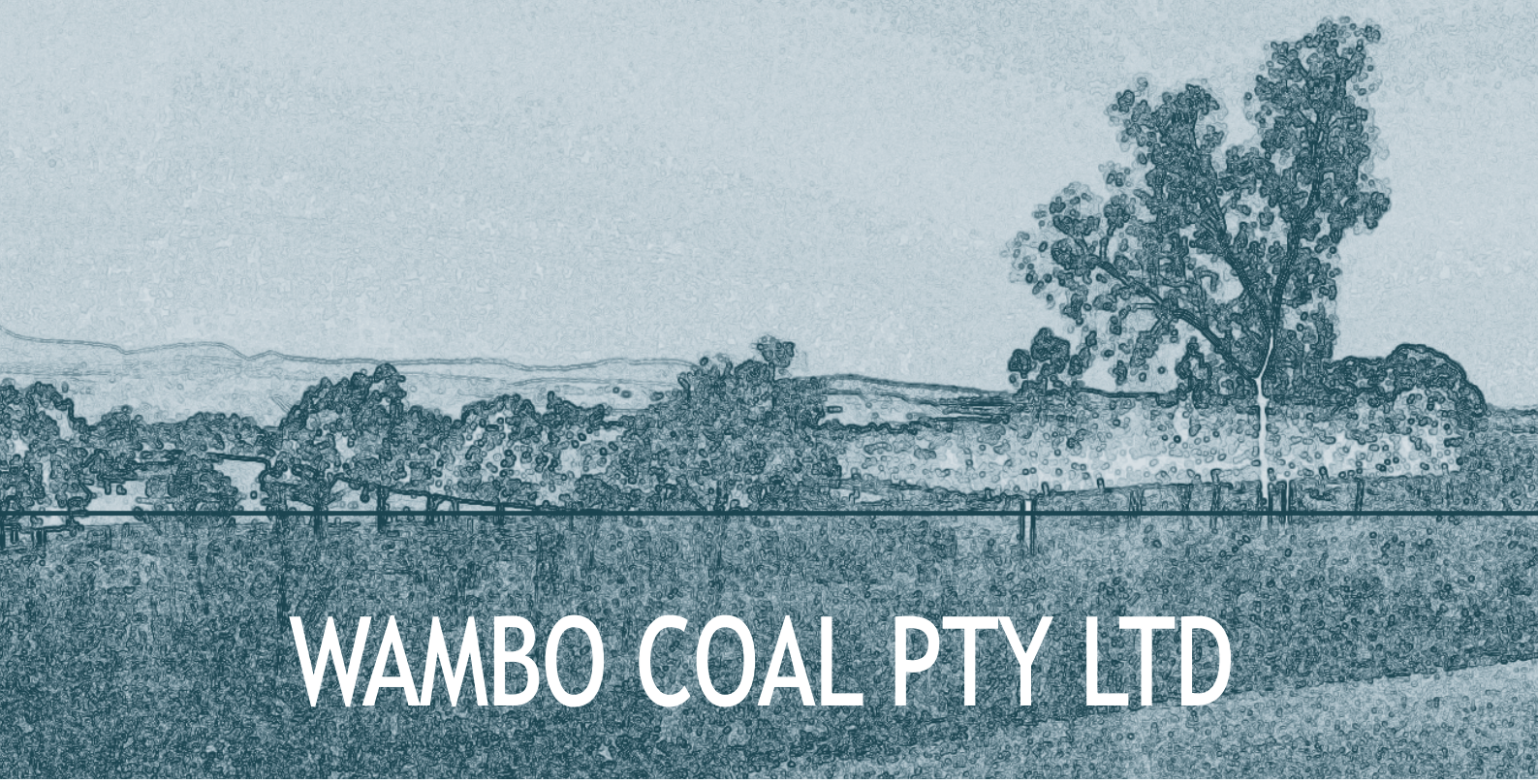


WAMBO COAL PTY LTD

NORTH WAMBO UNDERGROUND MINE MODIFICATION

ENVIRONMENTAL ASSESSMENT

APPENDIX D

FLORA ASSESSMENT

Peabody ENERGY

North Wambo Underground Mine Modification - Flora Assessment

Prepared for Wambo Coal Pty Limited
by FloraSearch

October 2012

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

TABLE OF CONTENTS (Continued)

LIST OF APPENDICES

EXECUTIVE SUMMARY

Flora Survey Findings

Flora Communities and Species

- A flora survey of the study area was conducted over 4 days in June (8 to 10) and 26 September 2011.
- The study area was found to support remnants of nine vegetation communities comprising Hunter Valley River Oak Forest, Hunter Lowland Red Gum forest, Central Hunter Box – Ironbark Woodland, Central Hunter Paperbark Soak Woodland, Central Hunter Bulloak Forest Regeneration, Southern Hunter Escarpment Spotted Gum Woodland, Narrabeen Footslopes Slaty Box Woodland, Native Olive – Scrub Wilga Woodland and Secondary Native Grassland.
- Totals of 173 (70%) native species and 74 (30%) introduced species were found by the surveys involving nine 20×20 m quadrat plots, 14 spot sampling sites and six random meanders.
- The surveys were conducted in good seasonal conditions.
- The plant families with the highest numbers of species were the Grasses, Poaceae (41 species); Daisies, Asteraceae (38 species); Pea Flowers, subfamily Faboideae (18 species); the saltbushes and bluebushes, Chenopodiaceae (11 taxa); the Wattles, subfamily Mimosoideae (9 species) and the Eucalypts and related genera in the family Myrtaceae (8 species). In all, some 59 plant families were represented.
- The highest proportions of introduced species and weeds were in the cleared pasture areas and along the watercourses. Least weeds were found in the less disturbed natural communities on steeper slopes and stony soils. Semi-cleared, grazed natural communities and disturbed sites in bushland areas had intermediate weed levels.

Condition of the Vegetation

- The condition of the native vegetation within the study area varied considerably. In general the most disturbed areas were the watercourses and the flat to gently undulating areas cleared for grazing on the valley floor. The least disturbed areas were the steep rocky slopes and foothills adjoining Wollemi National Park. The remaining areas with natural vegetation cover were all semi-cleared, former or current grazing land, with open areas and regeneration of various ages.

Threatened Species

- No flora species listed in the schedules of the New South Wales *Threatened Species Conservation Act, 1995* or Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* were found in the targeted searches conducted over the study area.

Threatened Vegetation Communities

- Three threatened ecological communities, listed in the schedules of the *Threatened Species Conservation Act, 1995* were identified during the survey, *viz.:*
  - *Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions Endangered Ecological Community;*
  - *Central Hunter Grey Box – Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions Endangered Ecological Community*; and
  - *Hunter Valley Footslopes Slaty Box Woodland in the Sydney Basin Bioregion Vulnerable Ecological Community.*

Conclusions of Assessment

Potential Impacts of the Modification on Flora

- With the exception of water bores to drain old workings, there would be no surface infrastructure. The proposed bores would be located on cleared grazing land and would not impact on remnant native vegetation.
- Subsidence modelling and experience from previous longwall mining in similar terrain nearby indicate some cracking of surface soils may occur in the lower parts of the Modification area only.
- Cracking of soils in similar terrain to the west of the Modification area has produced no observable changes to vegetation condition or the health of individual plants.

Assessment of Significance

- Seven Part Tests of Significance were conducted to assess the potential impacts of the Modification on three threatened ecological communities present on the Modification area. It is clear from the assessment that the Modification is unlikely to have a significant impact on the remnants of the *Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions EEC*, the *Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions* Endangered Ecological Community or the *Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion* Vulnerable Ecological Community.

- Seven Part Tests of Significance were also conducted to assess the potential impacts of the Modification on one endangered flora population and seven threatened flora species that may potentially occur on the Modification area, but were not found by the surveys. The assessment found that the Modification is unlikely to have a significant impact on the *Cymbidium canaliculatum R. Br. in the Hunter Catchment endangered population*, or on the White-flowered Wax Plant, *Dillwynia tenuifolia*, Slaty Red Gum, *Prasophyllum* sp. Wybong, Illawarra Greenhood, Austral Toadflax or *Euphrasia arguta*.

1 INTRODUCTION

FloraSearch was commissioned by Wambo Coal Pty Limited (WCPL) to conduct a flora assessment for the North Wambo Underground Mine Modification (the Modification), located approximately 15 kilometres (km) west of Singleton and 80 km north-west of Newcastle in the Hunter Valley, New South Wales (NSW) (Figure 1 of Appendix A).

The Modification includes the development of two additional longwall panels in the Wambo seam, adjacent to the existing North Wambo Underground Mine (Figures 2 and 3 of Appendix A). Access to the longwall panels would be via the existing North Wambo Underground Mine. The Modification would use existing surface infrastructure of the North Wambo Underground Mine.

Further detail in regard to the Modification is provided in Section 3 of the North Wambo Underground Mine Modification Environmental Assessment main text.

1.1 SURVEY AND ASSESSMENT OBJECTIVES

The objectives of the survey and assessment were to:

- sample the natural vegetation on the study area using standard flora survey techniques.
- determine and map the vegetation communities present within the study area;
- compile a comprehensive plant species list for each vegetation community;
- develop a list of threatened plant species, populations, ecological communities or critical habitat, listed in the schedules of the NSW *Threatened Species Conservation Act, 1995* (TSC Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act*, *1999* (EPBC Act), those considered to be Rare or Threatened Australian Plants (ROTAP) by Briggs and Leigh (1996), that could potentially occur in the Modification area;
- conduct targeted searches for potentially occurring threatened plant species, populations, communities and critical habitat, and map any occurrences;
- undertake detailed analysis of the potential impacts of the proposed modification on flora and their habitats;
- include a discussion of avoidance and mitigation measures to minimise impacts on threatened flora; and
- assess the impact of the Modification on threatened flora by consideration of the seven factors of assessment in the *Threatened Species Assessment Guidelines: The Assessment of Significance* (NSW Department of Environment and Climate Change [DECC], 2007).

1.2 STUDY AREA

The study area extent can be inferred from the extent of vegetation mapping shown on Figure 3. The study area includes the original proposed mine layout and surrounds. The mine layout has subsequently been refined based on mine planning considerations and is shown on Figures 2 and 3 as the extent of secondary extraction.

The description of the study area included in this report refers to the larger study area. For the impact assessment, the focus of the discussion is on the extent of secondary extraction and its relevant extent of subsidence impacts, as provided by MSEC (2012). The extent of subsidence impacts is referred to and labelled on Figure 3 as the Modification area.

1.3 REGIONAL SETTING

The subject area for the flora survey in this report includes the Modification area and areas to the south and south-west, which constitute the study area. The study area is situated in the central Hunter Valley, to the south of the Hunter River (Figure 1). The Hunter River, and its main tributary, the Goulburn River, drain the third largest eastward flowing catchment in NSW. The Goulburn River extends some 210 km inland from the coast to just west of Cassilis, where the uppermost parts of the Hunter Valley coincide with the lowest point (ca. 500 metres [m]) of the Great Dividing Range in NSW. The lowness of the Great Dividing Range at this point has significant implications for both the climate of the Hunter Valley and the movement of plant communities into the valley from the west (Anderson, 1968).

The rugged and densely forested lands of the Narrabeen sandstone–dominated Yengo and Wollemi National Parks occur to the south and west of the Modification area. These ranges reach altitudes of some 600 to 700 m. The Liverpool and Mount Royal Ranges, which rise to much higher altitudes, in excess of 1,100 m, occur in the north. The valley floor is broad, relatively flat and low, being only 40 m altitude at Singleton. Adjacent to the major watercourses, such as the Hunter and Goulburn Rivers and Wollombi Brook, are extensive flat floodplains. These adjoin more extensive gently undulating lands that gradually rise away from the rivers into the foothills of the fringing ranges.

Geologically, the Hunter Valley is part of the Sydney Basin comprising mainly Permian and Triassic sediments. However, on the northern side of the valley Tertiary basalt flows have covered the sediments over considerable areas (e.g. the Merriwa Plateau). The Liverpool and Mount Royal Ranges also comprise mainly basalt rocks resulting from Tertiary volcanic activity. The Permian sediments contain the coal measures which form the basis of the Hunter Valley coal industry and also comprise shale, sandstone, conglomerate, coal, tuff and some older basalt. They are overlain on the southern and western margins of the Valley by the harder Triassic sandstones of the Narrabeen Group that form rugged ranges and plateaux in the Yengo, Wollemi and Goulburn River National Parks. The broad valley floor of the Hunter Valley has developed in the softer Permian sediments. By contrast, the Narrabeen sandstone areas resist erosion forming narrow valleys and gorges with much shallower soils.

1.4 DESCRIPTION OF THE MODIFICATION AREA AND SURROUNDS

1.4.1 Topography and Drainage

The Modification area lies to the west of Wollombi Brook, mostly south of North Wambo Creek near its confluence with Wollombi Brook and north of Wambo Creek near its confluence with Wollombi Brook. Wollombi Brook joins the Hunter River approximately 4 km north east of Warkworth (Figure 1). The southern part of the study area is traversed by Stony Creek including its confluence with Wambo Creek. The study area occupies the broad valley floor comprising the lower floodplains of North Wambo Creek, Wambo Creek and Stony Creek and includes a low ridge and its footslopes between Stony Creek and North Wambo Creek. Altitudes in the study area and surrounds range from 60 m at Wollombi Brook to approximately 140 m on the foot of the escarpment east of Mt. Wambo. Neither the escarpment nor the Wollemi National Park would be affected by the Modification.

1.4.2 Geology, Geomorphology and Soils

The Modification area is situated within the Late Permian age coal measures of the Singleton Supergroup which, in addition to coal, comprise mainly shale, sandstone, siltstone, mudstone and conglomerate. The study area is fringed on the south and west sides by an escarpment of Triassic Narrabeen series sandstone overlying the Permian sediments. Above the narrow alluvial flats on the creeks is gently undulating to hilly country, becoming steeper as it approaches the escarpment.

Kovac and Lawrie (1991) define three Soil Landscapes in the Modification area and surrounds; the Bulga, Benjang and Lees Pinch Soil Landscapes.

- **Bulga.** This Soil Landscape occurs on the lowest elevations of the study area on gently undulating terrain. It is formed in colluvial material derived from the steep slopes of the Lees Pinch Soil Landscape. The underlying geological unit is the Singleton Coal Measures with overlying colluvium from Narrabeen Sandstone. It comprises sandstone, conglomerate, red and green claystone, shale, mudstone and coal. On the study area, it occupies the low flat valleys of North Wambo Creek, Wambo Creek and Stony Creek. The soils, formed from weathered parent rock and derived colluvium, include soloths on upper slopes, solodic soils on mid slopes and brown earths on lower slopes.
- **Benjang.** The Benjang Soil Landscape occupies the low ridge between Stony Creek and North Wambo Creek and the footslopes of the main escarpment. Hills of the Benjang Soil Landscape often have flat-topped surfaces, protected by basalt caps, with steep stony sideslopes. It is developed in the Singleton Coal Measures comprising shale, sandstone, conglomerate, mudstone, coal, tuff and some basalt. The soils include yellow, red and brown solodic soils on imperfectly drained benched slopes, with brown podzolic soils on upper slopes, non-calcic brown soils on lower parts of flatter slopes and siliceous sands on midslopes on quartz sandstone.
- **Lees Pinch.** The Lees Pinch Soil Landscape encompasses the steep high sandstone ranges to the south and west of the Modification area comprising mountains with rounded summits edged by sandstone cliffs. The steep-sided valley of Stony Creek cuts into this soil landscape. Precipitous slopes with gradients to 90 percent (%) are littered with boulders, scree and minor rockfalls. The geological unit is Narrabeen Sandstone comprising lithic and quartz sandstone, conglomerate, green and red claystone, shale and siltstone. The soils include lithosols; shallow siliceous sands and shallow loams; some yellow and brown earths on footslopes; yellow and grey soloths in breaks of slope; and yellow podzolic soils and earthy sands on some upper slopes. This soil landscape would not be affected by the Modification.

1.4.3 Climate

The Modification area is situated some 80 km inland from the coastline. While annual rainfall on the coast may average greater than 1,200 millimetres (mm), it declines rapidly with distance inland, such that it averages only 640 mm at Jerrys Plains, to the north-west of the Modification area (www.bom.gov.au/climate). This rainfall is similar to that experienced on the upper parts of the north-west slopes of NSW. While significant rain may occur at any time of the year, on average it is summer dominant, with January being the highest rainfall month, similar to the north-west slopes. The total annual rainfall at Wambo between 2006-2007 and 2009-2010 has ranged between 564 and 787 mm. Evaporation is of the order of 1,600 mm per annum, or 2.5 times the annual rainfall, indicating a moderate degree of water stress in Australian terms. Relative humidities are comparatively high and do not vary greatly through the year reflecting the near coastal location of the Modification area. In January the 9.00 am and 3.00 pm relative humidities average 67 and 47%, respectively, while the comparable figures for July are 78 and 50% (www.bom.gov.au/climate).

Summers are warm to hot with mean daily maximum temperatures of 31.7 degrees Celsius (^{o}C) in January, the hottest month. July is the coldest month with a mean minimum temperature of 3.7^{o}C. Frosts are common in winter; with July having an average lowest minimum temperature -4.5^{o}C and an average of 5.2 days per annum with minimums below 0^{o}C.

1.4.4 Land Use

The Modification area was part of the tribal lands of the Wonnarua people who inhabited most of the Hunter Valley. The European history of the valley began soon after the first settlement of Sydney Cove in 1788 (www.hvrf.com.au/hunter_history_highlights). The Hunter River was discovered in 1797 by Lieutenant John Shortland while searching for escaped convicts. Shortland noted the presence of numerous coal outcrops, abundant red cedar trees and good grazing lands. By 1799 the first coal had been exported from the valley beginning an industry which has been important for the economy of the valley ever since. Cedar was being exported by 1801, like coal, using convict labour.

In 1819 John Howe blazed Howes Track from Sydney to Maitland, the first overland route to the Hunter Valley. A member of the party, John Singleton, received a land grant of 240 acres and established a trading business on the site of the town now bearing his name (www.singleton.nsw.gov.au/visitors/profilelochist). By 1828 the Great North Road from Windsor on the Hawkesbury River to Jerrys Plains had been completed. The early 1820s saw widespread settlement of the area around Singleton following the awarding of land grants to free settlers, soldiers and freed convicts. The clearing of the Modification area for farming would date from this time. A great variety of crops was grown in the Hunter in the 1800s, including wine grapes, which date from 1823 and continue to be a major industry. Currently, the main agricultural industries within the Modification area and surrounds include beef cattle and dairying. Alluvial soils along the Hunter River are used for irrigated pastures, lucerne hay production and some vegetable growing.

Coal mining around Singleton began in the 1870s and is now the major local industry. Mining at Wambo began in 1969 with underground operations. The commencement of open cut mining at Wambo in 1974 was the beginning of this kind of operation in the Hunter Valley. There are now around 20 open-cut pits in Singleton–Muswellbrook area, which collectively are transforming the local environment, and represent the largest environmental change since the clearing of much of the valley floor in the early 1800s.

1.5 BOTANICAL/BIOGEOGRAPHIC REGIONS

The Modification area lies in the north of the Sydney Basin Bioregion as defined originally by Thackway and Cresswell (1995) and in the south west corner of the North Coast Botanical Division (Anderson, 1968; Harden, 2002). It is close to the southern boundary of the Brigalow Belt South Bioregion (Thackway and Cresswell, 1995) and just outside the eastern boundary of the Central Western Slopes Botanical Division (Anderson, 1968; Harden, 2002).

The intrusion of the Hunter Valley through the Great Dividing Range forms, in combination with the vast sandstone areas to the south, a critical biogeographical barrier for the dispersal of higher altitude plants along the Range (Anderson, 1968). Hence the Hunter Valley marks the northern limit of the Central Tablelands and the southern limit of the Northern Tablelands Botanical Divisions (Anderson, 1968), respectively. The absence of high altitudes in the upper Hunter provides a direct link to the western slopes. This has allowed dispersal of Western Slopes Botanical Division plants into the Valley, so that many plants characteristic of the Western Slopes comprise an important component of the central and upper Hunter Valley flora. Indeed, the Central West Slopes Botanical Division (Anderson, 1968; Harden, 2002) extends into the Hunter Valley almost as far as Singleton where it abuts the southern end of the North Coast Botanical Division.

The Modification area lies just within the North Coast Botanical Division close to the junction of the North and Central Coast Botanical Divisions. Botanically therefore, the Modification area can be expected to comprise a mix of Central Western Slopes and both Central Coast and North Coast plants.

The Interim Biogeographic Regionalisation of Thackway and Cresswell (1995) shows much of the upper Hunter Valley in the Brigalow Belt South Bioregion, which extends up the NSW North Western Slopes into south east Queensland, suggesting the flora has greater affinities with that region than the NSW South Western Slopes Bioregion flora. The Hunter Valley is the only area where the Brigalow Belt South Bioregion crosses to the coastal side of the Great Dividing Range.

1.6 PREVIOUS VEGETATION STUDIES

Several broad scientific studies of flora communities and species within the Hunter Valley have been conducted (Story *et al*., 1963; House, 2003; Peake, 2006). The geographical scope of these studies varies; Story *et al*. (1963), documented the flora as part of an overall study of the land systems for the whole valley, House (2003) was part of a detailed series of investigations and mapping of the flora of the Lower Hunter and Central Coast Regions, while Peake documented the flora of the central parts of the valley, including the study area. A large number of more localised studies have been conducted for environmental assessment purposes in the coal mining industry, including Orchid Research (2003) and FloraSearch (2011) which included parts of the study area.

The vegetation communities mapped by Peake (2006) as occurring within the study area are summarised in Table 1. This scheme was adopted by FloraSearch (2011) with some adjustments and is also broadly followed in this report.

Table 1
Vegetation Communities Mapped by Peake (2006) within the Study Area

	Map Unit (MU)	Community name	Scientific name	Comment
Riparian	MU30	Hunter Valley River Oak Forest	*Casuarina cunninghamiana* subsp. *cunninghamiana*	
Gentle lower slopes	MU24	Hunter Lowlands Red Gum Forest	*Eucalyptus tereticornis – E. punctata – E. crebra – Angophora floribunda – Corymbia maculata*	
	MU10	Central Hunter Box – Ironbark Woodland	*E. crebra – E. moluccana – E. moluccana-E. albens – Allocasuarina luehmannii*	
	MU17	Central Hunter Paperbark Soak Woodland	*Melaleuca decora*	
	MU32	Central Hunter Bulloak Forest Regeneration	*A. luehmannii*	
Steep hills and footslopes	MU12	Southern Hunter Escarpment Spotted Gum Woodland	*C. maculata – E. crebra – E. moluccana – Callitris endlicheri*	
	MU4	Hunter Valley Vine Thicket	*Elaeodendron australe – Geijera parviflora – Notelaea microcarpa* var. *microcarpa – Alectryon oleifolius* subsp. *elongatus – Melia azedarach – Brachychiton populneus* subsp. *Populneus*	FloraSearch (2011) showed that references to the potential occurrence of this community on WCPL-owned land by Orchid Research (2003), followed by Peake (2006), are incorrect. This community does not occur on or near the Modification area
	MU7	Narrabeen Footslopes Slaty Box Woodland	*E. dawsonii – E. moluccana – Acacia salicina*	

2 THREATENED SPECIES, POPULATIONS, ECOLOGICAL COMMUNITIES AND CRITICAL HABITAT

Lists of threatened species, populations, ecological communities and critical habitat that are known, or have potential to occur in the Modification area were derived by consulting the following sources. Database searches were conducted within a 20 × 20 km square centred on the Modification area. The databases were accessed on 21 February 2012.

- BioNet website incorporating searches of the databases of the Atlas of NSW Wildlife and Royal Botanic Gardens, Domain Trust, Forests NSW and the Australian Museum.
- Protected Matters Search Tool (Commonwealth Department of Sustainability, Environment, Water, Population and Communities).
- Schedules of the TSC Act and the EPBC Act.
- Preliminary and Final Determinations of the NSW Scientific Committee.

2.1 THREATENED FLORA SPECIES

Table 2 shows threatened plant species listed in the schedules of the TSC Act and the EPBC Act that are considered possible occurrences within the Modification area or surrounds. These species were specifically targeted during the surveys conducted for this study.

Of the threatened species selected for targeted searches, one is a climber, six are shrubs or trees, four are herbs and one is a grass (Table 2). The presence of the trees, shrubs and climber can be detected at any time of the year and in any seasonal conditions, although identification is usually easier when flowering or fruiting material is present. However, detection of the herbs and grass depend on flowering time and seasonal conditions. Plants would not grow at all, much less flower, in very dry conditions and would not be detectable.

2.2 THREATENED POPULATIONS

Twenty-four endangered populations are currently (February 2012) listed in Schedule 1 of the TSC Act. Three of the populations may potentially occur on the Modification area, *viz*.

- *Acacia pendula* population in the Hunter Catchment;
- *Eucalyptus camaldulensis* population in the Hunter Catchment; and
- *Cymbidium canaliculatum* population in the Hunter Catchment.

Table 3 discusses the likelihood of these three populations being represented in the Modification area or surrounds. These populations were specifically targeted during the surveys conducted for this study.

Table 2
Threatened Plant Species Targeted During the Surveys

Family Name	Scientific Name	Conservation Status		Likelihood of Occurrence	Comment
		TSC Act[1]	EPBC Act[2]		
Araucariaceae	*Wollemia nobilis*	E	E	Low	A pine-like tree that grows to 40 m tall, often multi-stemmed at the base. The bark is thin and fragile and in older trees becomes densely covered with soft and spongy nodules. The side branches terminate in a male or female cone (NSW Department of Environment and Conservation [DEC], 2005a).
Asclepiadaceae	*Cynanchum elegans*	E	E	Medium	Small slender climber, twining stems to 1m, opposite broad acute leaves, milky sap, oval 6 to 10 centimetres (cm) long seed pod, seeds with silky hairs. Mainly rainforest, but also woodland, coast to escarpment. Wollongong to Qld border (DEC, 2005b).
Asteraceae	*Olearia cordata*	V	V	Low	Shrub to 2 m; alternate, narrow-lanceolate, finely mucronate, entire, sessile leaves with revoluta margins and glandular concolorous surfaces; flower heads terminal, solitary with purple ray florets. Dry sclerophyll forest and woodland on sandstone. Wiseman's Ferry to Wollombi (DEC, 2005c).
Fabaceae	*Dillwynia tenuifolia*	V	-	Low	Shrub to 1 m; stems hairy; linear leaves to 12 mm with recurved acuminate apex; yellow and red 'egg and bacon' flowers axillary or terminal, usually solitary; pod 4 to 5 mm long, seeds reticulate. Dry sclerophyll woodland on sandstone, shale or laterite. Cumberland Plain and Blue Mountains to Howes Valley (DEC, 2005d).
Myrtaceae	*Eucalyptus glaucina*	V	V	Medium	Tree to 30 m, red gum bark, juvenile leaves ovate, glaucous; adult leaves lanceolate to 18 × 3 cm, green or grey-green, concolorous; umbellasters 7-flowered, buds glaucous; fruit ovoid to globose, to 10×10 mm, disc raised, valves exserted. On deep, fertile soils. Taree to Broke, Casino (DEC, 2005e).
	Melaleuca groveana	V	-	Low	Small tree to 5 m or more; bark fibrous and papery. Leaves narrow-elliptic, to 55 × 8 mm, acute, apiculate, glabrous; spikes to 30 mm with few to many white flowers; fruit 4 to 7 mm diameter, barrel-shaped, sepals non-persistent. Heath in higher areas. Port Stephens to Queensland (DEC, 2005f).
Orchidaceae	*Prasophyllum* sp. Wybong	-	CE	Low	A terrestrial orchid that grows to approximately 30 cm high. It has a single, tubular, fleshy, dull-green leaf and a single flower spike with numerous fragrant flowers (SEWPaC, 2009).
	Pterostylis gibbosa	E	E	Low	Herb to 45 cm high. Greenhood of the 'rufa' group. Prostrate rosette of 4 to 7 elliptic to ovate basal leaves to 11 × 25 mm, margins entire; flowers 2 to 7, bright green, shiny, semi-erect, labellum broad oblong-obovate, brownish-black, deeply grooved. In grassy sclerophyll forest. Wollongong to Nowra and disjunct populations near Milbrodale and Weston in the Hunter Valley (DEC, 2005g).
Poaceae	*Digitaria porrecta*	E	E	Low	A loosely tufted grass growing to 60 cm tall with grey leaves 2 to 3 mm wide and sharp hairs along the middle. The flowers are clustered in long spikes that spread stiffly from the flowering stem, with the lower spikes arranged in a whorl of four to six, each up to 30 cm long (DEC, 2005h).
Rhamnaceae	*Pomaderris brunnea*	V	V	Low	A shrub to 3 m tall with hairy stems, comprising a layer of long brownish hairs above a thick white hairy under-coat. The leaves are up to 4 cm long and 1.5 cm wide with the leaf veins extending to the toothed margins. The upper leaf surface is hairless; the lower surface is densely hairy like the stem. The small, yellowish flowers have no petals and form dense clusters at the ends of the branches (DEC, 2005i).

Table 2 (Continued)
Threatened Plant Species Targeted During the Surveys

Family Name	Scientific Name	Conservation Status		Likelihood of Occurrence	Comment
		TSC Act[1]	EPBC Act[2]		
Santalaceae	*Thesium australe*	V	V	Low	A small, straggling herb to 40 cm tall with pale green to yellow-green, somewhat succulent leaves, 1 to 4 cm long and 0.5 to 1.5 mm wide. Flowers are minute, white and emerge from the leaf axils. The fruit is small and nut-like (DEC, 2005j).
Scrophulariaceae	*Euphrasia arguta*	CE	CE	Low	An erect, semi-parasitic annual herb growing up to 45 cm high. The branches are very hairy with recurved stiff, non-glandular hairs. The plant has 18 to 30 pairs of sessile, opposite, toothed leaves along the stem. The white to pinkish-lilac flowers are numerous in racemes that contain a number of flowers on lateral stalks with the oldest at the base and the youngest at the top (SEWPaC, 2011).

[1] NSW *Threatened Species Conservation Act, 1995.*

[2] Commonwealth *Environment Protection and Biodiversity Conservation Act*, *1999.*

E Endangered.

CE Critically Endangered

V Vulnerable.

Table 3
Threatened Plant Populations Targeted During the Surveys

Family Name	Scientific Name	Conservation Status		Likelihood of Occurrence	Comment
		TSC Act[1]	EPBC Act[2]		
Mimosoideae	*Acacia pendula*	E	-	High	*A. pendula* (Weeping Myall) is a small tree to 13 m high that is widespread in inland NSW. It occurs as a disjunct population in the central and upper Hunter Valley on six known sites, including two close to the Modification area; Jerrys Plains cemetery and east of the Modification area on WCPL owned land. The total population in the Hunter Valley is estimated at less than 1000 (DEC 2005k). Potential habitat occurs in the Modification area.
Myrtaceae	*Eucalyptus camaldulensis*	E	-	Low	Occurs as a disjunct population on the major floodplains of the Hunter River and large tributaries, including Wollombi Brook and the Goulburn River. It is estimated that only 600 to 1,000 mature of semi-mature trees remain (DEC, 2005l). No major floodplains occur within the Modification area.
Orchidaceae	*Cymbidium canaliculatum*	E	-	High	*C. canaliculatum* (Tiger Orchid) is a large epiphytic orchid that grows in the forks of tree branches, mainly eucalypts, but also *Angophora floribunda* (Rough-barked Apple) and *Acacia salicina* (Cooba). A small population (as few as 90 plants) in the Hunter Valley is at the south eastern extremity of the species' range (DEC, 2006). Suitable hosts and habitat occur within the Modification area.

[1] NSW *Threatened Species Conservation Act, 1995.*

[2] Commonwealth *Environment Protection and Biodiversity Conservation Act*, *1999.*

E Endangered.

2.3 THREATENED ECOLOGICAL COMMUNITIES

Seven Endangered Ecological Communities (EECs) listed in the schedules of the TSC Act are considered possible occurrences within the Modification area, *viz.*

- *Central Hunter Grey Box—Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions;*
- *Central Hunter Ironbark—Spotted Gum—Grey Box Forest in the New South Wales North Coast and Sydney Basin Bioregions;*
- *Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions;*
- *Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions;*
- *Hunter Valley Weeping Myall Woodland of the Sydney Basin Bioregion.* This community is also listed under the EPBC Act as the *Weeping Myall – Coobah – Scrub Wilga Shrubland of the Hunter Valley Critically Endangered Ecological Community;*
- *Warkworth Sands Woodland in the Sydney Basin Bioregion;* and
- *White Box – Yellow Box – Blakely's Red Gum Woodland.* This community is also listed under the EPBC Act as the *White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Grassland Critically Endangered Ecological Community.*

One Vulnerable Ecological Community (VEC) listed in the schedules of the TSC Act is considered a possible occurrence within the Modification area, *viz.*

- *Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion*

Table 4 summarises the known distributions and characteristics of each of the above EECs and VEC with an assessment of their likelihood of occurring on the Modification area.

2.4 CRITICAL HABITAT

No Critical Habitat for flora has been declared on or near the Modification area under the TSC Act or the EPBC Act.

Table 4
Potential Threatened Plant Communities on the Modification Area

Community Name	Conservation Status		Dominant Species	Known Distribution	Potential Habitats	Likelihood of Occurrence
	TSC Act[1]	EPBC Act[2]				
Central Hunter Grey Box - Ironbark Woodland	E	-	*Eucalyptus crebra – Brachychiton populneus – E. moluccana*	Singleton to Muswellbrook area of the Central Hunter Valley.	Gently undulating hills, slopes and valleys, occasionally on rocky knolls, Permian lithology (NSW Department of Environment, Climate Change and Water [DECCW], 2010a).	High
Central Hunter Ironbark - Spotted Gum - Grey Box Forest	E	-	*E. crebra – Corymbia maculata – E. moluccana*	Mainly Maitland to Muswellbrook in the central Hunter Valley.	Undulating terrain on low rises and slopes. Permian clays and colluvium and alluvium in valleys (DECCW, 2010b).	High
Hunter Floodplain Red Gum Woodland	E	-	*E. camaldulensis – E. tereticornis – E. melliodora – Angophora floribunda*	Hunter Valley including LGAs of Maitland, Mid-Western, Muswellbrook, Singleton, and Upper Hunter.	Major floodplains and floodplain rises (DECCW 2010c). No major floodplains occur on the Modification area.	Low
Hunter Lowland Redgum Forest	E	-	*E. tereticornis – E. punctata ± E. moluccana, Angophora costata, C. maculata* or *E. crebra*	Hunter Valley LGAs of Maitland, Cessnock, Port Stephens, Muswellbrook and Singleton.	Gently sloping depressions and drainage flats of the Hunter Valley floor (DEC, 2005n).	High
Hunter Valley Weeping Myall Woodland	E	CE	*Acacia pendula – E. crebra – Acacia salicina*	Singleton and Muswellbrook LGAs in the central Hunter Valley.	Occurs on heavy Permian clay soils (DEC 2005m). There are two known occurrences close to the Modification area; Jerrys Plains cemetery and east of the Modification area on WCPL owned land.	High
Warkworth Sands Woodland	E	-	*Angophora floribunda – Banksia integrifolia*	Limited to the Warkworth area in the Singleton LGA of the central Hunter Valley.	Restricted to aeolian sand deposits along Wollombi Brook, north and south of Warkworth (NSW National Parks and Wildlife Service [NPWS] 2002b). Although the known occurrences of this community are relatively close (8 km) to the Modification area, suitable soil types are absent from it.	Low
White Box - Yellow Box - Blakely's Red Gum Woodland	E	CE	*E. albens - E. melliodora – E. blakelyi*	Tablelands and western slopes of NSW and the upper Hunter Valley.	Deep fertile soils on undulating terrain (DEC, 2005o). Occurs on the footslopes of the Narrabeen Sandstone escarpments of the upper Hunter Valley. Not considered to have potential to occur on the study area by the NSW BioNet database, but was returned by the EPBC Act Protected Matters search.	Low
Hunter Valley Footslopes Slaty Gum Woodland	V	-	*E. dwyeri – E. moluccana ± A. salicina, Allocasuarina luehmannii*	South side of the Hunter Valley from Bulga to the Bylong / Goulburn River National Park area in the Singleton, Muswellbrook and Upper Hunter LGAs.	Occurs mainly on colluvium derived from Triassic sandstones and conglomerates over Permian lithology (DECCW 2010d). Suitable environments occur in the Modification area.	High

[1] NSW *Threatened Species Conservation Act, 1995.*

[2] Commonwealth *Environment Protection and Biodiversity Conservation Act*, *1999.*

E Endangered.

CE Critically Endangered.

V Vulnerable.

LGA Local Government Area.

3 METHODS

The vegetation survey was carried out over 4 days in the periods 8 to 10 June and 26 September 2011. At the time of the field survey the Modification area was larger than in the current application. All data collected in the survey is presented here to provide greater context to the current smaller Modification area. The Modification area and the larger survey area are referred to as the study area herein. The survey encompassed all remnants of native vegetation within the study area in order to sample and identify all communities present. All habitat types were surveyed to maximise the chances of finding populations of any threatened species that may occur. Complete coverage of the area was facilitated by recent aerial photography showing remnant vegetation. Good four wheel drive access was available via fire trails and paddock tracks through most of the area. Areas inaccessible by vehicle were traversed on foot.

3.1 VEGETATION SAMPLING

Three methods of documenting the vegetation were employed; quadrat sampling, spot sampling and random meanders. These methods are detailed in Sections 3.1.1, 3.1.2 and 3.1.3, respectively. Figure 3 shows the locations of flora sample sites.

3.1.1 Quadrat Sampling

A total of nine 20 × 20 m (0.04 hectares [ha]) flora quadrat sites was sampled over the study area (Figure 3). Within each plot the dominant species in each vegetation stratum were recorded, with an estimate of the percentage of the ground surface covered by their canopies. A list of all vascular plant species present within the quadrat was also made with each being assigned a cover abundance rating using a modified Braun-Blanquet scale (Table 5). Details recorded for each site included its Global Positioning System (GPS) position, landform, physiography, soil characteristics, disturbance, vegetation structural formation and general comments. Plots were stratified across all vegetation communities in proportion to their representation on the study area (Table 6).

Table 5
Modified Braun-Blanquet Cover Abundance Rating Scale

Rating	Percent Ground Cover
1	<1
2	1 to 5
3	6 to 25
4	26 to 50
5	51 to 75
6	76 to 100

3.1.2 Rapid Assessment Spot Sampling

In addition to the quadrat samples, and in order to comprehensively survey the flora over the entire study area, 14 rapid assessment spot samples were conducted (Figure 3). Spot samples listed all vascular plants within a 15 m radius of the central point at which a GPS reading was taken. The dominant tree species were noted to allow classification of the site according to community. Brief notes were made on site characteristics, the condition of the vegetation and any disturbance. Spot samples were mainly taken in heavily cleared and other highly disturbed vegetation types (Table 6).

Table 6
Sampling Effort Stratified by Vegetation Communities

Community Number (this study)	Map Unit (Peake 2006)	Community Name	Quadrat Numbers	Spot Sample Numbers
1	MU30	Hunter Valley River Oak Forest	-	2, 3, 4
2	MU24	Hunter Lowland Red Gum Forest	2	1, 6, 7, 14
3	MU10	Central Hunter Box – Ironbark Woodland	1, 6, 7	8
4	MU17	Central Hunter Paperbark Soak Woodland	4	-
5	MU32	Central Hunter Bulloak Forest Regeneration	3	-
6	MU12	Southern Hunter Escarpment Spotted Gum Woodland	8	-
7	MU7	Hunter Valley Footslopes Slaty Box Woodland	5, 9*	10
8	-	Native Olive – Scrub Wilga Woodland	-	-
9	-	Secondary Native Grassland	-	5, 9, 11, 12, 13

* Quadrat 9 is within an area of Community 7 that is too small to be accurately mapped on Figure 3.

3.1.3 Random Meanders

Random meanders were used to search for threatened flora species and populations (DEC, 2004). 'Random meander' describes the nature of the search which is a randomly directed walk through habitat considered likely to support populations of the targeted species. The random meanders in this survey were targeted to the known habitats described in fact sheets and profiles of threatened species published on the websites of the NSW Office of Environment and Heritage (OEH) and the Commonwealth Department of Sustainability, Environment, Populations and Communities (SEWPaC), as well as on the website of the Royal Botanic Gardens Sydney. The species and populations targeted are given in Tables 2 and 3. Four random meanders each of 30 minutes duration were conducted by a team of two people walking approximately 10 m apart from each bushland quadrat site. For each meander, lists of all flora species, additional to those recorded at the quadrat site, were compiled to provide further data on community composition and the flora diversity of the study area.

3.2 VEGETATION MAPPING

The approximate distribution of each vegetation community was mapped onto detailed colour aerial photos of the study area during the field work. The field mapping was later refined by air photo interpretation in the office.

3.3 SPECIES LISTING

All observed plant species were recorded, whether identified on formal sample sites or not. Some less common plants were only observed on one occasion whilst moving between sample sites. Where plants could not be quickly identified in the field, a sample was taken for later examination. Samples were preserved in a plant press and identified later using a binocular microscope and flora keys. The principal reference was the *Flora of New South Wales* (Ed. G. Harden 1990-2002) and it is used as the basis for nomenclature in this report along with any updates on the PlantNet web site of the Royal Botanic Gardens Trust, Sydney.

3.3.1 Rare or Threatened Australian Plants (ROTAP)

All plants found in the surveys were checked for their status in The Rare or Threatened Australian Plants (ROTAP) (Briggs and Leigh, 1996) classification.

3.3.2 Regionally Significant Flora

The Rare Plants Committee of the Hunter Region Botanic Gardens has compiled a Preliminary List of Regionally Significant Plants (Bell *et al*., in prep), comprising 1,217 species. The status of most species on the list is yet to be finally determined. All species found in the surveys of the Modification area and surrounds were checked for their presence on the list and this data is presented in the results.

3.4 VEGETATION CONDITION ASSESSMENT

Native vegetation condition varies widely across the study area according to the history of land use. This report does not aim to provide a detailed quantitative assessment of vegetation condition across the study area similar to those generated by methodologies such as Biometric (Gibbons *et al.,* 2005) or Biobanking (DEC, 2008). Rather, the aim is to broadly describe vegetation condition enabling a general understanding of the variation across the study area. The condition assessment considers the status of key parameters commonly used in vegetation condition monitoring. These are:

- *Disturbance*. Anthropogenic disturbance factors such as land clearing, vegetation thinning, fire roads and tracks, grazing, logging, quarrying, hazard reduction burning and recreation are considered. Natural disturbance factors considered include wildfires, storms and drought.
- *Native vegetation cover*. Broad comparisons are made between the current cover percentages of each vegetation layer and those expected in undisturbed examples of each community.
- *Juveniles*. The presence of juvenile plants of perennial species indicating that successful reproduction is occurring.
- *Exotic flora.* The presence of exotic flora species and their likely impacts on the viability of natural communities.
- *Fragmentation.* The degree to which the original natural vegetation has been broken into small patches isolated from other such patches and/or large undisturbed areas.
- *Overall degradation*. An overall level of degradation (nil, low, moderate, high, completely alienated) is assessed from the degree of disturbance and weed invasion.
- *Resilience*. An assessment is made of the likely ability of the area to naturally regenerate its native vegetation cover, either partially or fully, if degrading influences are removed.

4 RESULTS AND DISCUSSION

4.1 VEGETATION COMMUNITIES

The survey revealed the presence on the study area of nine vegetation communities (Table 7). The distribution of each community located in the study area is shown on Figure 3. Not all vegetation communities in the study area occur over the Modification area. In particular, communities 6 (Southern Hunter Escarpment Spotted Gum Woodland) and 8 (Native Olive – Scrub Wilga Woodland) in Table 7 are outside the Modification area (Figure 3).

Table 7
Vegetation Communities Recognised within the Study Area

Community Number (this report)	Community Number (Peake 2006)	Common Names	Scientific Names
1	MU30	Hunter Valley River Oak Forest	*Casuarina cunninghamiana* subsp. *cunninghamiana*
2	MU24	Hunter Lowland Red Gum Forest	*Eucalyptus tereticornis – Angophora floribunda ± E. melliodora*
3	MU10	Central Hunter Box – Ironbark Woodland	*E. crebra – E. moluccana – Allocasuarina luehmannii*
4	MU17	Central Hunter Paperbark Soak Woodland	*Melaleuca decora*
5	MU32	Central Hunter Bulloak Forest Regeneration	*A. luehmannii*
6	MU12	Southern Hunter Escarpment Spotted Gum Woodland	*Corymbia maculata – E. crebra – E. moluccana – Callitris endlicheri*
7	MU7	Hunter Valley Footslopes Slaty Box Woodland	*E. dawsonii – E. moluccana – Acacia salicina*
8	NA*	Native Olive – Scrub Wilga Woodland	*Notelaea microcarpa* var. *microcarpa – Geijera salicifolia* var. *salicifolia*
9	NA*	Secondary Native Grassland	

* Not mapped by Peake (2006).

The following sections provide descriptions of each plant community specific to the study area using sample data collected in this survey.

Community 1. Hunter Valley River Oak Forest

River Oak Forest is confined to the riparian zone and adjacent alluvial soils on the lower reaches of North Wambo Creek, where it forms a discontinuous strip along the creek owing to past clearing. Three rapid assessment samples were conducted in this community due to its small representation on the study area (Plate 1) and highly fragmented nature.

Community 1 is highly variable across its distribution in the Hunter Valley (Peake, 2006). While River Oak, *Casuarina cunninghamiana* subsp. *cunninghamiana*, is always the dominant mid storey species it may associate with a variety of other trees. On lower North Wambo Creek, the dominant upper canopy associate is Forest Red Gum, *Eucalyptus tereticornis*, with Rough-barked Apple, *Angophora floribunda* as a less common associate.

Most of the upper and mid storeys have been cleared historically from all but the sloping creek banks for grazing. Common remnant mid storey species on lower North Wambo Creek include Cooba, *Acacia salicina*; Scrub Wilga, *Geijera salicifolia*, and Bulloak, *Allocasuarina luehmannii*. The low native shrub Small-leaf Bluebush, *Maireana microphylla*, is also present.

Plate 1. Community 1, River Sheoak within the incised parts of North Wambo Creek with fringing Forest Red Gum on the adjacent alluvial floodplain.

The most common native ground cover species included Pennywort, *Hydrocotyle tripartita*; Stinging Nettle, *Urtica incisa*; Slender Bamboo Grass, *Austrostipa verticillata*; Red Grass, *Bothriochloa decipiens*; Couch, *Cynodon dactylon* and Slender Rat's Tail Grass, *Sporobolus creber*.

The understorey of Community 1 tends to be dominated by introduced species. These included trees; Pepper Tree, *Schinus areira*; shrubs including Common Olive, *Olea europaea* and African Boxthorn, *Lycium ferocissimum*. Common introduced herbs and grasses are Galenia, *Galenia pubescens*; Narrow-leaved Cotton Bush, *Gomphocarpus fruticosus*; Spear Thistle, *Cirsium vulgare*; Fireweed, *Senecio madagascariensis*; Common Sowthistle, *Sonchus oleraceus*; Common Chickweed, *Stellaria media*; Red-flowered Mallow, *Modiola caroliniana*; Scarlet Pimpernel, *Anagallis arvensis*; Lamb's Tongue, *Plantago lanceolata*; a Purpletop, *Verbena caracasana*; Sharp Rush, *Juncus acutus* and Rhodes Grass, *Chloris gayana*.

Community 2. Hunter Lowland Red Gum Forest

Remnants of Hunter Lowland Red Gum Forest occur along the course of Stony Creek in the south of the study area and in the north-east corner near the confluence of North Wambo Creek and Wollombi Brook (Plate 2). This community was sampled by one quadrat, four rapid assessment samples and one random meander. The community is characterised by an overstorey dominated by Forest Red Gum, *Eucalyptus tereticornis*. The most common associate of Forest Red Gum along Stony Creek is Rough-barked Apple, *Angophora floribunda*, while Coast Grey Box, *Eucalyptus moluccana* is a less common associate.

The most frequent tall shrubs include Cooba, *Acacia salicina*, White Cedar, *Melia azedarach*; Native Olive, *Notelaea microcarpa* var. *microcarpa* and Scrub Wilga, *Geijera salicifolia* var. *salicifolia*. Small leaf Bluebush, *Maireana microphylla*, is a common native low shrub, while *Bertya oleifolia* and Native Rosella, *Hibuscus heterophyllus* subsp. *heterophyllus* are occasional.

Common native ground cover species include Common Everlasting, *Chrysocephalum apiculatum*; Carrot Weed, *Cotula australis*; Red Berry Saltbush, *Einadia hastata*; Slender Tick-trefoil, *Desmodium varians*; a *Glycine*, *Glycine tabacina*; Slender Flat-sedge, *Cyperus gracilis*; Speargrass, *Austrostipa scabra*; Slender Bamboo Grass, *Austrostipa verticillata*; Brown's Lovegrass, *Eragrostis brownii* and Weeping Grass, *Microlaena stipoides*.

Plate 2. Community 2, Hunter Lowland Red Gum Forest (Quadrat 2).

Introduced species are common and include Galenia, *Galenia pubescens*; Narrow-leaved Cotton Bush, *Gomphocarpus fruticosus*; Spear Thistle, *Cirsium vulgare*; Tall Fleabane, *Conyza sumatrensis*; Smooth Catsear, *Hypochaeris glabra*; Fireweed, *Senecio madagascariensis*; Stinking Roger, *Tagetes minuta*; Common Chickweed, *Stellaria media*; Paddy's Lucerne, *Sida rhombifolia*; Scarlet Pimpernel, *Anagallis arvensis*; Lamb's Tongue, *Plantago lanceolata*; Black-berry Nightshade, *Solanum nigrum*; Stinging Nettle, *Urtica incisa*; Purpletop, *Verbena bonariensis* and Pale Pigeon Grass, *Setaria pumila*.

Community 3. Central Hunter Box – Ironbark Woodland

Central Hunter Box – Ironbark Woodland, as defined by Peake (2006), is the most widespread community on the study area (Plate 3). It is dominated by Narrow-leaved Ironbark, *Eucalyptus crebra* and Coast Grey Box, *Eucalyptus moluccana*. Low trees include mainly Bulloak, *Allocasuarina luehmannii*; Honeymyrtle, *Melaleuca decora* and Cooba, *Acacia salicina*.

Plate 3. Community 3, Central Hunter Box – Ironbark Woodland (Quadrat 6).

The most prominent tall shrub species is Native Olive, *Notelaea microcarpa* var. *microcarpa*. Low shrubs are relatively diverse and include Cunningham's Everlasting, *Cassinia cunninghamii*; Small-leaf Bluebush, *Maireana microphylla*; Broom Bitter-pea, *Daviesia genistifolia*; Fan Wattle, *Acacia amblygona* and Western Boobialla, *Myoporum montanum* among others.

The ground cover in this community tends to be sparse but relatively diverse. The dominant native ground cover species are Poison Rock Fern, *Cheilanthes sieberi*; Purple Burr-daisy, *Calotis cuneifolia*; Yellow Burr-daisy, *Calotis lappulacea*; Common Everlasting, *Chrysocephalum apiculatum*; Cobbler's Tack, *Glossocardia bidens*; Vernonia, *Vernonia cinerea*; Fuzzweed, *Vittadinia cuneata* var. *hirsuta*; Climbing Saltbush, *Einadia nutans* subsp. *linifolia*; Kidney Weed, *Dichondra repens*; Slender Tick-trefoil, *Desmodium varians*; a Glycine, *Glycine tabacina*; Round-leaf Goodenia, *Goodenia rotundifolia*; Amulla, *Eremophila debilis*; Trailing Speedwell, *Veronica plebeia*; Slender Flat-sedge, *Cyperus gracilis*; Wattle Mat-rush, *Lomandra filiformis* Subsp. *filiformis*; Many-flowered Mat-rush, *Lomandra multiflora*; Purple Wire-grass, *Aristida personata*; Three-awn Speargrass, *Aristida vagans*; a Wallaby Grass, *Austrodanthonia fulva*; Speargrass, *Austrostipa scabra*; Red Grass, *Bothriochloa decipiens*; Plump Windmill Grass, *Chloris ventricosa*; Hairy Panic, *Panicum effusum* and Slender Rat's Tail Grass, *Sporobolus creber*.

Introduced species are much less frequent in Community 3 than in Communities 1 and 2 owing to drier conditions and less fertile soils. The main species include Fireweed, *Senecio madagascariensis*; the Peppercress, *Lepidium africanum*; Creeping Pear, *Opuntia humifusa*; Common Prickly Pear, *Opuntia stricta* and African Lovegrass, *Eragrostis curvula*.

Community 4. Central Hunter Paperbark Soak Woodland

Within the Modification area Community 4 is confined to a small area adjacent to the south and east sides of the centrally placed water storage facility (Plate 4). The community was sampled by one quadrat and one random meander only. This community is dominated by White Feather Honeymyrtle, *Melaleuca decora*, which forms continuous stands in areas of impeded drainage, or where there are springs and soaks that remain moist for long periods. There may be emergent trees of Narrow-leaved Ironbark, *Eucalyptus crebra* and/or Forest Red Gum, *Eucalyptus tereticornis*. The community is characterised by a range of species that tolerate moist conditions, especially various rushes and sedges, but is also strongly influenced by the surrounding vegetation and may have many understorey species in common with adjacent communities (Peake 2006).

Plate 4. Community 4, Central Hunter Paperbark Soak Woodland (Quadrat 4)

Other low trees or tall shrubs occurring in Community 4 were Sickle Wattle, *Acacia falcata*; Western Boobialla, *Myoporum montanum* and Scrub Wilga, *Geijera salicifolia* var. *salicifolia*. The main low shrubs included Small-leaf Bluebush, *Maireana microphylla*; Straggly Lantern-bush, *Abutilon oxycarpum* and Spiked Sida, *Sida subspicata*.

The dominant ground cover species were Bristly Cloak Fern, *Cheilanthes distans*; Carrot Weed, *Cotula australis*; Star Cudweed, *Euchiton involucratus*; Kidney Weed, *Dichondra repens*; a Glycine, *Glycine tabacina*; Slender Flat-sedge, *Cyperus gracilis*; Purple Wire-grass, *Aristida personata*; Red Grass, *Bothriochloa decipiens*; Plump Windmill Grass, *Chloris ventricosa*; Paddock Lovegrass, *Eragrostis leptostachya*; Weeping Lovegrass, *Eragrostis parviflora* and Slender Rat's Tail grass, *Sporobolus creber*.

Introduced species were more frequent than in the drier communities and included Galenia, *Galenia pubescens*; Flaxleaf Fleabane, *Conyza bonariensis*; Smooth Catsear, *Hypochaeris glabra*; Fireweed, *Senecio madagascariensis*; a Peppercress, *Lepidium bonariense*; Red-flowered Mallow, *Modiola caroliniana*; Paddy's Lucerne, *Sida rhombifolia* and Lamb's Tongue, *Plantago lanceolata*.

Community 5. Central Hunter Bulloak Forest Regeneration

Community 5 is a secondary community resulting from the regeneration and/or recolonisation of cleared areas formerly occupied by Community 3. This community comprises dense monospecific stands of Bulloak, *Allocasuarina luehmannii* (Plate 5) which tend to project heavy shade on the ground, thereby excluding most other species. On the study area, Community 5 lacks other emergent tall or low tree species, or tall shrubs. This vegetation type is limited to several small patches in the north of the study area (Figure 3). One quadrat was undertaken in this community (Table 6).

Plate 5. Community 5, Central Hunter Bulloak Forest Regeneration (Quadrat 3).

Low shrubs tend to be a minor component of the community except where openings occur in the dense canopy. The only low shrub recorded was Broom Bitter-pea, *Daviesia genistifolia*. The ground cover is sparse due to heavy shading by the Bulloak and the relatively poor soils on which this community occurs. Ground cover species include many characteristic of Community 3; Poison Rock Fern, *Cheilanthes sieberi*; the Yellow-daisy, *Calotis lappulacea;* Common Everlasting, *Chrysocephalum apiculatum*; Red Berry Saltbush, *Einadia hastata*; Climbing Saltbush, *Einadia nutans* subsp. *nutans*; Australian Stonecrop, *Crassula sieberiana*; Caustic Weed, *Chamaesyce drummondii*; Threeawn Speargrass, *Aristida vagans*; Plump Windmill Grass, *Chloris ventricosa*; Barbwire Grass, *Cymbopogon refractus*; Curly Windmill Grass, *Enteropogon acicularis*; Clustered Lovegrass, *Eragrostis elongata*; Hairy Panic, *Panicum effusum* and Fine Panic, *Paspalidium criniforme*.

Due to its poor soils this community has few introduced species; only Fireweed, *Senecio madagascariensis* and Creeping Pear, *Opuntia humifusa* were recorded.

Community 6. Southern Hunter Escarpment Spotted Gum Woodland

Community 6 is confined to small occurrences outside the Modification area, mainly on the footslopes of the escarpment (Plate 6). One quadrat and one random meander were conducted in Community 6 (Table 6). This community is characterised and dominated by Spotted Gum, *Corymbia maculata*, often with smaller amounts of other canopy species, particularly Narrow-leaved Ironbark, *Eucalyptus crebra*.

Low trees or tall shrubs are often also present including Native Cherry, *Exocarpos cupressiformis*; Scrub Wilga, *Geijera salicifolia* var*. salicifolia*; Blackthorn, Winged Broom-pea, *Jacksonia scoparia*; *Bursaria spinosa*; Shiny-leaved Canthium, *Psydrax odorata*; *Choretrum* species A and Wedge-leaf Hop-bush, *Dodonaea viscosa* subsp. *cuneata*. Low shrubs included Cunningham's Everlasting, *Cassinia cunninghamii*; Sticky Daisy-bush, *Olearia elliptica*; Hoary Guinea Flower, *Hibbertia obtusifolia*; Large Tick-trefoil, *Desmodium brachypodum*; Fan Wattle, *Acacia amblygona*; Bead Bush, *Spartothamnella juncea* and Amulla, *Eremophila debilis*.

The ground cover tends to be sparse in Community 6 and includes Bristly Cloak Fern, *Cheilanthes distans*; Poison Rock Fern, *Cheilanthes sieberi*; Kidney Weed, *Dichondra repens*; the Slender Tick-trefoils, *Desmodium gunnii* and *D. varians*; Round-leaf Goodenia, *Goodenia rotundifolia*; Small Vanilla Lily, *Arthropodium minus*; the Wattle Mat-rushes, *Lomandra filiformis* subsp. *coriacea* and *L. filiformis* subsp. *filiformis*; Barbwire Grass, *Cymbopogon refractus* and Long-leaved Wallaby Grass, *Notodanthonia longifolia*.

Introduced species are generally uncommon; Narrow-leaved Cotton Bush, *Gomphocarpus fruticosus*; Fireweed, *Senecio madascariensis* and Common Prickly Pear, *Opuntia stricta*.

Plate 6. Community 6, Southern Hunter Escarpment Spotted Gum Woodland (Quadrat 8).

Community 7. Hunter Valley Footslopes Slaty Box Woodland

Narrabeen Footslopes Slaty Box Woodland is dominated by Slaty Box, *Eucalyptus dawsonii*, a tall straight tree that may form extensive monospecific stands, although usually having Narrow-leaved Ironbark, *Eucalyptus crebra*, as a less common associate (Plate 7). Community 7 occurs extensively in the southern half of the study area on the footslopes of the Narrabeen Sandstone escarpment (Figure 3). It was sampled by two quadrats, one rapid assessment sample and one random meander (Table 6).

Plate 7. Community 7; Hunter Valley Footslopes Slaty Box Woodland (Quadrat 5)

Low trees and tall shrubs most commonly included Kurrajong, *Brachychiton populneus* and Native Olive, *Notelaea microcarpa* var. *microcarpa*. Community 7 often has dense stands of medium height shrubs (1 to 3 m approximately) comprising various combinations of Blackthorn, *Bursaria spinosa*; White Sour Bush, *Choretrum* species A; and Hop-bushes, *Dodonaea viscosa* subsp. *cuneata*, *Dodonaea viscosa* subsp. *spatulata* and *D. sinuolata* subsp. *sinuolata*.

Low shrubs are also common and diverse, including Sticky Daisy-bush, *Olearia elliptica*; Cunningham's Everlasting, *Cassinia cunninghamii*; Rice Flower, *Ozothamnus diosmifolius*; Narrow-leaved Orangebark, *Maytenus silvestris*; Large Tick-trefoil, *Desmodium brachypodum*; Fan Wattle, *Acacia amblygona*; Spiked Sida, *Sida subspicata*; Amulla, *Eremophila debilis* and Violet Nightshade, *Solanum brownii*.

The ground cover in this community is generally quite open with bare ground and leaf litter predominant. The main herbaceous species present include Bristly Cloak Fern, *Cheilanthes distans*; Poison Rock Fern, *Cheilanthes sieberi*; Blue Trumpet, *Brunoniella australis*; Pink Tongues, *Rostellularia adscendens* var. *adscendens*; Yellow Burr-daisy, *Calotis lappulacea*; Cobbler's Tack, *Glossocardia bidens*; Climbing Saltbush, *Einadia nutans* subsp. *linifolia*; Kidney Weed, *Dichondra repens*; Variable Glycine, *Glycine tabacina*; Round-leaf Goodenia, *Goodenia rotundifolia* and Corrugated Sida, *Sida corrugata*.

A variety of sedges, mat-rushes, lilies and grasses are also sparsely distributed, including Slender Flat-sedge, *Cyperus gracilis*; Wattle Mat-rush, *Lomandra filiformis* subsp. *filiformis*; Purple Wiregrass, *Aristida personata*; Speargrass, *Austrostipa scabra* subsp. *falcata*; Plump Windmill Grass, *Chloris ventricosa*; Barbwire Grass, *Cymbopogon refractus*; Paddock Lovegrass, *Eragrostis leptostachya*; Weeping Grass, *Microlaena stipoides*; Hairy Panic, *Panicum effusum* and Slender Rat's Tail grass, *Sporobolus creber*.

Introduced species are uncommon in Community 7. The most prominent are Narrow-leaved Cotton Bush, *Gomphocarpus fruticosus*; Fireweed, *Senecio madagascariensis*; Common Sowthistle, *Sonchus oleraceus* and Common Prickly Pear, *Opuntia stricta*.

Community 8. Native Olive – Scrub Wilga Woodland

A small patch of Community 8 occurs in the extreme south-west of the study area outside the Modification area (Figure 3). Native Olive – Scrub Wilga Woodland was not identified as a separate vegetation type by Peake (2006). However, Story *et al*. (1963), Orchid Research (2003) and FloraSearch (2011) consider it to be a distinct vegetation association along the footslopes of the southern escarpment of the Hunter Valley. FloraSearch (2011) noted that Native Olive – Scrub Wilga Woodland appears to be associated with the Benjang Soil Landscape of Kovac and Lawrie (1991). FloraSearch also noted that extant occurrences of this vegetation association may be a derived community following clearing of the distinctive 'hill form' of 'Central Hunter Box – Ironbark Woodland' that occurs on the Benjang Soil Landscape. The small occurrence of this community on the margins of the study area was not sampled during this study. Its occurrence was mapped by Orchid Research (2003) and refined by air photo interpretation for Figure 3. A full description of the community on WCPL-owned land is given in FloraSearch (2011). Community 8 would not be impacted by the Modification.

Community 9. Secondary Native Grassland

Much of the lower lying and flatter parts of the study area comprise cleared grazing paddocks (Figure 3 and Plate 8). North of Stony Creek, the paddocks are predominantly native grasslands with varying proportions of introduced pasture and weed species. South of Stony Creek, the paddocks comprise mainly improved pastures dominated by exotic pasture and weed species. Five rapid assessment samples were conducted in the pastures; three to the north and two to the south of Stony Creek (Table 6).

Plate 8. Community 9: Secondary Native Grassland

Some 12 species of grasses were recorded in the paddocks, nine of which are native and three introduced (Appendix B). The dominant native species are Red Grass, *Bothriochloa decipiens*; Hairy Panic, *Panicum effusum*; Purple Wire Grass, *Aristida personata* and Couch, *Cynodon dactylon*. The main introduced grasses are Paspalum, *Paspalum dilatatum* and Pale Pigeon Grass, *Setaria pumila*.

A few scattered native herbs and others have persisted in the paddocks despite a long history of grazing including mainly Common Everlasting, *Chrysocephalum apiculatum* and Small-leaf Bluebush, *Maireana microphylla.*

The paddocks are greatly dominated by introduced herbs including Slender Celery, *Cyclospermum leptophyllum*; Spear Thistle, *Cirsium vulgare*; Flaxleaf Fleabane, *Conyza bonariensis*; Facelis, *Facelis retusa*; Cudweed, *Gamochaeta americana*; Smooth Catsear, *Hypochaeris radicata*; Fireweed, *Senecio madagascariensis*; Mouse-ear Chickweed, *Cerastium glomeratum*; Proliferous Pink, *Petrorhagia nanteuilii*; seven clover species, *Trifolium* spp.; Paddy's Lucerne, *Sida rhombifolia*; Scarlet Pimpernel, *Anagallis arvensis*; Lamb's Tongue, *Plantago lanceolata* and Onion Grass, *Romulea rosea*.

4.2 FLORA SPECIES

A total 247 plant species was identified by the quadrat plots, spot samples, random meanders and in general movement around the study area (Table 8). Of these, 173 (70%) are native to the natural communities of the study area and 74 (30%) are introduced. The numbers of species found in each community generally varied according to the sampling intensity (Table 8), except for Community 9, secondary native grassland, which had relatively few species, and a very small marginal area of Community 8 (Figure 3), which was not sampled by this study. The largest number of species was found in Communities 2 and 7, with 118 and 107, respectively.

The plant families with the highest numbers of species (Appendix B) were the Grasses, Poaceae (41 species); Daisies, Asteraceae (38 species); Pea Flowers, subfamily Faboideae (18 species); the saltbushes and bluebushes, Chenopodiaceae (11 taxa); the Wattles, subfamily Mimosoideae (9 species) and the Eucalypts and related genera in the family Myrtaceae (8 species). In all, some 59 plant families were represented.

Table 8
Numbers and Percentages of Native and Introduced Vascular Plant Species Identified in the Vegetation Communities within the Study Area

Community	Number of Samples	Total Plant Species	Number of Native Species	% of Native Species	Number of Introduced Species	% Introduced Species
1	3	62	32	51.6	30	48.4
2	6	118	78	66.1	40	33.9
3	6	99	88	88.9	11	11.1
4	2	63	46	73.0	17	27.0
5	1	19	17	89.5	2	10.5
6	2	54	48	88.9	6	11.1
7	4	107	96	89.7	11	10.3
8	0	-	-	-	-	-
9	5	53	21	39.6	32	60.4
Total	29	247	173	70.0	74	30.0

4.3 INTRODUCED SPECIES AND WEEDS

The number of introduced species is relatively high (74) (30%) (Table 8) largely because much of the study area is cleared or semi-cleared farmland used for grazing livestock. The highest proportion of introduced species (60.4%) was found in the grazing paddocks (Community 9). High proportions of introduced species (48.4%) also comprised Community 1, Hunter Valley River Oak Forest, which occurs in moist fertile soils along North Wambo Creek. Relatively high proportions of exotic species also occurred in communities 2 and 4, 33.9% and 27%, respectively, owing to the relatively higher soil fertility and moisture status of these communities. As would be expected, the lowest percentages of introduced species were recorded in the less disturbed habitats on poorer, drier soils; *viz*., Community 3 (11.1%), Community 5 (10.5%) and Communities 6 and 7 (11.1% and 10.3%, respectively). Apart from Prickly Pear, *Opuntia stricta* var. *stricta*, which was scattered throughout the bushland areas, and to a lesser extent Fireweed, *Senecio madagascariensis*, most other weeds were confined to tracks and other disturbances.

A small number of the introduced species recorded in this survey are regarded as noxious weeds in the Singleton Shire, the Prickly Pears, *Opuntia* spp. (class 4[1]) and African Boxthorn, *Lycium ferocissimum* (class 4). However, none were abundant anywhere within the study area, although *Opuntia stricta* is widespread (Appendix B).

4.4 THREATENED FLORA SPECIES

No flora species listed in the schedules of the TSC Act or EPBC Act was found in the targeted searches or other sampling conducted over the study area. However, one species listed as rare in ROTAP (Briggs and Leigh 1996), *Acacia bulgaensis*, was recorded. *A. bulgaensis* was recorded once only in Community 3 in the south of the study area, outside the Modification area.

4.5 REGIONALLY SIGNIFICANT FLORA

Some 28 species listed in the *Hunter Rare Plants Database* (Bell *et al.*, in prep) were recorded within the study area. The majority of these species are listed because a distributional limit for the species is thought to occur in the Hunter Valley. While this highlights the importance of the Hunter Valley as a biogeographical boundary for many species, most of the species identified as having distributional limits in the region are common over much of the rest of their ranges.

Eight of the study area species listed in the database are considered to be rare or uncommon within the Hunter Valley (Bell *et al.*, in prep). These are listed in Table 9, along with an assessment by Bell *et al.* (in prep.) of their rarity, and the communities in which they were found on the study area. While none of the species in Table 9 is listed as rare or threatened in NSW or nationally, their appearance in this list reflects their limited occurrence in the Hunter Valley. In some cases this is due to loss of habitat through clearing historically, but also reflects the existence of some species that, although common elsewhere, have limited occurrences in the valley.

[1] For class 4 noxious weeds, *'the growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant must not be sold, propagated or knowingly distributed.'*

Table 9
Study Area Plant Species Listed as Rare or Uncommon in the Hunter Rare Plants Database[1]

Family	Species	Listing Status	Vegetation Communities
Celastraceae	*Maytenus silvestris*	U	7
Chenopodiaceae	*Enchylaena tomentosa*	U	4
Euphorbiaceae	*Bertya oleifolia*	U	2, 3, 6
Fabaceae: Mimosoideae	*Acacia bulgaensis*	R	3
Fabaceae: Mimosoideae	*Acacia decora*	T	3, 7
Myrtaceae	*Melaleuca decora*	D	2, 4, 8
Poaceae	*Ancistrachne uncinulata*	DUR	7
Ranunculaceae	*Clematis microphylla*	DU	2

[1] Bell *et al.* (in prep). Hunter Rare Plants Database.

D Disjunct in the Hunter region, widespread and uncommon.

R Rare in the Hunter region.

T Threatened in the Hunter region.

U Uncommon in the Hunter region.

4.6 THREATENED POPULATIONS

No occurrence of any threatened populations was found by the surveys.

4.7 THREATENED PLANT COMMUNITIES

Three threatened ecological communities listed in the schedules of the TSC Act were identified by the survey, *viz.:*

- *Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions Endangered Ecological Community;*
- *Central Hunter Grey Box – Ironbark Woodland in the New South Wales North Coast and Sydney Basin Bioregions Endangered Ecological Community; and*
- *Hunter Valley Footslopes Slaty Box Woodland in the Sydney Basin Bioregion Vulnerable Ecological Community.*

No threatened ecological communities listed under the EPBC Act occur on the Modification area.

The Central Hunter Grey Box – Ironbark Woodland EEC is equivalent to Map Unit 10 of Peake (2006) and Community 3 of this study (Central Hunter Box – Ironbark Woodland).

The Hunter Valley Footslopes Slaty Box Woodland VEC is equivalent to Map Unit 7 of Peake (2006) and Community 7 of this study (Hunter Valley Footslopes Slaty Box Woodland).

The Hunter Lowland Redgum Forest Endangered Ecological Community is equivalent to Map Unit 24 of Peake (2006) and Community 2 of this study (Hunter Lowland Red Gum Forest).

4.8 CONDITION OF THE VEGETATION

The study area encompasses varied geology, soils and topography that have strongly influenced past land use and, consequently, the condition of the native vegetation. Historic disturbance factors on the study area have included clearing of native vegetation, generally on areas of gentler topography and better soil types; logging; grazing by livestock and introduced feral herbivores such as rabbits; the construction of tracks and fire trails; wildfires, the most recent being in 1994; and mining.

The most alienated parts of the study area are the flat valley floor and gentle lower slopes in the valleys of North Wambo Creek and Stony Creek, which have been almost completely cleared of their original native tree and shrub cover. This cleared land has been used mainly for grazing in recent decades, but may have been cropped historically. The cleared grazing paddocks north of Stony Creek are currently secondary native grassland with a predominance of native grass species. South of Stony Creek, the cleared pastures are dominated by a wide variety of introduced pasture species and weeds. These areas lack the capacity to regenerate native tree and shrub cover in the short term since the soil seed bank is fully depleted. Long-term unassisted recovery would depend on slow recolonisation of the area from adjacent bushland, although a proportion of the original species are likely to have been lost completely. The biodiversity value and resilience of the cleared pastures is considered to be low.

The vegetation within the incised watercourses of North Wambo Creek and Stony Creek comprises a mix of native and introduced species. The tree cover has been considerably thinned into disjunct patches and scattered individuals, especially along Stony Creek. Some introduced tree species have also become established, although they are not dominant. The ground cover vegetation has high proportions of introduced species owing to the moist conditions and fertile alluvial soils. Overall, the riparian vegetation on the study area is considered to be in poor condition.

Adjacent to the lowlands of North Wambo Creek and Stony Creek is steeper partially cleared land on the footslopes and ridges of the Narrabeen Sandstone escarpment. These areas have been semi-cleared and logged historically and have been used mainly for grazing. The tree cover is predominantly regeneration approximately 30 or more years old with occasional scattered old growth trees. These wooded areas tend to occupy poorer soils, and are dominated by native species in all canopy layers. There is a high diversity of the original flora and low numbers and biomass of introduced species. These sites are considered to have retained most of their ecological resilience with a high capacity for regeneration. They are assessed to be in moderate to good condition.

5 FLORA IMPACT ASSESSMENT

5.1 POTENTIAL IMPACTS OF SURFACE ACTIVITIES ON FLORA

Vehicular movements (outside the open cut) would be limited to those required for monitoring and general site maintenance activities. The only surface infrastructure that would be required are water bores to drain the voids of previous underground workings above the proposed longwalls. These bores would be located within already cleared farmland and would not impact any remnant native vegetation.

5.2 POTENTIAL IMPACTS OF SUBSIDENCE ON FLORA

A subsidence assessment for the Modification has been undertaken by MSEC (2012) (Appendix A of the Environmental Assessment). Potential impacts described below are referenced to MSEC (2012). Mine subsidence effects on the surface of the immediate Modification area are expected to vary slightly according to the depth of cover above the coal seam. Surface cracking of soils may potentially occur over most parts of the Modification area which is relatively flat such that depth of cover does not change greatly across the site.

Inspection of previously undermined areas to the west of the Modification area showed that surface cracking of the soil was relatively frequent on low flat areas supporting Central Hunter Grey Box – Ironbark Woodland (Plates 9 to 12). The condition of the vegetation on the undermined area was not noticeably different from that on adjacent similar unmined areas. Tree health in the Central Hunter Grey Box – Ironbark Woodland was good with no signs of dieback. The naturally sparse shrub and ground layers were likewise in good health (Plates 13 to 15). Similarly, areas of Central Hunter Paperbark Soaks Woodland also showed no signs of decline (Plate 16). The latter community might be expected to be susceptible to water loss through soil cracking, since it occurs on sites that remain wet for long periods in the winter months.

In addition, no scientific evidence of adverse surface effects on vegetation is known from underground mining anywhere in Australia. Consequently, it is unlikely vegetation within the Modification area would be adversely affected by mine subsidence.

Plate 9. Typical soil cracking

Plate 11. Typical soil cracking

Plate 10. Typical soil cracking

Plate 12. Typical soil cracking

Plate 13. Undermined Central Hunter Box – Ironbark Woodland

Plate 14. Undermined Central Hunter Box – Ironbark Woodland

Plate 15. Undermined Central Hunter Box – Ironbark Woodland

Plate 16. Undermined Central Hunter Paperbark Soak Woodland

5.3 THREATENED FLORA

The likelihood of the Modification significantly affecting threatened flora species, populations or ecological communities or their habitats listed under the TSC Act is assessed below in accordance with Section 5A of the NSW *Environmental Planning and Assessment Act, 1979* and the *Threatened Species Assessment Guidelines: The Assessment of Significance* (DECC, 2007).

The following factors (Seven Part Test of Significance) are considered in order to determine the likelihood of a significant impact:

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

(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the lifecycle 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.

(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.***

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

(e) 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;***
- ***(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.***

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

(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.

Evaluations are conducted for threatened flora that are known to occur or may potentially occur on the Modification area and immediate surrounds i.e. suitable habitat is considered to occur on or near the Modification area (Tables 2 to 4).

5.4 THREATENED ECOLOGICAL COMMUNITIES

Two Endangered Ecological Communities (EEC) and one Vulnerable Ecological Community (VEC) were found on the Modification area by the survey:

Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions

This community occurs on gentle slopes above drainage flats and depressions on Permian sediments in the coastal valleys on the NSW North Coast including the mid to lower Hunter Valley region in the Maitland, Cessnock, Muswellbrook and Singleton local government areas (NPWS, 2002a). It is mapped as Community 2 on Figure 3. Threats to this EEC are habitat loss and fragmentation due to clearing for agriculture and residential development, habitat degradation resulting from grazing, weed invasion, altered fire regimes and rubbish dumping (DEC, 2005n).

Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions EEC

This community occurs on Permian sediments in the Hunter Valley in the Local Government Areas of Cessnock, Singleton and Muswellbrook (DECCW, 2010a). The community occurs on gently undulating hills, slopes and valleys, and occasionally on rocky ridges (DECCW, 2010a). Within the study area it is mapped as Community 3 (Figure 3). Threats to the EEC are considered to be grazing by domestic livestock, weed invasion, and clearing and fragmentation for agriculture, development and mining (DECCW, 2010a).

Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion VEC

This community forms a mid-high woodland, usually at the interface of Narrabeen Sandstone and Permian sediments in the Hunter Valley in the local government areas of Singleton, Muswellbrook and Upper Hunter (DECCW, 2010d). The community occurs on colluvial soils on exposed footslopes (DECCW, 2010d). Across the study area it is mapped as Community 7 (Figure 3). Threats to the EEC are considered to be inappropriate fire regimes, grazing by domestic livestock, removal of bush rock, weed invasion, and removal of fallen timber and dead trees (DECCW, 2010d).

The potential impact of the Modification on these communities is assessed below. Owing to the relatively flat topography of the Modification area, a similar risk of soil cracking occurs across the whole site and all plant communities.

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

Not applicable.

(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the lifecycle 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.

Potential impacts of surface activities and mine subsidence are described in Sections 5.1 and 5.2 respectively.

Vehicular movements within the Modification area would be limited to those required for monitoring and general site maintenance activities. With the exception of water bores to drain old workings, no surface disturbance would be required for the Modification. As described in Section 5.1, the proposed water bores would be located on cleared grazing land and would not impact on remnant native vegetation.

Following subsidence induced movements in the low flatter parts of the immediate Modification area, minor earthworks may be required at the completion of mining to reinstate the farm dams. However, these works would be localised and undertaken within areas already subject to heavy historical disturbance (Section 5.1). Surface activities associated with the Modification would not have a significant impact on threatened ecological communities.

Surface soil cracks are not expected to have any biologically significant effect on the flora, including all of the threatened ecological communities. As described in Section 5.2, the main impact of these soil cracks is likely to be point scale erosion if they are left untreated.

An inspection was made of recently undermined areas to the north of the Modification area on 13 September 2010 to determine whether there were any obvious deleterious effects on the vegetation. This included inspection of previously undermined Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions EEC. Surface cracking of the soil was observed to be relatively frequent on low flat areas (Plates 9 to 12). Evidence of cracking disappeared on higher ground within the subsidence area (i.e. at higher depths of cover). The condition of the vegetation on the undermined area was not noticeably different from that on adjacent similar unmined areas with no evidence of dieback, tree decline or other symptoms of poor community health. The naturally sparse shrub and ground layers were likewise in good health (Plates 13 to 15).

In addition, no scientific evidence of adverse surface effects on terrestrial vegetation from subsidence effects is known from underground mining anywhere in Australia. Consequently, it is unlikely the EEC would be adversely affected by mine subsidence.

It is concluded that the Modification is unlikely to significantly reduce the quality or availability of habitat for these threatened ecological communities.

(d) 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 and EPBC Acts, has not been declared for any of the *Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions* EEC, the *Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC nor the *Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion* VEC. There is no critical habitat listed on the NSW Critical habitat register (DECCW, 2010e) or the Commonwealth Register of Critical Habitat (SEWPaC, 2010) for any of the threatened ecological communities in the Modification area or surrounds.

(e) 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;

(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 Modification would not result in the removal or modification of any of the *Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions* EEC, the *Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC nor the *Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion* VEC. Any surface infrastructure needed would be constructed in areas of cleared land. Since no habitat would be removed, there would be no increase in existing habitat fragmentation or isolation, and consequently, no additional effect on the long term survival of the ecological communities on the Modification area.

As demonstrated in Section 5.2 minor cracking of the soil surface owing to subsidence may occur, but is unlikely to significantly affect the health of the surface vegetation, and consequently is unlikely to result in dieback or loss of any parts of the threatened ecological communities. Subsidence impacts are similarly unlikely to cause any increase in existing habitat fragmentation or isolation, and consequently, no additional effect on the long term survival of the ecological communities on the Modification area.

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

No recovery plans have been written for any of the Hunter Lowland Redgum Forest in the Sydney Basin and NSW North Coast Bioregions EEC, the Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions EEC or the Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion VEC. However, recommended recovery actions for each of the communities are included in their community profiles on the OEH website (accessed February 2012). The recovery actions are similar for the three communities and comprise the following:

- Prevent further clearing of remnants.
- Exclude grazing by domestic stock.
- Prevent removal of bush rock and dead timber.
- Control invasive weed species.
- Apply appropriate fire regimes.
- Protect remnants through mechanisms such as covenanting or management plans.
- Improve connectivity between remnants by revegetation / regeneration programs.

The operation of the Modification is neutral with respect to the above recovery actions; it will neither assist nor prevent the above actions taking place. Accordingly, the Modification is not inconsistent with the recovery actions for these communities.

(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.

Threats to the *Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions* EEC, the *Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC or the *Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion* VEC are included in their community profiles on the OEH website (accessed February 2012). The Key Threatening Processes relevant to these threats comprise the following (OEH, 2012a):

- Alteration of habitat following subsidence due to longwall mining.
- Bush rock removal.
- Clearing of native vegetation.
- High frequency fire.
- Removal of dead wood and dead trees.

As indicated in the previous sections, there would be very little impact by the Modification on the surface, such that the Modification is unlikely to increase the impact of the above key threatening processes.

The impact of subsidence due to longwall mining has been discussed in Section 5.2 and in this assessment above. In the environment of the Hunter Valley, no adverse effects of longwall mining on surface vegetation have been documented, despite a long history of such mining in the region.

No clearing of native vegetation would take place for the Modification and consequently no increase in habitat fragmentation would occur. Bush rock and timber removal are controlled by restrictions on public access to the Modification area and this would continue during the Modification.

There is a small risk of higher fire frequencies resulting from the Modification due to increased movements by WCPL personnel, contractors and vehicles in the Modification area, e.g. by the ignition of dry vegetation by petrol vehicle exhaust pipes. WCPL personnel and contractors are required to use diesel vehicles to minimise fire risks. These and other protocols for bushfire management would be implemented to manage the behaviour of people in the Modification area, making it unlikely there would be an increase in fire frequency resulting from Modification related human activities. In addition, the presence of WCPL personnel on the Modification area would provide early warning of any fires lit by lightning with rapid suppression activities being implemented.

Conclusion

It is clear from the above assessment that the Modification is unlikely to have a significant impact on the remnants of the *Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions* EEC, the *Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions* EEC or the *Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion* VEC that are present on the Modification area.

5.5 ENDANGERED POPULATIONS

The Hunter Valley populations of Weeping Myall, *Acacia pendula* and River Red Gum, *Eucalyptus camaldulensis* that were considered possible occurrences within the Modification area and surrounds (Table 3) were not detected by the survey. Both Weeping Myall and River Red Gum are large conspicuous species that would have been detected if they were present. They are therefore not considered further here.

In contrast, one species that is part of a population listed as endangered under the TSC Act; *Cymbidium canaliculatum R. Br. in the Hunter Catchment*, may potentially have been missed in the study area survey owing to its smaller size. The potential impact of the Modification on this population is assessed below.

***Cymbidium canaliculatum* R. Br. in the Hunter Catchment Endangered Population**

C. canaliculatum is an epiphytic orchid that grows in the forks of branches of mainly rough-barked trees in the Hunter Valley, including White Box, *Eucalyptus albens*; Coast Grey Box, *E. moluccana*; Narrow-leaved Ironbark, *E. crebra*; Rough-barked Apple, *Angophora floribunda*; Cooba, *Acacia salicina*; and Slaty Gum, *E. dawsonii* (DEC, 2006). One colony of *C. canaliculatum* is known to occur on WCPL owned land to the north west of the study area in a fork of a large Cooba tree in the south of 'Montrose' property. No *C. canaliculatum* were found in close proximity to the study area.

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

Not applicable.

(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the lifecycle 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.

Theoretically, there are two potential ways the Modification might adversely affect the Hunter Valley *C. canaliculatum* population; by removal of host trees through clearing, or death of a host tree as a result of subsidence effects on the soil. The underground mining method to be employed by this Modification would result in very little impact on the surface. There are minimal requirements for surface infrastructure (i.e. water bores) and any that may be needed would be sited in historically cleared areas that do not support potential host trees for *C. canaliculatum*.

Surface soil cracking is not expected to have any biologically significant effect on the flora, including potential host trees of *C. canaliculatum*. As described in Section 5.2, the main impact of such soil cracks is likely to be point scale erosion if they are left untreated.

An inspection was made of recently undermined areas to the north-west of the Modification area on 13 September 2010 to determine whether there were any obvious deleterious effects on the vegetation. Surface cracking of the soil was observed to be relatively frequent on low flat areas (Plates 9 to 12). Evidence of cracking disappeared on higher ground within the subsidence area (i.e. at higher depths of cover). The condition of the vegetation on the undermined area was not noticeably different from that on adjacent similar unmined areas with no evidence of dieback, tree decline or other symptoms of poor community health. The naturally sparse shrub and ground layers were likewise in good health (Plates 13 to 15).

In addition, no scientific evidence of adverse surface effects on terrestrial vegetation is known from underground mining anywhere in Australia. Consequently, it is unlikely that potential host trees for *C. canaliculatum* would be adversely affected by mine subsidence.

(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) 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 and EPBC Acts, has not been declared for the *Cymbidium canaliculatum R. Br. in the Hunter Catchment Endangered Population*. There is no critical habitat for the *Cymbidium canaliculatum R. Br. in the Hunter Catchment Endangered Population* listed on the NSW Critical habitat register (DECCW, 2010e) or the Commonwealth Register of Critical Habitat (SEWPaC, 2012).

(e) 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;

(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 Modification would not result in the removal or modification of any potential habitat for the *Cymbidium canaliculatum R. Br. in the Hunter Catchment Endangered Population*. Any surface infrastructure needed (i.e. water bores) would be constructed in areas of cleared land. Since no habitat would be removed, there would be no increase in existing habitat fragmentation or isolation, and consequently, no additional effect on the long term survival of host trees for *C. canaliculatum*.

As demonstrated in Section 5.2 minor cracking of the soil surface owing to subsidence may occur, but is unlikely to significantly affect the health of the surface vegetation, and consequently is unlikely to result in dieback or loss of *C. canaliculatum* host trees. Subsidence impacts are similarly unlikely to cause any increase in existing habitat fragmentation or isolation, and consequently, no additional effect on the long term survival of *C. canaliculatum* habitat on the Modification area.

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

No recovery plans or recovery actions have been written for the *Cymbidium canaliculatum R. Br. in the Hunter Catchment Endangered Population* (OEH, 2012b). Accordingly, the Modification does not contravene any known recovery action for this endangered population.

(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.

Threats to the *Cymbidium canaliculatum R. Br. in the Hunter Catchment Endangered Population* are listed in the Final Determination of the NSW Scientific Committee (DEC, 2006) and include land clearing and associated habitat fragmentation, on-going removal of remnant trees and illegal collecting. The Key Threatening Processes relevant to these threats are (OEH, 2012a):

- Clearing of native vegetation.
- Removal of dead wood and dead trees.

As indicated in previous sections, there would be very little impact by the Modification on the surface, such that the Modification is unlikely to increase the impact of the above key threatening processes. No clearing of native vegetation would take place for the Modification and consequently no increase in habitat fragmentation would occur. Timber removal is controlled by restrictions on public access to the Modification area and this would continue during the life of the Modification.

Conclusion

The above assessment indicates that the Modification is unlikely to have a significant impact on the *Cymbidium canaliculatum R. Br. in the Hunter Catchment Endangered Population*.

5.6 THREATENED FLORA SPECIES

The baseline flora survey targeted 12 threatened flora species for field searches. The targeted species included all threatened flora known or considered to have potential to occur within a 20 × 20 km square centred on the Modification area. Five of these species are considered highly unlikely to occur, or to have once occurred, on the Modification area because suitable habitat for them is absent (Table 10). The assessment in this section is confined to the seven remaining species that have potential habitat within the Modification area.

Table 10
Threatened Flora Species Considered in this Assessment

Family Name	Scientific Name	Justification for Exclusion from Assessment
Araucariaceae	*Wollemia nobilis*	Occurs only in sandstone gorges in the west of Wollemi National Park (DEC, 2005a).
Asclepiadaceae	*Cynanchum elegans*	Included.
Asteraceae	*Olearia cordata*	Occurs on steep slopes and sandstone outcrops (DEC, 2005c).
Fabaceae	*Dillwynia tenuifolia*	Included.
Myrtaceae	*Eucalyptus glaucina*	Included.
	Melaleuca groveana	Occurs on steep slopes and sandstone outcrops (DEC, 2005f).
Orchidaceae	*Prasophyllum* sp. Wybong	Included.
	Pterostylis gibbosa	Included.
Poaceae	*Digitaria porrecta*	No records east of the Great Dividing Range (NSW Atlas of Wildlife, accessed February 2012). Grows on inland floodplains (DEC, 2005h).
Rhamnaceae	*Pomaderris brunnea*	Occurs mainly in sandstone gorges and also riparian areas (DEC, 2005i).
Santalaceae	*Thesium australe*	Included.
Scrophulariaceae	*Euphrasia arguta*	Included.

5.7 THREATENED SPECIES ASSESSMENT

Seven threatened flora species with potential to occur on the immediate Modification area may occur in habitats on the more fertile Permian clay soils associated with the valley floor. None of these species were recorded by the surveys (or other surveys) within the study area.

White-flowered Wax Plant (Cynanchum elegans)

The White-flowered Wax Plant is a climber with white, tubular flowers that appear between August and May (NPWS, 2002c; DEC, 2005b). The slow-developing fruit, a dry pointed pod, takes up to six months to mature. It is considered unlikely that this species has a soil seed bank (*ibid*.). The White-flowered Wax Plant typically occurs on the edge of dry rainforest, although the species may occur in other vegetation types (*ibid*.). Threats relevant to the White-flowered Wax Plant include loss and fragmentation of habitat through clearing, habitat degradation resulting from grazing, weed invasion, inappropriate fire management, rubbish dumping and track construction or widening (*ibid*.).

The White-flowered Wax Plant occurs from the far North Coast of NSW (Brunswick Heads) to the Illawarra region. In the Hunter Valley it extends west to Sandy Hollow and Cassilis. The nearest records to the study area are near Broke to the south east. The Modification area is within the known distribution of the White-flowered Wax Plant.

Dillwynia tenuifolia

Dillwynia tenuifolia is a low spreading shrub to 1 m high, with small narrow untwisted leaves having a recurved acute tip, and one or two flowers on short peduncles (to 3 mm) in the terminal leaf axils (Weston and Jobson, 2002). Plants are killed by hot fires with regeneration from the soil seed bank (DEC, 2005d). The life span is thought to be 20 to 30 years and seed production commences after 3 to 4 years (*ibid.*). Habitats are dry woodlands and forests on clay, alluvium or sandstone soils (*ibid*.). Threats include clearing of habitat, inappropriate fire regimes, rubbish dumping and vehicle movements.

Dillwynia tenuifolia occurs on the Cumberland Plain west of Sydney, the lower Blue Mountains, Yengo, Howes Valley and the Bulga area in the Hunter Valley. The closest records to the Modification area are to the south and west of Bulga. If *D. tenuifolia* was to occur on the Modification area it would be an extension of its range to the north.

Slaty Red Gum (Eucalyptus glaucina)

The Slaty Red Gum is a tree to 30 m tall, with smooth mottled white to grey bark, conspicuously glaucous oval leaves, and glaucous fruits and buds (DEC, 2005e). The fruits are large, up to 10 mm long and 10 mm in diameter. It favours grassy woodlands and eucalypt forests on deep, well-watered, moderately fertile soils (*ibid.*). Threats include clearing of habitat, logging and suppression of regeneration by grazing (*ibid.*).

The Slaty Red Gum has two centres of distribution; around Casino on the far North Coast and in the Taree to Broke area on the lower North Coast. In the Hunter Valley the distribution extends from Dungog and Stroud in the east to Warkworth in the west, and Pokolbin and Broke in the south. Two Warkworth records in the Wallaby Scrub are closest to the Modification area.

Prasophyllum sp. Wybong (C. Phelps ORG 5269)

Prasophyllum sp. Wybong (C. Phelps ORG 5269) is a terrestrial orchid that grows to approximately 30 cm high. It has a single, tubular, fleshy, dull-green leaf and a single flower spike with numerous fragrant flowers (SEWPaC, 2009). *Prasophyllum* sp. Wybong (C. Phelps ORG 5269) is endemic to NSW. *Prasophyllum* sp. Wybong (C. Phelps ORG 5269) is a perennial orchid, appearing as a single leaf over winter and spring. The species flowers in spring and dies back to a tuber over summer and autumn. *Prasophyllum* sp. Wybong (C. Phelps ORG 5269) is known to occur in open eucalypt woodland and grassland. The main threats to the species include weed invasion, vehicle traffic, inappropriate disturbance regimes and habitat clearance. Chemical drift from agricultural properties, illegal collection, trampling by people and climate change are considered potential threats (SEWPaC, 2009).

It is known from seven populations in eastern NSW near Ilford, Premer, Muswellbrook, Wybong, Yeoval, Inverell and Tenterfield. If the species occurred on the Modification area, it would represent an extension of the known range to the south-southeast of Muswellbrook.

Illawarra Greenhood (Pterostylis gibbosa)

The Illawarra Greenhood Orchid is a perennial renascent herb with an annually renewed underground tuberoid, which gives rise to a flat rosette of leaves (each to 35 mm long) at the soil surface in late summer. A single flower stem shoots from the middle of the rosette in spring growing to 45 cm high and bearing up to 7 translucent bright green flowers in late spring. The flowers are characterised by a dark protruding brownish black lip. The above ground parts of the plant die back in summer. The habitat is flat to gently sloping, poorly drained land on Permian clay soils (DEC, 2005g). A population near Milbrodale in the southern Hunter Valley grows with Narrow-leaved Ironbark, *Eucalyptus crebra*, Forest Red Gum, *Eucalyptus tereticornis* and Black Cypress Pine, *Callitris endlicheri*, in the overstorey (*ibid.*). Threats to the Illawarra Greenhood Orchid include loss of habitat for agriculture and residential development, invasion of sites by introduced grasses and blackberry, inappropriate fire regimes and habitat degradation by unrestricted vehicle and pedestrian access (*ibid.*).

Pterostylis gibbosa occurs as disjunct populations from near Nowra and the Illawarra region on the NSW South Coast to two locations in the Hunter Valley; Milbrodale and Weston. The closest population to the Modification area is at Milbrodale, south of Bulga. If the species occurred on the Modification area, it would represent an extension of the known range to the north west of Milbrodale.

Austral Toadflax (Thesium australe)

Austral Toad-flax (*Thesium australe*) is a perennial pale green or yellow-green herb with 1-30 branched stems up to 60 cm long (Scarlett *et al*., 2003). The leaves are sessile, linear and acute, mostly 1-3 cm long with a decurrent midrib. The whitish flowers are solitary in the leaf axils, borne on a peduncle (1-3 mm long) which is united with the leaf bases. The fruit is a globose, slightly fleshy drupe 2 mm in diameter, crowned with the persistent tepals. The dry drupe has a markedly reticulate-striate surface. The Austral Toad-flax is a member of the Santalaceae (Sandalwood Family) and, like many members of this genus, is hemiparasitic on the roots of other plants, notably *Themeda triandra* (Kangaroo Grass). Collections in Australian herbaria indicate that Austral Toad-flax was widespread in eastern Australia, from the Bunya Mountains in Queensland south to eastern Tasmania. The Austral Toad-flax has a wide ecological tolerance having been recorded from subtropical, temperate and sub-alpine climates, and on soils derived from sedimentary, igneous and metamorphic rocks as well as recent alluvium. However, it is largely confined to grasslands, grassy woodlands or sub-alpine grassy heathlands. While Austral Toad-flax is usually associated with Kangaroo Grass and (less frequently) with *Poa* spp., it will grow with other hosts, at least in the glasshouse (Scarlett *et al*., 2003). Threats to the Austral toadflax include loss or degradation of habitat through land clearing, grazing, invasion by exotic weeds and road works (DEC, 2005j).

Although there are no records of the Austral toadflax from the Hunter Valley, it is likely to have occurred there pre-European settlement, given its former wide distribution and ecological tolerance.

Euphrasia arguta

Euphrasia arguta is an erect, semi-parasitic annual herb growing up to 45 cm high (SEWPaC, 2011)). The branches have dense recurved stiff, non-glandular hairs. The plant has 18–30 pairs of opposite, sessile leaves along the stem with alternate pairs arranged at right angles. Leaves are 7–15 mm long with long slender 'tooth-like' projections and may be smooth or rough to the touch. The plant has numerous white to pinkish-lilac flowers in racemes. Both the petals and sepals are tubular. The upper lip of the petals is hooded with two downward curved lobes. The fruit is a capsule 4–8 mm long containing many minute seeds (SEWPaC, 2011). Actual and potential threats to *E. arguta* include grazing, road works and logging.

Until recently, *E. arguta* was thought to be extinct. However, several populations were found in 2008 in the Nundle area of the Nandewar Bioregion. Known distribution records include Bathurst, Nundle, Walcha and the type area on the Paterson and Williams Rivers in the Hunter Valley.

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

Potential impacts of surface activities and mine subsidence are described in Sections 5.1 and 5.2, respectively.

Since the mining operation would take place underground and the workings would be accessed from an existing open cut pit, there is no requirement for surface disturbance with the exception of water bores to drain old workings. The proposed water bores would be located on cleared grazing land and would not impact on remnant native vegetation. No clearing of potential habitat for the White-flowered Wax Plant, *Dillwynia tenuifolia*, Slaty Red Gum, *Prasophyllum* sp. Wybong, Illawarra Greenhood, Austral Toadflax or *Euphrasia arguta* would take place.

Surface soil cracking is not expected to have any biologically significant effect on the flora, including any of the threatened species. As described in Section 5.2, the main impact of these soil cracks is likely to be point scale erosion if they are left untreated.

An inspection was made of recently undermined areas to the north of the Modification area on 13 September 2010 to determine whether there were any obvious deleterious effects on the vegetation. Surface cracking of the soil was observed to be relatively frequent on low flat areas (Plates 9 to 12). Evidence of cracking disappeared on higher ground within the subsidence area (i.e. at higher depths of cover). The condition of the vegetation on the undermined area was not noticeably different from that on adjacent similar unmined areas with no evidence of dieback, tree decline or other symptoms of poor community health. The naturally sparse shrub and ground layers were likewise in good health (Plates 13 to 15).

In addition, no scientific evidence of adverse surface effects on terrestrial vegetation is known from underground mining anywhere in Australia. Consequently, it is unlikely that the White-flowered Wax Plant, *Dillwynia tenuifolia*, Slaty Red Gum, *Prasophyllum* sp. Wybong, Illawarra Greenhood, Austral Toadflax or *Euphrasia arguta* would be adversely affected by mine subsidence, if they were present.

It is concluded that the Modification is unlikely to affect the lifecycle of these threatened species such that a viable local population is likely to be placed at risk of extinction, if they were present.

(b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the lifecycle 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) 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 and EPBC Acts, has not been declared for the White-flowered Wax Plant, *Dillwynia tenuifolia*, Slaty Red Gum, *Prasophyllum* sp. Wybong, Illawarra Greenhood, Austral Toadflax or *Euphrasia arguta*. There is no critical habitat for these species listed on the NSW Critical habitat register (DECCW, 2010e) or the Commonwealth Register of Critical Habitat (SEWPaC, 2010).

(e) 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;

(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 Modification would not result in the removal or modification of any potential habitat for the White-flowered Wax Plant, *Dillwynia tenuifolia*, Slaty Red Gum, *Prasophyllum* sp. Wybong, Illawarra Greenhood, Austral Toadflax or *Euphrasia arguta*. Any surface infrastructure needed would be constructed in areas of cleared land. Since no habitat would be removed, there would be no increase in existing habitat fragmentation or isolation, and consequently, no additional effect on the long term survival of these species.

As demonstrated in Section 5.2 minor cracking of the soil surface owing to subsidence may occur, but is unlikely to significantly affect the health of the surface vegetation, and consequently is unlikely to result in dieback or loss of habitat for the White-flowered Wax Plant, *Dillwynia tenuifolia*, Slaty Red Gum, *Prasophyllum* sp. Wybong, Illawarra Greenhood, Austral toadflax or *Euphrasia arguta*. Subsidence impacts are similarly unlikely to cause any increase in existing habitat fragmentation or isolation, and consequently, no additional effect on the long term survival of the potential habitats of these species on the Modification area.

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

No recovery plans have been written for the White-flowered Wax Plant, *Dillwynia tenuifolia*, Slaty Red Gum, *Prasophyllum* sp. Wybong, Illawarra Greenhood, Austral Toadflax or *Euphrasia arguta*. However, a range of recovery actions has been recommended for each species in their profiles on the OEH and SEWPaC websites (accessed February 2012). The recovery actions are summarised as follows:

- Determine and implement appropriate fire management practices.
- Consider off-site impacts in the assessment of nearby developments.
- Prevent inappropriate water run-off entering sites.
- Prevent rubbish and fill dumping, and weed invasion.
- Install fencing to exclude livestock and machinery, and control access where required.
- Protect areas of known and potential habitat from road works, clearing, further fragmentation, timber harvesting and canopy thinning.
- Identify populations of high conservation priority.
- Restore degraded habitat using bush regeneration techniques, including linking populations where possible.
- Monitor populations for changes in numbers and health status.
- Mark sites and potential habitat onto maps used for planning maintenance work.
- Map known sites and conduct searches of potential habitat for new sites.
- Support and provide information to landholders regarding appropriate management
- Establish covenants to protect populations on private land where possible.
- Educate the public and encourage landholders to conserve populations on private land.
- Undertake seed collection and storage

All of the above recovery actions relate to known populations of the species. No populations of any of the species were detected during the field survey of the study area. Except for the Slaty Red Gum, none of these species has they been found on WCPL land by numerous previous surveys. The Slaty Red Gum has been recorded twice in the Wallaby Scrub area across the Wollombi Brook to the east of the study area (NSW Atlas of Wildlife, accessed February 2012). Slaty Red Gum is a large tree and would have been detected by the survey if present on the study area.

In the absence of any populations of the White-flowered Wax Plant, *Dillwynia tenuifolia*, Slaty Red Gum, *Prasophyllum* sp. Wybong, Illawarra Greenhood, Austral Toadflax or *Euphrasia arguta* on the study area, the above recovery actions are not directly relevant. Accordingly, the Modification is not inconsistent with the recovery actions for these 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.

Threats to the White-flowered Wax Plant, *Dillwynia tenuifolia*, Slaty Red Gum, Illawarra Greenhood and Austral Toadflax are listed in the species profiles on the OEH website (accessed February 2012), and those for *Prasophyllum* sp. Wybong and *Euphrasia arguta* are listed in their conservation advices on the SEWPaC website (accessed February 2012).

Threats include:

- Land clearing and associated habitat fragmentation.
- Habitat degradation and suppression of regeneration through changes in community structure (loss of tree canopy), logging and timber harvesting, weed invasion, grazing, rubbish dumping, landfill, urban rub-off and road works.
- Inappropriate fire regimes.
- Loss of small populations through natural catastrophes, climate change or genetic decline.
- Uncontrolled access by people and vehicles to sensitive sites.
- Illegal collection (orchids).
- Chemical drift from agricultural activities.

The Key Threatening Processes relevant to these threats are the following (OEH, 2012a):

- Alteration of habitat following subsidence due to longwall mining.
- Anthropogenic climate change.
- Clearing of native vegetation.
- Competition and grazing by the feral European rabbit (*Oryctolagus cuniculus*).
- High frequency fire.
- Invasion of native plant communities by exotic perennial grasses.

The impact of subsidence due to longwall mining has been discussed in Section 5.2 and in this assessment above. In the environment of the Hunter Valley, no adverse effects of longwall mining on terrestrial vegetation have been documented, despite a long history of such mining in the region, nor is there any scientific documentation of adverse effects on terrestrial vegetation due to longwall mining in Australia.

The issue of anthropogenic climate change is discussed in the main report and will not be considered separately here.

As indicated in previous sections, there would be very little impact by the Modification on the surface or on existing surface land management. No clearing of native vegetation would take place for the Modification and consequently no loss of potential habitat or increase in habitat fragmentation would occur.

There is a small risk of higher fire frequencies resulting from the Modification due to increased movements by WCPL personnel, contractors and vehicles in the Modification area, e.g. by the ignition of dry vegetation by petrol vehicle exhaust pipes and cigarette butts. WCPL personnel and contractors are required to use diesel vehicles to minimise fire risks, and to dispose of cigarette butts correctly. These and other protocols for bushfire management would be implemented to manage the behaviour of people in the Modification area, making it unlikely there would be an increase in fire frequency resulting from human activities. In addition, the presence of WCPL personnel on the Modification area would provide early warning of any fires lit by lightning with rapid suppression activities being implemented.

Feral European rabbits and noxious weeds are controlled on WCPL land under the Flora and Fauna Management Plan and this would continue for the duration of the Modification.

Conclusion

The above assessment indicates that the Modification is unlikely to have a significant impact on the White-flowered Wax Plant, *Dillwynia tenuifolia*, Slaty Red Gum, *Prasophyllum* sp. Wybong, Illawarra Greenhood, Austral Toadflax or *Euphrasia arguta.*

5.8 OVERALL CONCLUSION OF THE FLORA ASSESSMENT

It is concluded from the above assessments that the proposed Modification would have no significant impact on threatened flora species, populations, ecological communities or critical habitat.

6 REFERENCES

Anderson, R.H. (1968). *The Trees of New South Wales*. Fourth Edition. New South Wales Department of Agriculture, Sydney.

Bell, S.A.J., Peake, T., Tame, T., Simpson, J., & Curran, T. (in prep.). *Regionally significant vegetation of the Hunter Valley and Central Coast, New South Wales: A working register.* Version 1. Hunter Rare Plants Committee, Hunter Region Botanic Gardens. January 2003.

Briggs, J.D. and Leigh, J.H. (1996). *Rare or Threatened Australian Plants*. CSIRO, Canberra.

Department of Environment and Climate Change (2007). *Threatened Species Assessment Guidelines: The Assessment of Significance.*

Department of Environment and Conservation (2004). *Threatened Species Survey and Assessment: Guidelines for Developments and Activities*. Working Draft. Department of Environment and Conservation (NSW), Hurstville.

Department of Environment and Conservation (2005a). *Wollemi Pine - profile*.
Website: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10840
Date accessed: February 2012.

Department of Environment and Conservation (2005b). *White-flowered Wax Plant – profile*.
Website: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10196
Date accessed: February 2012.

Department of Environment and Conservation (2005c). *Olearia cordata – profile*.
Website: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10576
Date accessed: February 2012.

Department of Environment and Conservation (2005d). *Dillwynia tenuifolia – profile*.
Website: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10226
Date accessed: February 2012.

Department of Environment and Conservation (2005e). *Slaty Red Gum – profile*.
Website: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10295
Date accessed: February 2012.

Department of Environment and Conservation (2005f). *Grove's Paperbark – profile*.
Website: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10516
Date accessed: February 2012.

Department of Environment and Conservation (2005g). *Illawarra Greenhood – profile*.
Website: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10701
Date accessed: February 2012.

Department of Environment and Conservation (2005h). *Finger Panic Grass – profile*.
Website: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10222
Date accessed: February 2012.

Department of Environment and Conservation (2005i). *Brown Pomaderris – profile*.
Website: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10647
Date accessed: February 2012.

Department of Environment and Conservation (2005j). *Austral toadflax – profile*.
Website: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10802
Date accessed: February 2012.

Department of Environment and Conservation (2005k). *Acacia pendula (a tree) in the Hunter catchment – endangered population listing*. Final Determination. NSW Scientific Committee.
Website: http://www.environment.nsw.gov.au/determinations/AcaciaPendulaHunterCatchmentEndangeredpop.htm
Date accessed: February 2012.

Department of Environment and Conservation (2005l). *Eucalyptus camaldulensis (a tree) in the Hunter catchment – endangered population listing*. Final Determination. NSW Scientific Committee.
Website: http://www.environment.nsw.gov.au/determinations/EucalyptusCamaldulensisHunterEndangeredpop.htm
Date accessed: February 2012.

Department of Environment and Conservation (2005m). *Hunter Valley Weeping Myall Woodland of the Sydney Basin Bioregion- endangered ecological community listing.* Final Determination. NSW Scientific Committee.
Website: http://www.environment.nsw.gov.au/determinations/HunterValleyWeepingMyallWoodlandEndSpListing.htm
Date accessed: February 2012.

Department of Environment and Conservation (2005n). *Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions - profile*. Department of Environment and Climate Change. Website: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10416
Date accessed: February 2012.

Department of Environment and Conservation (2005o). *White Box Yellow Box Blakely's Red Gum woodland – profile.*
Website: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10837
Date accessed: February 2012.

Department of Environment and Conservation (2006). *Cymbidium canaliculatum* R. Br. – *endangered population listing*. Final Determination. NSW Scientific Committee.
Website: http://www.environment.nsw.gov.au/determinations/CymbidiumCanaliculatumEndSpListing.htm
Date accessed: February 2012.

Department of Environment and Conservation (2008). *BioBanking Assessment Methodology*. Department of Environment and Climate Change, Hurstville.

Department of Environment, Climate Change and Water (2010a). *Central Hunter Grey Box-Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions - endangered ecological community listing*. Final Determination, NSW Scientific Committee.
Website: http://www.environment.nsw.gov.au/determinations/centralhuntergreyboxFD.htm
Date accessed: February 2012.

Department of Environment, Climate Change and Water (2010b). *Central Hunter Ironbark-Spotted Gum-Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions - endangered ecological community listing*. Final Determination, NSW Scientific Committee. Website: http://www.environment.nsw.gov.au/determinations/centralhunterironbarkFD.htm Date accessed: February 2012.

Department of Environment, Climate Change and Water (2010c). *Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions - endangered ecological community listing*. Final determination, NSW Scientific Committee. Website: http://www.environment.nsw.gov.au/determinations/huntervalleyfloodplainFD.htm Date accessed: February 2012.

Department of Environment, Climate Change and Water (2010d). *Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion - vulnerable ecological community listing*. Final determination, NSW Scientific Committee.
Website: http://www.environment.nsw.gov.au/determinations/huntervalleyfootslopesFD.htm Date accessed: February 2012).

Department of Environment, Climate Change and Water (2010e). *Critical habitat register*.
Website: http://www.environment.nsw.gov.au/criticalhabitat/CriticalHabitatProtectionByDoctype.htm
Date accessed: February 2012.

Department of Sustainability, Environment, Water, Population and Communities (2009). *Approved Conservation Advice for Prasophyllum sp. Wybong (C. Phelps ORG 5269) (a leek orchid)*
Website: http://www.environment.gov.au/biodiversity/threatened/species/pubs/81964-conservation-advice.pdf
Date accessed: February 2012.

Department of Sustainability, Environment, Water, Population and Communities (2010). *Register of Critical Habitat*.
Website: http://www.environment.gov.au/cgi-bin/sprat/public/publicregisterofcriticalhabitat.pl
Date accessed: February 2012.

Department of Sustainability, Environment, Water, Population and Communities (2011). *Commonwealth Listing Advice on Euphrasia arguta (Threatened Species Scientific Committee)*.
Website: http://www.environment.gov.au/biodiversity/threatened/species/pubs/4325-listing-advice.pdf
Date accessed: February 2012.

Department of Sustainability, Environment, Water, Population and Communities (2012). *Register of Critical Habitat*.
Website: http://www.environment.gov.au/cgi-bin/sprat/public/publicregisterofcriticalhabitat.pl
Date accessed: February 2012.

FloraSearch (2011). *Montrose East Underground Modification – Flora Assessment*. Prepared for Wambo Coal Pty Ltd.

Gibbons, P., Ayers, D., Seddon, J., Doyle, S. and Briggs, S. (2005) *Operational Manual for Biometric – A terrestrial Biodiversity Assessment Tool for the NSW Property Vegetation Plan Developer*. NSW Department of Environment and Conservation, Hurstville.

Harden, G.J. (Ed.) (1990 - 2002). *Flora of New South Wales*, Volumes 1 to 4 and revisions. University of New South Wales Press, Sydney.

House, S. (2003). *Lower Hunter and Central Coast Regional Biodiversity Conservation Strategy Technical Report*: *Digital Aerial Photo Interpretation and Updated Extant Vegetation Community Map, May 2003.* Lower Hunter and Central Coast Regional Environmental Management Strategy, Callaghan, NSW.

Kovac, M. and Lawrie, J.W. (1991). *Soil Landscapes of the Singleton 1:250,000 Sheet*. Soil Conservation Service of NSW.

MSEC (2012) *Mine Subsidence Assessment for the North Wambo Underground Mine Modification*.

National Parks and Wildlife Service (2002a). *Hunter lowland redgum forest in the Sydney Basin and NSW North Coast bioregions - endangered ecological community listing*. Final Determination, NSW Scientific Committee.
Website: http://www.environment.nsw.gov.au/determinations/HunterLowlandRedgumForestEndCom Listing.htm
Date accessed: February 2012.

National Parks and Wildlife Service (2002b). *Warkworth Sands woodland in the Sydney Basin Bioregion - endangered ecological community listing*. Final Determination, NSW Scientific Committee.
Website: http://www.environment.nsw.gov.au/determinations/WarkworthSandsWoodlandSydneyEndComListing.htm
Date accessed: February 2012.

National Parks and Wildlife Service (2002c). *Cynanchum elegans*. *Threatened Species Information*. NSW.
Website: http://www.environment.nsw.gov.au/resources/nature/tsprofileCynanchum Elegans.pdf
Date accessed: February 2012.

Office of Environment and Heritage (2012a). *List of Key Threatening Processes.*
Website: http://www.environment.nsw.gov.au/threatenedspecies/KeyThreateningProcessesByDoctype.htm
Date accessed: February 2012.

Office of Environment and Heritage (2012b). *Cymbidium canaliculatum population in the Hunter Catchment - Profile.*
Website: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=20049
Date accessed: February 2012.

Orchid Research (2003). *Wambo Development Project Flora Assessment.* Appendix HA of the Wambo Development Project Environmental Impact Statement. Prepared for Resource Strategies and Wambo Coal Pty Ltd.

Peake, T.C. (2006). *The Vegetation of the Central Hunter Valley, New South Wales.* A report on the findings of the Hunter Remnant Vegetation Project. Hunter-Central Rivers Catchment Management Authority, Paterson.

Scarlett, N., Bramwell, M. and Earl, G. (2003). *Austral Toad Flax – Thesium australe.* Flora and Fauna Guarantee Action Statement 56. Department of Sustainability and Environment, Victoria.

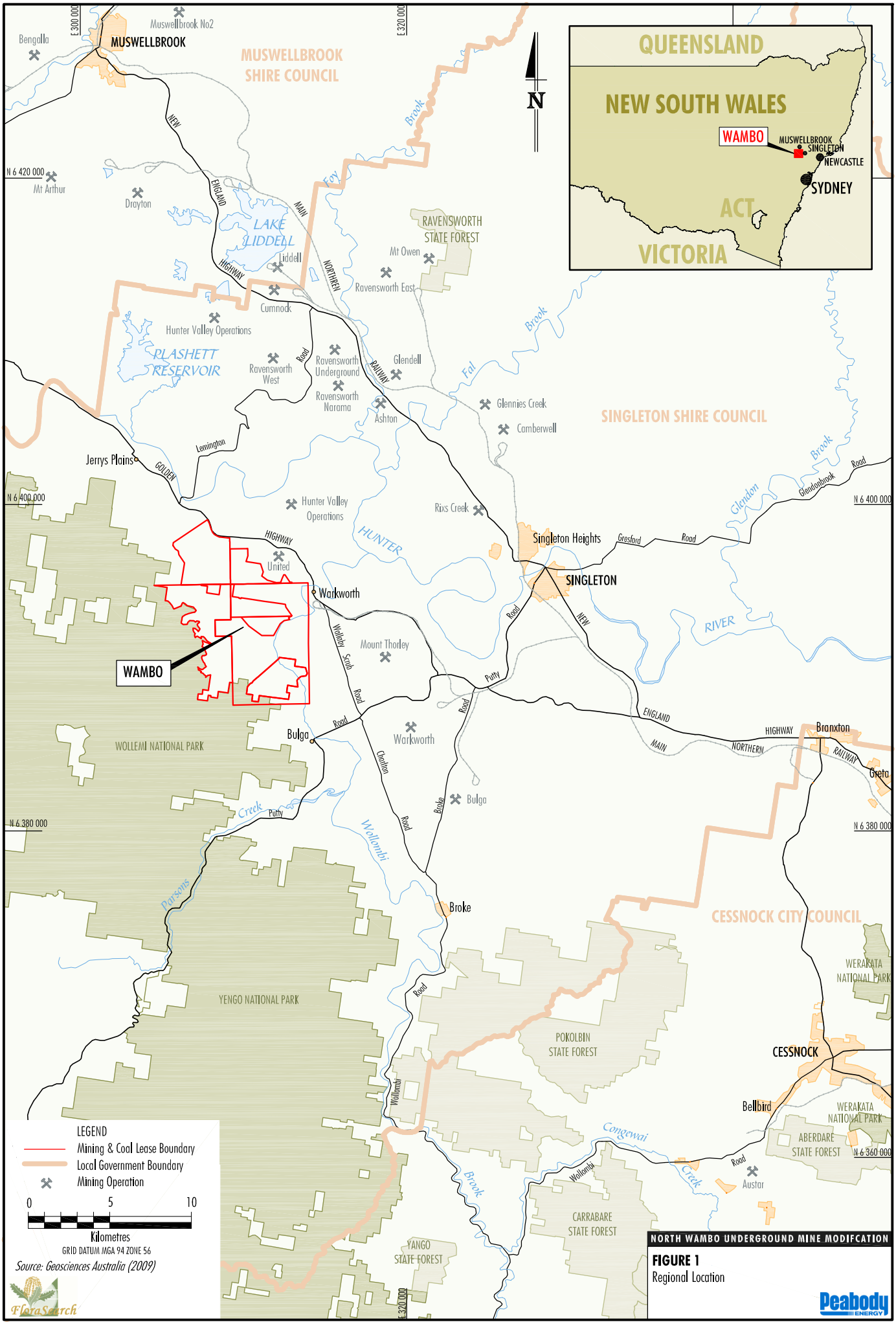
Story, R., Galloway, R.W., and Van De Graaff, R.H.M and Tweedie, A.D. (1963) *General Report on the Lands of the Hunter Valley.* Land Research Series No. 8. Commonwealth Scientific and Industrial Research Organisation, Melbourne.

Thackway, R. and Cresswell, I.D. (eds) (1995). *An Interim Biogeographic Regionalisation for Australia: a framework for establishing the national system of reserves.* Version 4.0. Australian Nature Conservation Agency: Canberra

Weston. P. H and Jobson. P. C. (2002). *Dillwynia*: In Harden, G.J. (Ed.) (1990 - 2002) *Flora of New South Wales*, Volume 2. University of New South Wales Press, Sydney.

APPENDIX A

FIGURES

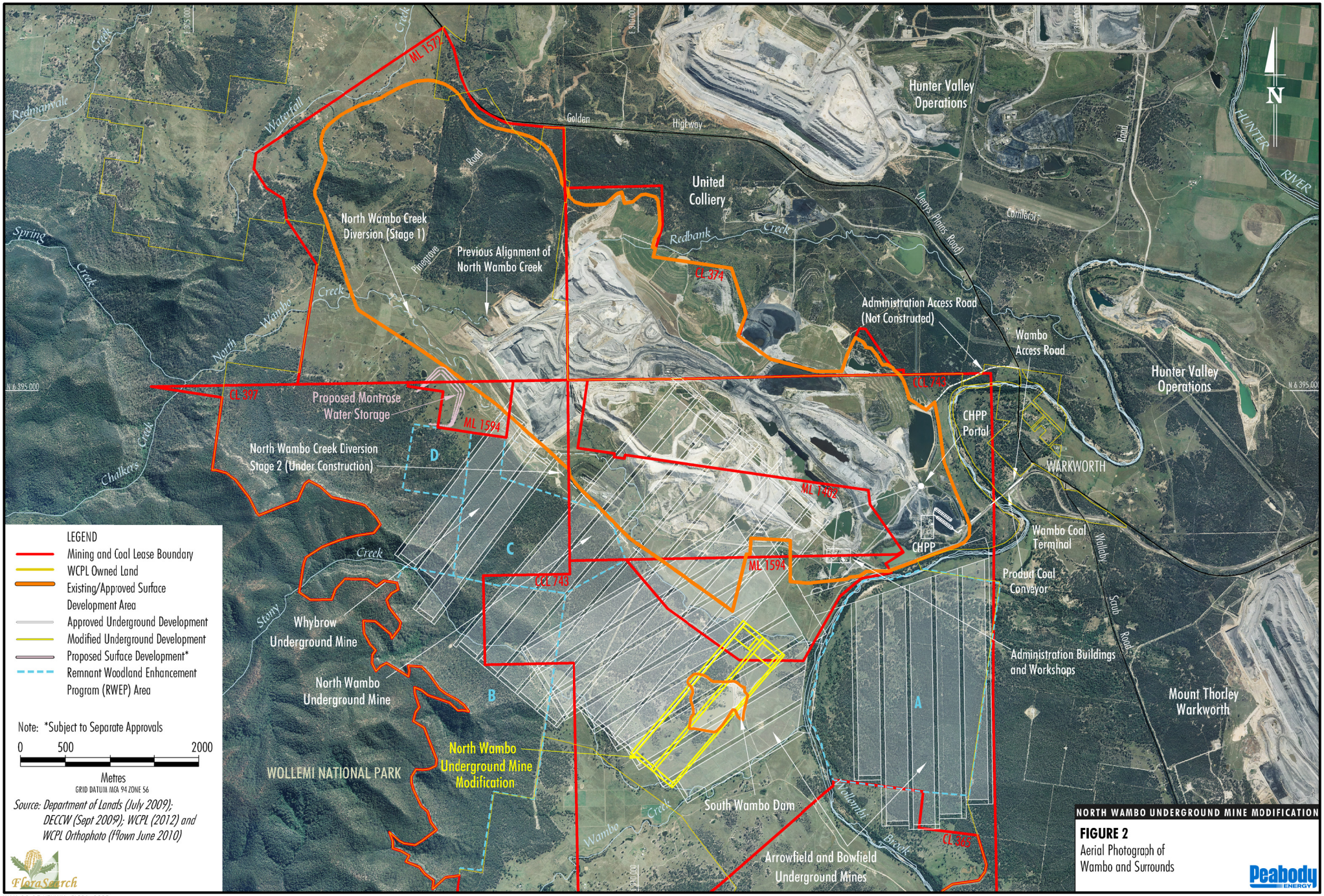


NORTH WAMBO UNDERGROUND MINE MODIFCATION

FIGURE 1
Regional Location

Peabody ENERGY

WAM-10-15 NTHWM_FLORA_103B



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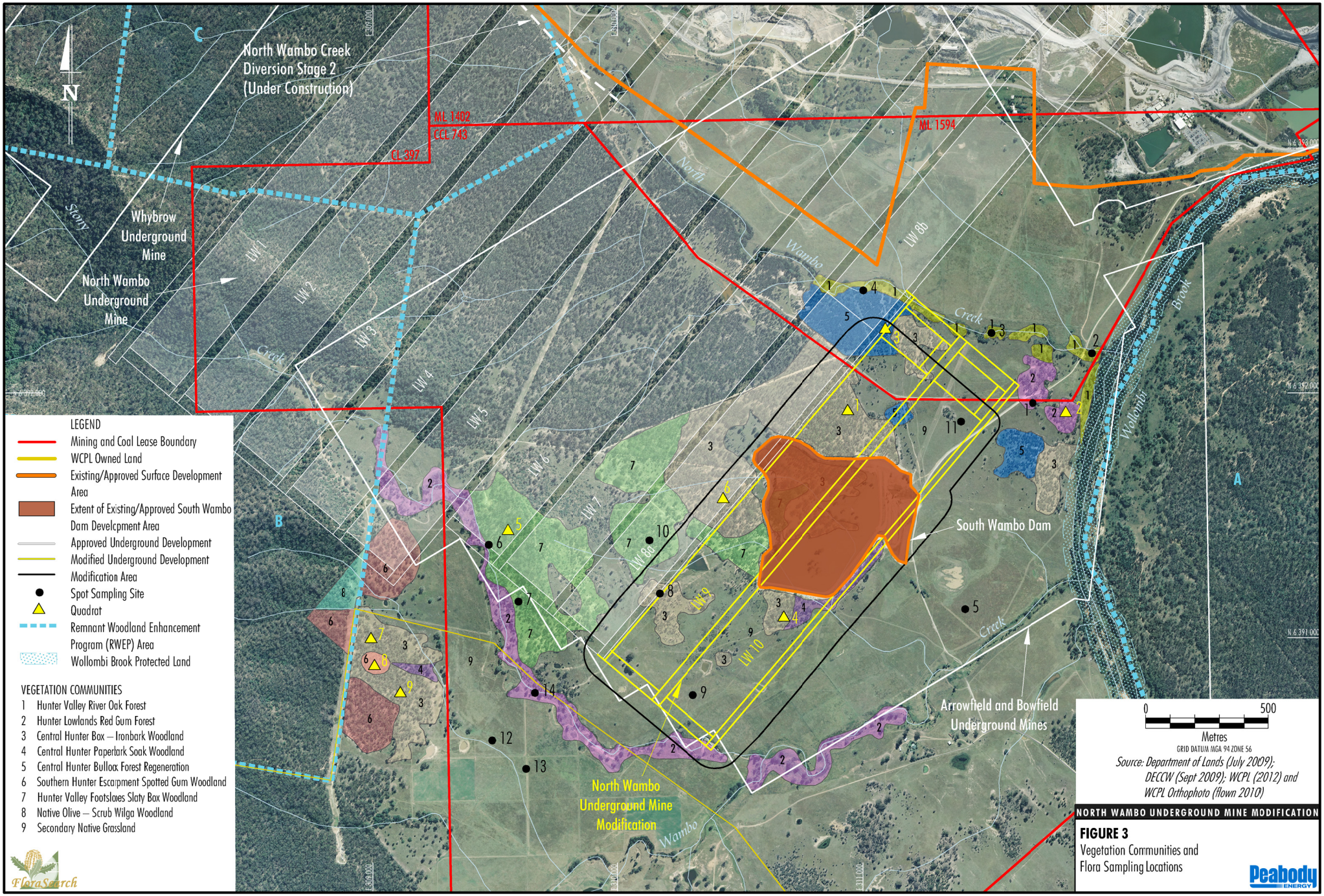

WAM-10-15 NTHWM_FLORA_104E

APPENDIX B

FLORA SPECIES LIST FOR THE STUDY AREA

APPENDIX B. FLORA SPECIES LIST FOR EACH VEGETATION COMMUNITY

Scientific Name	Common Name	Community								
		1	2	3	4	5	6	7	8	9
CLASS FILICOPSIDA										
Adiantaceae										
Cheilanthes austrotenuifolia	Rock Fern		•					•		
Cheilanthes distans	Bristly Cloak Fern	•	•	•	•		•	•		
Cheilanthes sieberi	Poison Rock Fern	•	•	•	•	•	•	•		•
CLASS CONIFEROPSIDA										
Cupressaceae										
Callitris endlicheri	Black Cypress Pine						•			
CLASS MAGNOLIOPSIDA										
SUBCLASS MAGNOLIIDAE										
Acanthaceae										
Brunoniella australis	Blue Trumpet		•	•			•	•		
Rostellularia adscendens var. *adscendens*	Pink Tongues							•		
Aizoaceae										
**Galenia pubescens*	Galenia	•	•		•					
Amaranthaceae										
Alternanthera sp. A					•					
Anacardiaceae										
**Schinus areira*	Pepper Tree	•	•							
Apiaceae										
**Cyclospermum leptophyllum*	Slender Celery									•
Daucus glochidiatus Form F	Native Carrot		•							
Hydrocotyle tripartita	Pennywort	•								
Apocynaceae										
**Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	•	•				•	•		
Asteraceae										
**Aster subulatus*	Wild Aster		•							
**Bidens subalternans*	Greater Beggar's Ticks		•		•					
Brachyscome multifida	Cut-leaved Daisy			•						
Calocephalus citreus	Lemon Beauty-heads			•						
Calotis cuneifolia	Purple Burr-daisy			•						
Calotis lappulacea	Yellow Burr-daisy		•	•	•	•		•		•
Cassinia cunninghamii	Cunninghams Everlasting			•			•	•		
Cassinia laevis	Cough Bush		•							•
Cassinia quinquefaria							•			
Chrysocephalum apiculatum	Common Everlasting		•	•	•	•		•		•
**Cirsium vulgare*	Spear Thistle	•	•		•					•
**Conyza bonariensis*	Flaxleaf Fleabane	•	•	•	•					•
**Conyza sumatrensis*	Tall Fleabane		•							•
Cotula australis	Carrot Weed		•		•		•	•		•
Cymbonotus sp.								•		
Euchiton involucratus	Star Cudweed		•	•	•					•
Euchiton sphaericus	Cudweed							•		
**Facelis retusa*	Facelis	•	•					•		•
**Gamochaeta americana*	Cudweed		•							•
Glossocardia bidens	Cobbler's Tack		•	•				•		
**Hypochaeris glabra*	Smooth Catsear		•		•					•
**Hypochaeris radicata*	Catsear				•					•
Leptorhynchos squamatus	Scaly Buttons		•	•				•		
Olearia elliptica	Sticky Daisy-bush			•			•	•		
Ozothamnus diosmifolius	Rice Flower			•				•		
**Schkuhria pinnata* var. *abrotanoides*	Dwarf Marigold		•							
Senecio linearifolius var. *macrodontus*			•							
**Senecio madagascariensis*	Fireweed	•	•	•	•	•	•	•		•
Senecio microbasis								•		
Sigesbeckia orientalis subsp. orientalis	Indian Weed		•							
**Silybum marianum*	Variegated Thistle	•								
**Sonchus asper*	Prickly Sowthistle		•							
**Sonchus oleraceus*	Common Sowthistle	•	•		•			•		
**Tagetes minuta*	Stinking Roger		•							
Vernonia cinerea	A Vernonia	•		•	•			•		
Vittadinia cuneata var. *cuneata* forma *cuneata*	Fuzzweed		•							

Scientific Name	Common Name	Community								
		1	2	3	4	5	6	7	8	9
Vittadinia cuneata var. *hirsuta*	Fuzzweed			•				•		
**Xanthium italicum*	Hunter Burr	•								
Brassicaceae										
**Capsella bursa-pastoris*	Shepherd's Purse		•							
**Lepidium africanum*	A Peppercress	•		•						
**Lepidium bonariense*	A Peppercress				•					
**Rorippa nasturtium-aquaticum*	Watercress	•								
Cactaceae										
**Opuntia aurantiaca*	Tiger Pear		•	•						
**Opuntia humifusa*	Creeping Pear		•	•		•		•		
**Opuntia stricta*	Common Prickly Pear			•	•		•	•		
Campanulaceae										
Wahlenbergia communis	Tufted Bluebell						•			
Wahlenbergia gracilis	Australian Bluebell			•	•		•	•		
Caryophyllaceae										
**Cerastium glomeratum*	Mouse-ear Chickweed		•							•
**Paronychia brasiliana*	Brasilian Whitlow		•		•					
**Petrorhagia nanteuilii*	Proliferous Pink									•
**Polycarpon tetraphyllum*	Four-leaved Allseed		•							
**Silene gallica*	French catchfly									•
**Spergularia rubra*	Sandspurry				•					
**Stellaria media*	Common Chickweed	•	•							
Casuarinaceae										
Allocasuarina luehmannii	Bulloak	•		•		•	•	•		
Casuarina cunninghamiana	River Oak	•								
Celastraceae										
Maytenus silvestris	Narrow-leaved Orangebark							•		
Chenopodiaceae										
Atriplex semibaccata	Creeping Saltbush	•								
Atriplex sp.			•							
**Chenopodium ambrosioides*	Mexican Tea	•								
Einadia hastata	Red Berry Saltbush		•	•	•	•		•		
Einadia nutans	Climbing Saltbush					•				
Einadia nutans subsp. *linifolia*	Climbing Saltbush	•		•	•			•		
Einadia nutans subsp. *nutans*	Climbing Saltbush					•		•		
Einadia polygonoides	Knotweed Goosefoot			•	•			•		
Einadia trigonos	Fishweed							•		
Enchylaena tomentosa	Ruby Saltbush				•					
Maireana microphylla	Small-leaf Bluebush	•	•	•	•					•
Clusiaceae										
Hypericum gramineum	Small St. John's Wort									•
Convolvulaceae										
Dichondra repens	Kidney Weed		•	•	•		•	•		
Crassulaceae										
Crassula sieberiana	Australian Stonecrop			•		•		•		
Dilleniaceae										
Hibbertia obtusifolia	Hoary Guinea Flower						•			
Euphorbiaceae										
Bertya oleifolia	A Bertya		•	•			•			
Chamaesyce drummondii	Caustic Weed		•	•		•		•		
Fabaceae - Caesalpinioideae										
Senna coronilloides	A Cassia	•	•					•		
Fabaceae - Faboideae										
Daviesia genistifolia	Broom Bitter Pea			•		•		•		
Daviesia ulicifolia	Gorse Bitter Pea			•			•	•		
Desmodium brachypodum	Large Tick-trefoil			•			•	•		
Desmodium gunnii	Slender Tick-trefoil			•			•	•		
Desmodium varians	Slender Tick-trefoil		•	•			•	•		
Glycine clandestina	Love Creeper		•							
Glycine tabacina	A Glycine		•	•	•			•		
Hardenbergia violacea	Purple Coral-pea						•			
Jacksonia scoparia	Winged Broom-pea						•			
**Medicago polymorpha*	Burr Medic									•
**Medicago* sp.	A Medic		•							•

Scientific Name	Common Name	Community								
		1	2	3	4	5	6	7	8	9
**Trifolium arvense*	Haresfoot Clover									•
**Trifolium campstre*	Hop Clover									•
**Trifolium dubium*	Yelow Suckling Clover									•
**Trifolium glomeratum*	Clustered Clover		•							•
**Trifolium repens*	White Clover		•							•
**Trifolium subterraneum*	Subterranean Clover									•
**Trifolium tomentosum*	Woolly Clover									•
Fabaceae - Mimosoideae										
Acacia amblygona	Fan Wattle			•			•	•		
Acacia binervia	Coast Myall			•				•		
Acacia bulgaensis	Bulga Wattle						•			
Acacia decora	Western Silver Wattle			•				•		
Acacia falcata	Sickle Wattle			•	•					
Acacia filicifolia	Fern-leaved Wattle		•							
Acacia implexa	Hickory Wattle		•					•		
Acacia salicina	Cooba	•	•	•				•		
Neptunia gracilis forma *gracilis*	Sensitive Plant		•							
Gentianaceae										
**Centaurium erythraea*	Common Centaury									•
Goodeniaceae										
Goodenia rotundifolia	A Goodenia			•			•	•		
Lamiaceae										
**Prunella vulgaris*	Self-heal						•	•		
Spartothamnella juncea	Bead Bush	•		•			•	•		
Loranthaceae										
Amyema cambagei		•								
Amyema miquelii	Stalked Mistletoe		•							
Amyema pendulum subsp. *pendulum*	Drooping Mistletoe		•	•	•		•			
Malvaceae										
Abutilon oxycarpum	Straggly Lantern-bush				•		•	•		
Hibiscus heterophyllus subsp. *heterophyllus*	Native Rosella		•							
**Modiola caroliniana*	Red-flowered Mallow	•			•					
**Pavonia hastata*	Pink Pavonia		•							
Sida corrugata	Corrugated Sida		•	•				•		
**Sida rhombifolia*	Paddy's Lucerne	•	•	•	•			•		•
Sida subspicata	Spiked Sida				•			•		
Meliaceae										
Melia azedarach	White Cedar		•							
Myoporaceae										
Eremophila debilis	Amulla	•		•	•		•	•		
Myoporum montanum	Western Boobialla		•	•	•			•		
Myrsinaceae										
**Anagallis arvensis*	Scarlet Pimpernel	•	•	•	•		•	•		•
Myrtaceae										
Angophora floribunda	Rough-barked Apple	•	•							
Corymbia maculata	Spotted Gum						•			
Eucalyptus crebra	Narrow-leaved Ironbark		•	•	•		•	•		
Eucalyptus dawsonii	Slaty Gum		•	•				•		
Eucalyptus melliodora	Yellow Box		•							
Eucalyptus moluccana	Grey Box		•	•	•		•	•		
Eucalyptus tereticornis	Forest Red Gum	•	•		•					
Melaleuca decora	A Honeymyrtle			•	•		•			
Oleaceae										
Jasminum voluble	Stiff Jasmine			•			•			
Notelaea microcarpa var. *microcarpa*	Native Olive	•	•	•				•		
**Olea europaea*	Common Olive	•								
Oxalidaceae										
Oxalis sp.	An Oxalis		•		•			•		•
Phyllanthaceae										
Breynia oblongifolia	Coffee Bush		•					•		
Phyllanthus sp.	A Phyllanthus			•						
Pittosporaceae										
Bursaria spinosa	Blackthorn	•		•			•	•		

Scientific Name	Common Name	Community								
		1	2	3	4	5	6	7	8	9
Plantaginaceae										
Plantago debilis	Slender Plantain									
**Plantago lanceolata*	Lamb's Tongue	•	•	•	•			•		•
**Plantago myosuros*										•
Polygonaceae										
Persicaria lapathifolia	Pale Knotweed		•							
Persicaria prostrata	Creeping Knotweed		•							
Rumex brownii	Swamp Dock		•							
**Rumex crispus*	Curled Dock	•								
Ranunculaceae										
Clematis microphylla	Small-leaved Clematis		•							
Rubiaceae										
Asperula conferta	Common Woodruff			•				•		
Opercularia diphylla				•			•			
Psydrax odorata	Shiny-leaved Canthium			•			•	•		
**Richardia stellaris*				•						
Rutaceae										
Geijera salicifolia		•	•		•		•	•		
Santalaceae										
Choretrum species A				•			•	•		
Exocarpos cupressiformis	Native Cherry						•			
Exocarpos strictus	Dwarf Cherry		•							
Sapindaceae										
Dodonaea sinuolata subsp. *sinuolata*								•		
Dodonaea viscosa subsp. *cuneata*	Wedge-leaf Hop-bush			•			•	•		
Dodonaea viscosa subsp. *spatulata*								•		
Scrophulariaceae										
Veronica plebeia	Trailing Speedwell		•	•						•
Solanaceae										
**Cestrum parqui*	Green Cestrum	•	•							
**Lycium ferocissimum*	African Boxthorn	•	•		•					
**Nicotiana glauca*	Tree Tobacco	•								
Solanum aviculare	Kangaroo Apple		•							
Solanum brownii	Violet Nightshade			•				•		•
**Solanum mauritianum*	Wild Tobacco Bush	•								
**Solanum nigrum*	Black-berry Nightshade	•	•					•		
Stackhousiaceae										
Stackhousia muricata	Western Stackhousia						•	•		
Sterculiaceae										
Brachychiton populneus	Kurrajong	•	•	•	•		•	•		
Rulingia dasyphylla	Kerrawang		•							
Ulmaceae										
Trema tomentosa var. *aspera*	Poison Peach		•							
Urticaceae										
Urtica incisa	Stinging Nettle	•	•							
Verbenaceae										
**Verbena caracasana*		•	•							•
**Verbena bonariensis*	Purpletop		•							•
**Verbena* sp.							•			
**Verbena supina*	Trailing Verbena		•							
Vitaceae										
Cayratia clematidea	Native Grape		•							
SUBCLASS LILIIDAE										
Anthericaceae										
Arthropodium milleflorum	Pale Vanilla-lily			•				•		
Arthropodium minus	Small Vanilla Lily						•	•		
Dichopopgon fimbriatus	Nodding Chocolate Lily				•					
Laxmannia gracilis	Slender Wire Lily			•						
Cyperaceae										
Carex appressa	Tall Sedge		•							
Cyperus gracilis	Slender Flat-sedge		•	•	•			•		
Fimbristylis dichotoma	Common Fringe-sedge							•		
Gahnia aspera	Common Saw-sedge		•					•		
Scleria mackaviensis								•		

Scientific Name	Common Name	Community								
		1	2	3	4	5	6	7	8	9
Iridaceae										
**Romulea rosea*	Onion Grass									•
Juncaceae										
**Juncus acutus*	Sharp Rush	•								
Juncus sp.	A Rush	•	•							
Lomandraceae										
Lomandra confertifolia	Mat-rush			•			•			
Lomandra filiformis subsp. *coriacea*	Wattle Mat-rush			•			•	•		
Lomandra filiformis subsp. *filiformis*	Wattle Mat-rush			•	•		•	•		•
Lomandra multiflora	Many-flowered Mat-rush			•				•		
Phormiaceae										
Dianella caerulea var. *cinerascens*	Blue Flax Lily			•				•		
Dianella longifolia	Blueberry Lily		•							
Dianella longifolia var. *stenophylla*							•	•		
Dianella revoluta	Spreading Flax-lily			•						
Dianella sp.				•				•		
Poaceae										
Ancistrachne uncinulata	Hooky Grass							•		
Aristida personata	Purple Wire-grass	•	•	•	•			•		•
Aristida vagans	Threeawn Speargrass			•		•		•		
Austrodanthonia fulva	Wallaby Grass			•				•		
Austrodanthonia racemosa var. *obtusata*	Wallaby Grass							•		
Austrostipa scabra	Speargrass		•	•	•			•		
Austrostipa sp.				•						
Austrostipa verticillata	Slender Bamboo Grass	•	•		•					
Bothriochloa decipiens	Red Grass	•	•	•	•			•		•
**Briza minor*	Quaking Grass		•							
**Bromus cartharticus*	Prairie Grass									•
**Chloris gayana*	Rhodes Grass	•								
Chloris truncata	Windmill Grass				•					
Chloris ventricosa	Plump Windmill Grass	•		•	•	•		•		
Cymbopogon refractus	Barbwire Grass	•	•	•		•	•	•		
Cynodon dactylon	Couch	•	•		•					•
Digitaria brownii	Cotton Panic Grass		•							
Digitaria diffusa	Open Summer Grass			•	•			•		
Digitaria divaricatissima	Umbrella Grass		•							
**Ehrharta erecta*	Panic Veldtgrass	•								
Enteropogon acicularis	Curly Windmill Grass			•	•	•				
Eragrostis brownii	Brown's Lovegrass		•					•		
**Eragrostis curvula*	African Lovegrass			•						
Eragrostis elongata	Clustered Lovegrass		•		•	•				•
Eragrostis lacunaria	Purple Love-grass			•						
Eragrostis leptostachya	Paddock Lovegrass		•	•	•			•		•
Eragrostis parviflora	Weeping Lovegrass		•	•	•			•		
Eriochloa pseudoacrotricha	Early Spring Grass				•			•		
Eulalia aurea	Silky Browntop		•							
Microlaena stipoides	Weeping Grass	•	•	•				•		
Notodanthonia longifolia	Long-leaved Wallaby Grass			•			•			
Oplismenus imbecillis	Basket Grass	•								
Panicum effusum	Hairy Panic		•	•		•		•		•
Panicum simile	Two Coloured Panic			•				•		•
Paspalidium criniforme	Fine Panic			•		•		•		
**Paspalum dilatatum*	Paspalum		•							•
**Pennisetum clandestinum*	Kikuyu Grass		•							
Phragmites australis	Common Reed	•								
**Setaria pumila*	Pale Pigeon Grass	•	•							•
Sporobolus creber	Slender Rat's Tail Grass	•	•	•	•			•		•
Sporobolus elongatus	Slender Rat's Tail Grass									•
TOTAL NATIVE SPECIES	173	32	78	88	46	17	48	96		21
TOTAL INTRODUCED SPECIES	74	30	40	11	17	2	6	11		32
GRAND TOTAL SPECIES	250	62	118	99	63	19	54	107		53