlier occurrences in sub-optimal habitat in an exceptional year for observation of this species. The core habitat for this species is Bladder Saltbush Shrubland and Black Bluebush Shrubland present either side of the Atlas-Campaspe MCTR, approximately 10 km to the east on the Magenta-Langleydale Road where an estimated meta population of greater than 200,000 plants occurs.

No other EPBC Act or TSC Act listed plant taxa or communities are present within the Hatfield West Gravel Pit Project Area and no critical habitat listed under the TSC Act or EPBC Act will be impacted. A suite of mitigation measures enshrined in Management Plans have been proposed to offset indirect impacts associated with the proposed development. In addition, a Biodiversity Offset Package has been proposed which would see a minimum of 716 Ha of land at a Cristal owned property approximately 10 km to the north of the Hatfield West Gravel Pit Project Area conserved in perpetuity. The proposed Biodiversity Offset occurs adjacent to an existing Private Conservation Reserve as well as with Mungo National Park and the Willandra Lakes World Heritage Area Property.

Through the implementation of avoidance measures, mitigation measures and the Biodiversity Offset Strategy, biodiversity values in the surrounding region and the viability of threatened species and communities that are impacted by the Hatfield West Gravel Pit Project will be maintained or improved over the medium to long term.

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Appendix 1 Combined Plant Taxon List From a Search of OEH Plant Records for the Bidura, Paika, Hatfield and Turlee 1: 100,000 Map Sheet Areas.

Scientific Name	Exotic	Common Name	NSW status	Comm. status
Abutilon fraseri		Dwarf Lantern-flower		
Abutilon otocarpum		Desert Lantern		
Abutilon spp.	*	Lantern-bush		
Acacia aneura		Mulga		
Acacia brachybotrya		Grey Mulga		
Acacia colletioides		Wait-a-while		
Acacia homalophylla		Yarran		
Acacia ligulata		Sandhill Wattle		
Acacia lineata		Streaked Wattle		
Acacia loderi		Nealie		
Acacia melvillei		Yarran		
Acacia montana		Mallee Wattle		
Acacia oswaldii		Miljee		
Acacia rigens		Needle Wattle		
Acacia salicina		Cooba		
Acacia sclerophylla var. sclerophylla		Hard-leaved Wattle		
Acacia spp.		Wattle		
Acacia stenophylla		River Cooba		
Acacia terminalis subsp. angustifolia				
Acacia victoriae				
Acacia victoriae subsp. victoriae		Elegant Wattle		
Acacia wilhelmiana		Wilhelm's Wattle		
Actinobole uliginosum		Flannel Cudweed		
Adriana tomentosa var. hookeri		Mallee Bitterbush		
Ailanthus altissima	*	Tree of Heaven		
Ajuga australis		Austral Bugle		
Alectryon oleifolius		Western Rosewood		
Alectryon oleifolius subsp. canescens				
Alopecurus geniculatus	*	Marsh Foxtail		
Alternanthera denticulata		Lesser Joyweed		
Alternanthera nodiflora		Common Joyweed		
Alternanthera sp. A				
Alternanthera spp.		Joyweed		
Alyssum linifolium	*	Flax-leaf Alyssum		
Amaranthus viridis	*	Green Amaranth		
Amphibromus macrorhinus		Long-nosed Swamp Wallaby-grass		
Amphibromus nervosus		Swamp Wallaby Grass		
Amphibromus spp.				
Amphipogon caricinus var. caricinus		Long Greybeard Grass		
Amsinckia calycina	*	hairy Fiddleneck		
Amsinckia intermedia	*	Common Fiddleneck		
Amyema linophyllum subsp. orientale				
Amyema miquelii		Box Mistletoe		
Amyema miraculosum subsp. boormanii				
Amyema pendula				
Amyema preissii				
Amyema quandang var. quandang		Grey Mistletoe		
Amyema spp.		Mistletoe		
Angianthus brachypappus		Spreading Cup-flower		
Apophyllum anomalum		Warrior Bush		
Arabidella nasturtium				
Arabidella trisecta				
Arctotheca calendula	*	Capeweed		
Argemone spp.	*			
Aristida contorta		Bunched Kerosene Grass		
Aristida nitidula				
Aristida spp.		A Wiregrass		
Arthropodium spp.				
Asperula conferta		Common Woodruff		
Asperula gemella		Twin-leaved Bedstraw		
Asphodelus fistulosus	*	Onion Weed		
Aster subulatus	*	Wild Aster		
Atriplex acutibractea subsp. acutibractea				
Atriplex angulata		Fan Saltbush		
Atriplex conduplicata				
Atriplex eardleyae		Small Saltbush		
Atriplex holocarpa		Pop Saltbush		
Atriplex leptocarpa		Slender-fruit Saltbush		
Atriplex limbata				
Atriplex lindleyi		Eastern Flat-top Saltbush		

Scientific Name	Exotic	Common Name	NSW status	Comm. status
Atriplex nummularia		Old Man Saltbush		
Atriplex pseudocampanulata				
Atriplex pumilio				
Atriplex rhagodioides				
Atriplex semibaccata		Creeping Saltbush		
Atriplex spinibractea		Spiny-fruit Saltbush		
Atriplex spongiosa		Pop Saltbush		
Atriplex spp.		A Saltbush		
Atriplex stipitata		Mallee Saltbush		
Atriplex vesicaria		Bladder Saltbush		
Atriplex vesicaria subsp. macrocystidia		Bladder Saltbush		
Austrostipa acrociliata				
Austrostipa drummondii				
Austrostipa elegantissima		Feather Speargrass		
Austrostipa eremophila				
Austrostipa nitida				
Austrostipa nodosa		A Speargrass		
Austrostipa platychaeta		Flat-awn Speargrass		
Austrostipa puberula				
Austrostipa scabra		Speargrass		
Austrostipa scabra subsp. falcata		Rough Speargrass		
Austrostipa scabra subsp. scabra		Rough Speargrass		
Austrostipa spp.		A Speargrass		
Avena barbata	*	Bearded Oats		
Avena fatua	*	Wild Oats		
Azolla filiculoides		Pacific Azolla		
Baeckea crassifolia		Desert Heath-myrtle		
Bergia trimera		Small Water-fire		
Beyeria opaca				
Billardiera versicolor		Pale Appleberry		
Blennodia canescens		Wild Stock		
Boerhavia dominii		Tarvine		
Bolboschoenus medianus				
Boronia coerulescens subsp. coerulescens		Blue Boronia	P	
Bossiaea walkeri		Cactus Pea		
Brachyscome basaltica var. gracilis		Swamp Daisy		
Brachyscome ciliaris		Variable Daisy		
Brachyscome ciliaris var. ciliaris		Variable Daisy		
Brachyscome ciliaris var. lanuginosa		Variable Daisy		
Brachyscome dentata				
Brachyscome exilis		Slender Daisy		
Brachyscome leptocarpa		Small Hairy Daisy		
Brachyscome lineariloba		Hard-headed Daisy		
Brachyscome multifida var. multifida				
Brachyscome papillosa		Mossgiel Daisy	V,P	V
Brachyscome perpusilla var. tenella		Tiny Daisy		
Brachyscome spp.				
Brachyscome trachycarpa		Smooth Daisy		
Brassica juncea	*	Indian Mustard		
Brassica spp.	*	Brassica		
Brassica tournefortii	*	Mediterranean Turnip		
Bromus arenarius		Sand Brome		
Bromus catharticus	*	Praire Grass		
Bromus molliformis	*	Soft Brome		
Bromus rubens	*	Red Brome		
Bulbine alata		Native Onion		
Bulbine bulbosa		Bulbine Lily		
Bulbine semibarbata		Wild Onion		
Bulbine spp.				
Calandrinia eremaea		Small Purslane		
Calandrinia volubilis				
Calendula arvensis	*	Field Marigold		
Callitriche spp.	*	Starwort		
Callitriche stagnalis	*	Common Starwort		
Callitriche umbonata		Winged Water-starwort		
Callitris columellaris				
Callitris glaucophylla		White Cypress Pine		
Callitris gracilis subsp. gracilis				
Callitris gracilis subsp. murrayensis		Murray Pine		
Callitris preissii				
Callitris verrucosa		Mallee Pine		
Calocephalus sonderi		Pale Beauty-heads		
Calotis cuneifolia		Purple Burr-Daisy		
Calotis cymbacantha		Showy Burr-daisy		

Scientific Name	Exotic	Common Name	NSW status	Comm. status
Calotis erinacea		Tangled Burr-daisy		
Calotis hispidula		Bogan Flea		
Calotis plumulifera		Woolly-headed Burr-daisy		
Calotis scabiosifolia		Rough Burr-daisy		
Calotis scapigera		Tufted Burr-daisy		
Calotis spp.		A Burr-daisy		
Capsella bursa-pastoris	*	Shepherd's Purse		
Cardamine moirensis				
Carduus tenuiflorus	*	Winged Slender Thistle		
Carex appressa		Tall Sedge		
Carex inversa		Knob Sedge		
Carrichtera annua	*	Ward's Weed		
Carthamus lanatus	*	Saffron Thistle		
Cassinia laevis		Cough Bush		
Cassytha melantha				
Casuarina pauper		Black Oak		
Casuarina spp.				
Centaurea melitensis	*	Maltese Cockspur		
Centaurea solstitialis	*	St Barnabys Thistle		
Centaurium spp.	*			
Centipeda cunninghamii		Common Sneezeweed		
Centipeda minima subsp. minima		spreading sneezeweed		
Centipeda thespidioides		Desert Sneezeweed		
Cestrum parqui	*	Green Cestrum		
Chamaesyce dallachyana				
Chamaesyce drummondii		Caustic Weed		
Chamaesyce sp. B				
Cheilanthes austrotenuifolia		Rock Fern		
Cheilanthes sieberi subsp. sieberi		Rock Fern		
Chenopodium album	*	Fat Hen		
Chenopodium cristatum		Crested Goosefoot		
Chenopodium curvispicatum				
Chenopodium desertorum		Desert Goosefoot		
Chenopodium desertorum subsp. anidiophyllum				
Chenopodium desertorum subsp. desertorum		Desert Goosefoot		
Chenopodium desertorum subsp. microphyllum				
Chenopodium desertorum subsp. rectum				
Chenopodium melanocarpum		Black Crumbweed		
Chenopodium murale	*	Nettle-leaf Goosefoot		
Chenopodium nitrariaceum		Nitre Goosefoot		
Chenopodium spp.	*	Goosefoot, Crumbweed		
Chloris truncata		Windmill Grass		
Chondrilla juncea	*	Skeleton Weed		
Chrysocephalum apiculatum		Common Everlasting		
Chrysocephalum semipapposum		Clustered Everlasting		
Chthonocephalus pseudevax		Ground-heads		
Cirsium vulgare	*	Spear Thistle		
Citrullus colocynthis	*	Colocynth		
Citrullus lanatus var. lanatus	*	Wild Melon, Camel Melon,Bitter		
Clematis microphylla		Small-leaved Clematis		
Codonocarpus cotinifolius		Native Poplar		
Convolvulus clementii		Desert Bindweed		
Convolvulus erubescens		Pink Bindweed		
Convolvulus graminetinus				
Convolvulus remotus				
Conyza bonariensis	*	Flaxleaf Fleabane		
Conyza sumatrensis	*	Tall fleabane		
Corynotheca licrota		Club-fruit Lily		
Cotula bipinnata	*	Ferny Cotula		
Cotula coronopifolia	*	Water Buttons		
Crassula colorata		Dense Stonecrop		
Crassula colorata var. acuminata				
Crassula sieberiana		Australian Stonecrop		
Crassula spp.	*	Stonecrop		
Cressa australis				
Cryptandra propinqua				
Cryptandra spp.				
Cucumis myriocarpus subsp. leptodermis	*	Paddy Melon		
Cullen patens		Spreading Scurf-pea		
Cuphonotus humistratus		Mother-of-misery		
Cuscuta campestris	*	Golden Dodder		
Cynodon dactylon		Common Couch		
Cynoglossum australe				
Cyperus gymnocaulos				

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Cyperus sesquiflorus	*			
Cyperus spp.				
Dactyloctenium radulans		Button Grass		
Damasonium minus		Starfruit		
Dampiera lanceolata var. lanceolata				
Daucus glochidiatus		Native Carrot		
Daviesia genistifolia		Broom Bitter Pea		
Dianella revoluta		Blueberry Lily		
Dianella revoluta var. revoluta		A Blue Flax Lily		
Dichopogon fimbriatus		Nodding Chocolate Lily		
Dicrastylis verticillata		Sand-sage		
Diplachne fusca		Brown Beetle Grass		
Diplotaxis muralis	*	Wall Rocket		
Disphyma crassifolium subsp. clavellatum				
Dissocarpus biflorus		Twin-horned Cpperburr		
Dissocarpus biflorus var. biflorus				
Dissocarpus paradoxus		Cannonball Burr		
Dittrichia graveolens	*	Stinkwort		
Dodonaea bursariifolia				
Dodonaea lobulata			P	
Dodonaea viscosa		Sticky Hop-bush		
Dodonaea viscosa subsp. angustissima		Narrow-leaf Hop-bush		
Duboisia hopwoodii		Pituri		
Duma florulenta		Lignum		
Duma horrida subsp. horrida				
Dysphania glomulifera subsp. eremaea				
Dysphania littoralis				
Dysphania pumilio		Small Crumbweed		
Echium plantagineum	*	Patterson's Curse		
Eclipta platyglossa		Yellow Twin-heads		
Einadia nutans		Climbing Saltbush		
Einadia nutans subsp. nutans		Climbing Saltbush		
Einadia polygonoides		Knotweed Goosefoot		
Elachanthus pusillus		Elachanth		
Eleocharis acuta				
Eleocharis pallens		Pale Spike Sedge		
Eleocharis plana		Flat Spike-sedge		
Eleocharis pusilla				
Eleocharis sphacelata		Tall Spike Rush		
Eleocharis spp.		Spike-rush, Spike-sedge		
Elymus scaber		Common Wheatgrass		
Emex australis	*	Spiny Emex		
Enchylaena tomentosa		Ruby Saltbush		
Enneapogon avenaceus		Bottle Washers		
Enneapogon nigricans		Niggerheads		
Enteropogon acicularis		Curly Windmill Grass		
Enteropogon ramosus		Curly Windmill Grass		
Epaltes australis		Spreading Nut-heads		
Epaltes cunninghamii		Tall Nut-heads		
Epilobium hirtigerum				
Eragrostis australasica		Canegrass		
Eragrostis cilianensis	*	Stinkgrass		
Eragrostis dielsii		Mallee Lovegrass		
Eragrostis falcata		Sickle Lovegrass		
Eragrostis lacunaria		Purple Lovegrass		
Eragrostis parviflora		Weeping Lovegrass		
Eragrostis setifolia		Neverfail		
Eragrostis spp.	*	A Lovegrass		
Eremophila deserti		Turkeybush		
Eremophila glabra		Tar Bush		
Eremophila longifolia		Emubush		
Eremophila maculata		Spotted Fuchsia		
Eremophila mitchellii		Budda		
Eremophila oppositifolia		Weeooka		
Eremophila oppositifolia subsp. oppositifolia				
Eremophila oppositifolia subsp. rubra				
Eremophila sturtii		Turpentine Bush		
Erodium cicutarium	*	Common Crowfoot		
Erodium crinitum		Blue Crowfoot		
Erodium cygnorum subsp. glandulosum				
Erodium spp.	*	Crowfoot		
Eucalyptus behriana		Bull Mallee		
Eucalyptus camaldulensis		River Red Gum		
Eucalyptus costata subsp. murrayana		Ridge-fruited Mallee		

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Eucalyptus dumosa		White Mallee		
Eucalyptus gracilis		Snap and Rattle		
Eucalyptus gracilis subsp. gracilis				
Eucalyptus intertexta		Gum Coolibah		
Eucalyptus largiflorens		Black Box		
Eucalyptus leptophylla		Narrow-leaved Red Mallee		
Eucalyptus oleosa subsp. oleosa		Red Mallee		
Eucalyptus porosa		Mallee Box		
Eucalyptus socialis		Red Mallee		
Eucalyptus spp.				
Euchiton involucratus		Star Cudweed		
Euchiton sphaericus		Star Cudweed		
Euphorbia tannensis subsp. eremophila				
Eutaxia microphylla				
Exocarpos aphyllus		Leafless Ballart		
Exocarpos sparteus		Slender Cherry		
Fimbristylis dichotoma		Common Fringe-sedge		
Fumaria indica	*			
Fumaria spp.	*	Fumitory		
Galium aparine	*	Goosegrass		
Galium gaudichaudii		Rough Bedstraw		
Galium spurium	*			
Geijera parviflora		Wilga		
Geococcus pusillus				
Geranium solanderi		Native Geranium		
Geranium solanderi var. solanderi				
Glinus lotoides		Hairy Carpet-weed		
Gnephosis arachnoidea		Erect Yellow-heads		
Gnephosis tenuissima				
Goodenia cycloptera		Cut-leaf Goodenia		
Goodenia fascicularis		Mallee Goodenia		
Goodenia glauca		Pale Goodenia		
Goodenia heteromera				
Goodenia pinnatifida		Scrambles Eggs		
Goodenia pusilliflora				
Goodenia spp.				
Goodenia varia		Sticky Goodenia		
Goodenia willisiana				
Gratiola pedunculata				
Grevillea huegelii				
Grevillea pterosperma		Desert Grevillea		
Hakea leucoptera		Needlewood		
Hakea leucoptera subsp. leucoptera				
Hakea tephrosperma		Hooked Needlewood		
Halgania andromedifolia		Lavender Halgania		
Halgania cyanea		Rough Halgania		
Haloragis glauca f. glauca				
Haloragis odontocarpa				
Haloragis odontocarpa f. pterocarpa				
Harmsiodoxa blennodioides				
Harmsiodoxa brevipes var. brevipes				
Harmsiodoxa puberula				
Hedypnois rhagadioloides	*	Cretan Weed		
Hedypnois rhagadioloides subsp. cretica	*	Cretan Weed		
Heliotropium curassavicum	*	Smooth Heliotrope		
Heliotropium europaeum	*	Potato Weed		
Heliotropium supinum	*	Prostrate Heliotrope		
Helminthotheca echioides	*	Ox-tongue		
Herniaria cinerea	*			
Hibbertia virgata subsp. virgata		Twiggy Guinea Flower		
Hibiscus sturtii var. sturtii		Hill Hibiscus		
Hirschfeldia incana	*	Buchan Weed		
Hordeum glaucum	*	Northern Barley Grass		
Hordeum hystrix	*	Mediterranean Barley Grass		
Hordeum leporinum	*	Barley Grass		
Hordeum marinum	*	Sea Barley Grass		
Hordeum spp.	*	A Barley Grass		
Hyalosperma demissum		Moss Sunray		
Hyalosperma glutinosum subsp. glutinosum				
Hyalosperma semisterile				
Hypochaeris glabra	*	Smooth Catsear		
Hypochaeris radicata	*	Catsear		
Isoetopsis graminifolia		Grass Cushion		
Isolepis australiensis				

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Isolepis spp.		Club-rush		
Jasminum lineare		Desert Jasmine		
Juncus amabilis				
Juncus aridicola		Tussock Rush		
Juncus articulatus	*	A Rush		
Juncus bufonius	*	Toad Rush		
Juncus flavidus				
Juncus spp.		A Rush		
Lachnagrostis filiformis				
Lactuca saligna	*	Willow-leaved Lettuce		
Lactuca serriola	*	Prickly Lettuce		
Lactuca serriola f. serriola	*			
Lamarckia aurea	*	Goldentop		
Lawrencia glomerata				
Lawrencia squamata				
Leiocarpa leptolepis		Pale Plover-daisy		
Leiocarpa panaetioides		Wooly Buttons		
Leiocarpa semicalva subsp. semicalva				
Leiocarpa websteri				
Lemna disperma				
Lemooria burkittii		Wires-a-wool		
Leontodon taraxacoides subsp. taraxacoides	*	Lesser Hawkbit		
Lepidium fasciculatum		Bundled Peppercress		
Lepidium leptopetalum				
Lepidium monoplocoides		Winged Peppercress	E1,P	E
Lepidium papillosum		Warty Peppercress		
Lepidium phlebopetalum		Veined Peppercress		
Lepidium pseudohyssopifolium		Peppercress		
Leptorhynchos baileyi		Woolly Buttons		
Leptospermum coriaceum		Green Tea-tree		
Leucochrysum albicans var. tricolor		Hoary Sunray	P	E
Leucochrysum molle		Hoary Sunray		
Limonium lobatum	*	Winged Sea Lavender		
Limosella australis		Australian Mudwort		
Limosella curdieana		Large Mudwort		
Lolium loliaceum	*	Stiff Ryegrass		
Lolium perenne	*	Perennial Ryegrass		
Lolium rigidum	*	Wimmera Ryegrass		
Lomandra collina				
Lomandra effusa		Scented Mat-rush		
Lomandra leucocephala		Woolly Mat-rush		
Lomandra leucocephala subsp. leucocephala		Woolly Mat-rush		
Lomandra leucocephala subsp. robusta				
Lomandra spp.		Mat-rush		
Lotus cruentus		Red-flowered Lotus		
Ludwigia peploides subsp. montevidensis		Water Primrose		
Lycium australe		Australian Boxthorn		
Lycium ferocissimum	*	African Boxthorn		
Lysiana exocarpi				
Lysiana exocarpi subsp. exocarpi				
Lysiana exocarpi subsp. tenuis				
Lysimachia arvensis	*	Scarlet Pimpernel		
Lythrum hyssopifolia		Hyssop Loosestrife		
Lythrum wilsonii				
Maireana aphylla		Cotton Bush		
Maireana appressa				
Maireana brevifolia				
Maireana coronata		Crown Fissure-weed		
Maireana decalvans		Black Cotton Bush		
Maireana erioclada				
Maireana georgei		Slit-wing Bluebush		
Maireana ovata				
Maireana pentagona		Hairy Bluebush, Slender Fissure-weed		
Maireana pentatropis				
Maireana pyramidata		Black Bluebush		
Maireana radiata				
Maireana schistocarpa				
Maireana sclerolaenoides				
Maireana sedifolia		Pearl Bluebush		
Maireana spp.		Cotton Bush, Bluebush, Fissure-weed		
Maireana trichoptera				
Maireana triptera		Three-wing Bluebush		
Maireana turbinata				
Maireana villosa		Silky Bluebush		

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Malacocera tricornis		Soft Horns		
Malva parviflora	*	Small-flowered Mallow		
Malva preissiana		Native Hollyhock		
Malva spp.	*	Mallow		
Malvastrum americanum	*	Spiked Malvastrum		
Marrubium vulgare	*	White Horehound		
Marsdenia australis		Doubah		
Marsilea costulifera				
Marsilea drummondii		Common Nardoo		
Marsilea hirsuta		Short-fruited Nardoo		
Medicago arabica	*	Spotted Burr Medic		
Medicago laciniata	*	Cut-leaved Medic		
Medicago minima	*	Woolly Burr Medic		
Medicago polymorpha	*	Burr Medic		
Medicago praecox	*	Small-leaved Burr Medic		
Medicago spp.	*	A Medic		
Medicago truncatula	*	Barrel Medic		
Melaleuca lanceolata		Moonah		
Melilotus indicus	*	Hexham Scent		
Mentha australis		River Mint		
Mesembryanthemum crystallinum	*	Common Ice Plant		
Microseris lanceolata		Yam Daisy		
Millotia greevesii subsp. greevesii				
Millotia macrocarpa				
Millotia perpusilla		Tiny Bow-flower		
Millotia tenuifolia var. tenuifolia				
Mimulus gracilis		Slender Monkey-flower		
Mimulus prostratus		Small Monkey-flower		
Minuria cunninghamii		Bush Minuria		
Minuria integerrima		Smooth Minuria		
Minuria leptophylla				
Monoculus monstrosus	*			
Myoporum montanum		Western Boobialla		
Myoporum platycarpum		Sugarwood		
Myoporum platycarpum subsp. platycarpum				
Myosurus australis		Mousetail		
Myriophyllum caput-medusae		Cat-tail		
Myriophyllum papillosum				
Myriophyllum propinquum				
Myriophyllum simulans				
Myriophyllum spp.				
Myriophyllum verrucosum		Red Water-milfoil		
Najas marina subsp. armata				
Neatostema apulum	*	Hairy Sheepweed		
Nicotiana glauca	*	Tree Tobacco		
Nicotiana goodspeedii				
Nicotiana suaveolens		Native Tobacco		
Nicotiana velutina				
Nitraria billardierei		Dillon Bush		
Nymphoides crenata		Wavy Marshwort		
Olearia lepidophylla		Club-moss Daisy-bush		
Olearia magniflora				
Olearia muelleri		Mueller's Daisy Bush		
Olearia pimeleoides				
Olearia rudis		Daisy-bush		
Olearia sp. aff. teretifolia				
Olearia subspicata				
Omphalolappula concava		Burr Stickseed		
Onopordum acanthium subsp. acanthium	*	Scotch Thistle		
Onopordum acaulon	*	Stemless Thistle		
Opercularia turpis		Twiggy Stinkweed		
Osteocarpum acropterum		Water Weed		
Osteocarpum acropterum var. acropterum				
Osteocarpum acropterum var. deminuta		Bonefruit		
Osteocarpum spp.				
Ottelia ovalifolia subsp. ovalifolia		Swamp Lily		
Oxalis chnoodes				
Oxalis corniculata	*	Creeping Oxalis		
Oxalis exilis				
Oxalis perennans				
Oxalis pes-caprae	*	Soursob		
Oxalis spp.				
Pachymitus cardaminoides				
Panicum effusum		Hairy Panic		

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Papaver hybridum	*	Rough Poppy		
Papaver somniferum subsp. setigerum	*			
Parapholis incurva	*	Coast Barb Grass		
Parietaria cardiostegia		Mallee Pellitory		
Parietaria debilis		Native Pellitory		
Parsonsia eucalyptophylla		Gargaloo		
Paspalidium constrictum		Knottybutt Grass		
Paspalidium distans				
Paspalidium jubiflorum		Warrego Grass		
Paspalum dilatatum	*	Paspalum		
Paspalum distichum		Water Couch		
Pelargonium australe		Native Storksbill		
Pentaschistis airoides	*	False Hairgrass		
Persicaria decipiens		Slender Knotweed		
Persicaria lapathifolia		Pale Knotweed		
Persicaria orientalis		Princes Feathers		
Persicaria prostrata		Creeping Knotweed		
Persicaria spp.	*	Knotweed		
Phalaris minor	*	Lesser Canary Grass		
Phalaris paradoxa	*	Paradoxa Grass		
Phlegmatospermum cochlearinum		Oval-podded Cress		
Phlegmatospermum eremaeum				
Phleum pratense	*	Timothy		
Phragmites australis		Common Reed		
Phyla canescens	*	Lippia		
Phyla nodiflora	*	Carpet Weed		
Phyllanthus lacunellus				
Picris angustifolia subsp. angustifolia				
Picris spp.				
Pimelea microcephala subsp. microcephala		Shrubby Rice-flower		
Pimelea simplex		Desert Rice-flower		
Pimelea simplex subsp. simplex				
Pimelea spp.				
Pimelea trichostachya				
Pittosporum angustifolium		Butterbush		
Pittosporum spp.	*			
Plagiobothrys plurisepaleus				
Plantago cunninghamii		Sago-weed		
Plantago drummondii		Dark Sago-weed		
Plantago turrifera		Small Sago-weed		
Plantago varia				
Poa annua	*	Winter Grass		
Poa fax		Scaly Poa		
Poa fordeana		Sweet Swamp-grass		
Podolepis canescens		Large Copper-wire Daisy		
Podolepis capillaris		Invisible Plant		
Podolepis jaceoides		Showy Copper-wire Daisy		
Podolepis muelleri		Small Copper-wire Daisy		
Podotheca angustifolia		Sticky-heads		
Pogonolepis muelleriana				
Polycalymma stuartii		Poached Eggs		
Polygonum aviculare	*	Wireweed		
Polygonum plebeium		Small Knotweed		
Polypogon monspeliensis	*	Annual Beardgrass		
Poranthera microphylla		Small Poranthera		
Portulaca oleracea		Pigweed		
Potamogeton crispus		Curly Pondweed		
Potamogeton sulcatus				
Potamogeton tricarinatus		Floating Pondweed		
Pratia concolor		Poison Pratia		
Prostanthera aspalathoides		Scarlet Mint-bush		
Pseudognaphalium luteoalbum		Jersey Cudweed		
Pseudoraphis spinescens		Spiny Mudgrass		
Psilocaulon tenue	*	Wiry Noon-flower		
Pterostylis biseta		Rustyhood	P	
^^Pterostylis cobarensis		Greenhood Orchid	V,P,2	
Pterostylis rufa		Rusty Hood	P	
Ptilotus exaltatus var. exaltatus		Tall Mulla Mulla	P	
Ptilotus gaudichaudii				
Ptilotus leucocomus		Small Purple Foxtail		
Ptilotus nobilis		Yellowtails		
Ptilotus obovatus		Smoke Bush	P	
Ptilotus obovatus var. obovatus		Silver Tails	P	
Ptilotus polystachyus var. polystachyus		Long Tails		

Ptilotus seminudus

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Ptilotus sessilifolius var. sessilifolius				
Ptilotus spathulatus f. spathulatus		Pussy-tails		
Ptilotus spp.				
Pycnosorus chrysanthes		Golden Billy-buttons	P	
Pycnosorus pleiocephalus			P	
Pycnosorus thompsonianus			P	
Radyera farragei		Bush Hibiscus		
Ranunculus inundatus		River Buttercup		
Ranunculus lappaceus		Common Buttercup		
Ranunculus pentandrus				
Ranunculus pentandrus var. platycarpus				
Ranunculus pumilio var. politus				
Ranunculus sceleratus	*	Celery Buttercup		
Ranunculus sessiliflorus		Small-flowered Buttercup		
Ranunculus sessiliflorus var. pilulifer		Common Buttercup		
Ranunculus sessiliflorus var. sessiliflorus				
Ranunculus spp.				
Ranunculus undosus		Swamp Buttercup		
Rapistrum rugosum	*	Turnip Weed		
Reichardia tingitana	*	False Sowthistle		
Rhagodia spinescens		Thorny Saltbush		
Rhagodia ulicina				
Rhodanthe corymbiflora		Small White Sunray		
Rhodanthe floribunda		Common White Sunray		
Rhodanthe moschata				
Rhodanthe polygalifolia		Brilliant Sunray		
Rhodanthe pygmaea		Pigmy Sunray		
Rhodanthe spp.				
Rhodanthe stuartiana				
Rhodanthe uniflora				
Rhyncharrhena linearis		Purple Pentatrope		
Rorippa laciniata				
Rorippa palustris	*	Yellow Cress		
Rostraria pumila	*	Roughtail		
Rumex bidens		Mud Dock		
Rumex brownii		Swamp Dock		
Rumex crispus	*	Curled Dock		
Rumex crystallinus		Shiny Dock		
Rumex spp.	*	Dock		
Rumex tenax		Shiny Dock		
Rutidosis helichrysoides		Grey Wrinklewort		
Rytidosperma caespitosum		Ringed Wallaby Grass		
Rytidosperma setaceum		Small-flowered Wallaby-grass		
Rytidosperma spp.				
Salsola kali var. kali		Buckbush		
Salsola tragus		Buckbush,Soft Rolpoly, Saltwort		
Salsola tragus subsp. tragus		Buckbush,Soft Rolpoly, Saltwort		
Salvia verbenaca	*	Vervain		
Santalum acuminatum		Sweet Quandong		
Santalum lanceolatum		Northern Sandalwood		
Santalum murrayanum		Bitter Quandong	E1,P	
Sarcozona praecox		Sarcozona		
Scaevola depauperata		Skeleton Fan-flower		
Scaevola spinescens				
Schenkia spicata		Spike Centaury		
Schinus areira	*	Pepper Tree		
Schismus barbatus	*	Arabian Grass		
Schoenus subaphyllus				
Scleranthus minusculus				
Scleranthus pungens				
Scleroblitum atriplicinum		Purple Goosefoot		
Sclerolaena bicornis var. bicornis				
Sclerolaena birchii		Galvinized Burr		
Sclerolaena brachyptera		Short-winged Copperburr		
Sclerolaena calcarata		Redburr		
Sclerolaena convexula		Tall Copperburr		
Sclerolaena decurrens		Green Copperburr		
Sclerolaena diacantha		Grey Copperburr		
Sclerolaena divaricata		Tangled Copperburr		
Sclerolaena eriacantha		Silky Copperburr		
Sclerolaena intricata		Poverty Bush		
Sclerolaena lanicuspis		Woolly Copperburr		
Sclerolaena muricata		Black Rolypoly		

Scientific Name	Exotic	Common Name	NSW status	Comm. status
Sclerolaena muricata var. muricata		Black Rolypoly		
Sclerolaena muricata var. semiglabra		Black Rolypoly		
Sclerolaena muricata var. villosa		Black Rolypoly		
Sclerolaena obliquicuspis				
Sclerolaena parviflora				
Sclerolaena patenticuspis				
Sclerolaena sp. B				
Sclerolaena spp.		Copperburr, Poverty-bush		
Sclerolaena stelligera		Star Copperburr		
Sclerolaena tricuspis		Giant Redburr		
Sclerolaena ventricosa		Salt Copperburr		
Senecio cunninghamii var. cunninghamii				
Senecio glomeratus				
Senecio glossanthus		Streaked Poverty Bush		
Senecio gregorii				
Senecio lautus		Variable Groundsel		
Senecio murrayanus				
Senecio pinnatifolius var. pinnatifolius				
Senecio platylepis				
Senecio quadridentatus		Cotton Fireweed		
Senecio runcinifolius		Tall Groundsel		
Senecio spp.	*	Groundsel, Fireweed		
Senna artemisioides subsp. filifolia				
Senna artemisioides subsp. X artemisioides				
Senna artemisioides subsp. X coriacea				
Senna artemisioides subsp. zygophylla				
Senna form taxon 'petiolaris'		Woody Cassia		
Senna spp.	*			
Sida corrugata		Corrugated Sida		
Sida cunninghamii		Ridge Sida		
Sida filiformis				
Sida intricata				
Sida spp.	*			
Sida trichopoda		High Sida		
Sigesbeckia orientalis subsp. orientalis		Indian Weed		
Silene apetala	*			
Silene gallica	*	French Catchfly		
Silene gallica var. gallica	*	French Catchfly		
Silene vulgaris subsp. vulgaris	*	Bladder Campion		
Sisymbrium erysimoides	*	Smooth Mustard		
Sisymbrium irio	*	London Rocket		
Sisymbrium orientale	*	Indian Hedge Mustard		
Sisymbrium spp.	*			
Solanum americanum		Glossy Nightshade		
Solanum coactiliferum		Western Nightshade		
Solanum esuriale		Quena		
Solanum karsense		Menindee Nightshade	V,P	V
Solanum nigrum	*	Black-berry Nightshade		
Solanum simile		Oondoroo		
Solanum spp.	*			
Sonchus asper	*	Prickly Sowthistle		
Sonchus oleraceus	*	Common Sowthistle		
Spergularia brevifolia				
Spergularia diandra	*	Lesser Sand-spurry		
Spergularia marina		Lesser Sea-spurrey		
Spergularia rubra	*	Sandspurry		
Stachys arvensis	*	Stagger Weed		
Stellaria angustifolia		Swamp Starwort		
Stellaria media	*	Common Chickweed		
Stemodia florulenta		Bluerod		
Stenopetalum lineare		Threadcress		
Stenopetalum sphaerocarpum				
Stylidium graminifolium		Grass Triggerplant		
Swainsona burkittii				
Swainsona microphylla				
Swainsona murrayana		Slender Darling Pea	V,P	V
Swainsona phacoides		Dwarf Swainson-pea		
Swainsona spp.				
Swainsona stipularis				
Taraxacum officinale	*	Dandelion		
Tecticornia tenuis				
Templetonia egena		Desert Broombush		
Templetonia spp.				
Templetonia sulcata		Flat Mallee Pea		

Scientific Name	Exotic	Common Name	NSW status	Comm. status
Tetragonia decumbens	*			
Tetragonia eremaea				
Tetragonia moorei				
Tetragonia spp.				
Tetragonia tetragonioides		New Zealand Spinach		
Teucrium albicaule				
Teucrium racemosum		Grey Germander		
Thysanotus baueri		Fringe-lily		
Thysanotus patersonii		Twining Fringe-Lily		
Thysanotus tuberosus subsp. tuberosus				
Trachymene cyanopetala		Purple Parsnip		
Tragopogon porrifolius subsp. porrifolius	*	Salsify		
Tragus australianus		Small Burrgrass		
Tribulus eichlerianus		Bull-head		
Tribulus spp.		Cat-head, Caltrop		
Trichanthodium skirrophorum				
Trifolium glomeratum	*	Clustered Clover		
Trifolium resupinatum	*	Shaftal Clover		
Trifolium subterraneum	*	Subterranean Clover		
Triglochin calcitrapa		Spurred Arrowgrass		
Triglochin dubia				
Triglochin procera		Water Ribbons		
Triodia scariosa		Porcupine Grass		
Triodia scariosa subsp. scariosa				
Tripogon loliiformis		Fiveminute Grass		
Triptilodiscus pygmaeus		Common Sunray		
Triraphis mollis		Purple Needlegrass		
Triticum aestivum	*	Wheat		
Typha domingensis		Narrow-leaved Cumbungi		
Typha orientalis		Broad-leaved Cumbungi		
Urtica urens	*	Small Nettle		
Vallisneria australis		Eelweed		
Velleia connata				
Velleia paradoxa				
Verbena gaudichaudii		Verbena		
Verbena officinalis	*	Common Verbena		
Verbena supina	*	Trailing Verbena		
Verbesina encelioides subsp. encelioides	*	Crownbeard		
Veronica peregrina	*	Wandering Speedwell		
Vicia monantha	*	Square-stemmed Vetch		
Vittadinia blackii		Western New Holland Daisy		
Vittadinia cervicularis				
Vittadinia cervicularis var. cervicularis		A Fuzzweed		
Vittadinia condyloides				
Vittadinia cuneata		A Fuzzweed		
Vittadinia cuneata var. cuneata		A Fuzzweed		
Vittadinia cuneata var. morrisii				
Vittadinia dissecta				
Vittadinia dissecta var. hirta				
Vittadinia eremaea				
Vittadinia gracilis		Woolly New Holland Daisy		
Vittadinia pterochaeta		Rough Fuzzweed		
Vittadinia spp.		Fuzzweed		
Vulpia muralis	*	Wall Fescue		
Vulpia myuros	*	Rat's Tail Fescue		
Vulpia spp.	*	Rat's-tail Fescue		
Wahlenbergia communis		Tufted Bluebell		
Wahlenbergia fluminalis		River Bluebell		
Wahlenbergia gracilenta		Annual Bluebell		
Wahlenbergia gracilis		Sprawling Bluebell		
Wahlenbergia luteola		Bluebell		
Wahlenbergia spp.		Bluebell		
Wahlenbergia tumidifructa				
Waitzia acuminata		Orange Immortelle		
Walwhalleya proluta				
Westringia rigida		Stiff Westringia		
Wurmbea dioica subsp. dioica		Early Nancy		
Xanthium occidentale	*	Noogoora Burr		
Xanthium orientale	*	Californian Burr		
Xanthium spinosum	*	Bathurst Burr		
Xerochrysum bracteatum		Golden Everlasting		
Zaleya galericulata subsp. australis				
Zygophyllum ammophilum		Sand Twinleaf		
Zygophyllum angustifolium				

Zygophyllum apiculatum		Common Twinleaf		
Scientific Name	**Exotic**	**Common Name**	**NSW status**	**Comm. status**
Zygophyllum aurantiacum		Shrubby Twinleaf		
Zygophyllum confluens				
Zygophyllum crenatum		Lobed Twinleaf		
Zygophyllum eremaeum		Climbing Twinleaf		
Zygophyllum glaucum		Pale Twinleaf		
Zygophyllum iodocarpum		Violet Twinleaf		
Zygophyllum ovatum		Dwarf Twinleaf		
Zygophyllum simile				
Zygophyllum spp.				

Appendix 2: Assessments of Significance for Impacts on Threatened Flora Species under EP&A Act (Seven Part Tests)

Brachyscome papillosa (Mossgiel Daisy)

Brachyscome papillosa (Mossgiel Daisy) is a multi-stemmed perennial herb which grows to 40cm high. Between June and December, solitary flowers occur on a peduncle up to 25 cm long. Flowers are white or mauve in colour with a yellow centre. Leaves are sessile and up to 7cm long (DoE 2008).

Brachyscome papillosa is endemic to NSW, and primarily found within the Riverina Bioregion. The species is distributed between Mossgiel in the north, Yanga National Park to the south west and Urana to the south east.

Brachyscome papillosa is vulnerable listed species under the TSC Act and the Commonwealth's EPBC Act.

Assessment of Significance

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

B. papillosa is known to occur mainly from Mossgiel to Urana, in south-western NSW with sites around Jerilderie, Hay Plain, Willandra Lakes, and north to Ivanhoe. A north-western outlier is at Byrnedale Station, north of Menindee. The only known site on the South Western Slopes is at Ganmain Reserve (DECC, 2005). The species is found primarily recorded in clay soils on Bladder Saltbush (*Atriplex vesicaria*) and Leafless Bluebush (*Maireana aphylla*) plains, but also in grassland and in Inland Grey Box (*Eucalyptus microcarpa*) - Cypress Pine (*Callitris* spp.) woodland.

A large population estimated at several thousand plants was recorded at a nearby location on both sides of a 1.5 km stretch of the Langleydale-Magenta Road in Black Bluebush (*Maireana pyramidata*) and Bladder Saltbush (*Atriplex vesicaria*) Shrubland habitat, approximately 3 km north-north-east of Pit B and 10 km east-north-east of Pits A and C (AMBS 2013). C (AMBS 2013). This location was surveyed again in October 2016 as part of this study with the population estimated at greater than 200,000 plants. The timing of the first survey of this study in late summer (January-February 2016) would have meant the chances of finding *B. papillosa* would have been low. A second survey in October 2016 recorded Mossgiel Daisy as single plants at 13 locations at and around Pits A and C. No plants were found at Pit B. The plants at Pits A and C are considered to be outlier locations of the meta-population occurring along the MCTR at the Langleydale - Magenta Road location.

Consequently, the Hatfield West Gravel Pit Project is unlikely to have an adverse impact on *B. papillosa* such that a viable population is likely to be placed at risk of extinction due to the following:

- the Hatfield West Gravel Pit Project will impact upon 9 individuals of *B. papillosa* only;
- the Hatfield West Gravel Pit Project is unlikely to result in the loss of any known pollinators of the species;
- the Hatfield West Gravel Pit Project is unlikely to change the fire regime associated with the species;
- the nearest known viable meta-population is 10 kms to the east-north-east will not be impacted by the project due to provisions enshrined within the Atlas-Campaspe EIS

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is

likely to be placed at risk of extinction.

Not applicable.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The habitat at Pits A and C where Mossgiel Daisy was found is primarily Belah Woodland which is considered to be marginal habitat for this species. Black Bluebush Shrubland and Pearl Bluebush does occur, but no plants were found in this plant community despite extensive targeted searches. No Bladder Saltbush habitat similar to that occurring on the Atlas-Campaspe MCTR at the Langleydale-Magenta Road exists within the Project Area.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical Habitat, as defined by the TSC Act, has not been declared for *B. papillosa*. There is no critical habitat listed on the NSW Critical Habitat register OEH (2011b) in the project area or surrounds.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is no adopted recovery plan for this species.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The relevant listed key threatening processes to this species is “Clearing of native vegetation”. The Hatfield West Gravel Pit Project would result in the removal of approximately 108.78 Ha of remnant vegetation which is considered to be sub-optimal habitat for *Brachysome papillosa*.

Conclusion

The Hatfield West Gravel Pit Project is unlikely to have a significant impact on *Brachyscome papillosa* due to the following:

- Only sub-optimal habitat for *Brachyscome papillosa* would be removed;
- Only 9 individuals which form part of an outlier of the main meta-population occurring 10km the east-north-east will be directly impacted; and
- fragmentation of the known main population of this species will not occur.

Pterostylis cobarensis (Rusty Greenhood)

Pterostylis cobarensis is a terrestrial orchid with seven to eleven narrow elliptic leaves forming a basal rosette. Stems are up to 40cm, producing between three and eight flowers per stem. Flowers are transparent with brown and green coloration. The species is deciduous with die back occurring after seed-set. Plants persist as the large, underground tubers. New rosettes form following rain in autumn and winter. The species is extremely drought tolerant, with a range of strategies to combat dry conditions. This includes large tubers which store moisture, rosettes with overlapping leaves which trap moisture and direct it to the root zone, and the tendency to grow in sites of litter accumulation and near rocks where run-off is concentrated.

In New South Wales, the species has a widespread distribution, but in the western part of the state, Nyngan-Cobar-Bourke is the core area of occurrence with minor outliers at Mootwingee NP (northeast of Broken Hill) and in the Hatfield West area (Atlas-Campaspe Mineral Sands Project area. Outside New South Wales, the species occurs near Olary in eastern South Australia (west of Broken Hill), and in southeast Queensland near Chinchilla-Brigalow. Porteners and Robertson (2003) suggest that *Pterostylis cobarensis* is potentially threatened by habitat disturbance including grazing, heavy Feral Goat browsing and clearing, but possibly also by competition.

The specific habitat for *Pterostylis cobarensis* in the Atlas-Campaspe Mine footprint at Hatfield West was not outlined by AMBS (2013), but was broadly referred to as 'mallee' in the Seven Part Test done for the species.

Assessment of Significance

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

This species was not recorded within the Project Area during the field surveys, but is known from 'mallee' habitat 4 km to the north-north-east. Potential habitat for the species within the project area would include Chenopod Sandplain/Swale Mallee Woodland (LM116) which occurs over just 1.02 Ha of the proposed gravel pit sites.

The Hatfield West Gravel Pit Project is unlikely to have an adverse impact such that a viable population is likely to be placed at risk of extinction due to the following:

- no known habitat *Pterostylis cobarensis* would be removed as a result of the project;
- no known individuals or populations will be directly or indirectly impacted by the project;
- the reduction of potential mallee habitat is just 1.02 Ha which is insignificant when balanced against the broad distribution of mallee shrublands in the Balranald North area;
- fragmentation of known populations or individuals will not occur; and
- an 'important population' that is necessary for a species' long-term survival and recovery was not recorded in the project area.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not applicable.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Extent of Habitat

The extent of mallee habitat is just 1.02 Ha.

Fragmentation

The Hatfield West Gravel Pit Project will only fragment a very small amount of potential habitat, and no known habitat for this species. No individuals or populations would be impacted.

Importance of Habitat

Habitat for this species within the project area is contiguous with habitat outside of the project area. There is approximately 200,000 Ha of vegetation comprising similar habitat for this species within the Locality. Given the abundance of habitat outside the project area, the habitat within the project area is not considered to be of high importance to the long-term survival of the species within the locality.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical Habitat, as defined by the TSC Act, has not been declared for *Pterostylis cobarensis*. There is no critical habitat listed on the NSW Critical Habitat register OEH (2011b) in the project area or surrounds.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is no adopted recovery plan for this species.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The relevant listed key threatening processes to this species is “Clearing of native vegetation”. The Hatfield West Gravel Pit Project would result in the removal of approximately 108.78 Ha of remnant vegetation, of which only 1.02 Ha is considered potential habitat for *P. cobarensis*.

Conclusion

The Hatfield West Gravel Pit Project is unlikely to have a significant impact on the *P. cobarensis* due to the following:

- no known habitat for *P. cobarensis* would be removed;
- no known individuals or populations will be directly or indirectly impacted; and
- fragmentation of known populations will not occur
- an 'important population' that is necessary for a species' long-term survival and recovery was not recorded in the Project Area